

food (bio)chemistry!

lecture 1

intro to organic chemistry,
lipids, polarity

sovannjet lim and boheng cao
february 28, 2026

fatty acid composition

saturation and temperature

- plant fatty acids are mostly **unsaturated** (double bond(s))
 - *liquid* at room temperature
 - exceptions: coconut and palm
 - many have **polyunsaturated** fatty acids (i.e. 2 or 3 double bonds)
- animal fatty acids are mostly **saturated** (no double bonds)
 - *solid* at room temperature
 - exceptions: fish oils, whale oil

green indicates plant oil; **yellow** indicates processed plant products; **red** indicates meat products

	saturated	unsaturated	poly-unsaturated
palm kernel oil	86%	12%	2%
coconut oil	87%	13%	trace
peanut oil	17%	46%	32%
soybean oil	15%	24%	58%
olive oil	14%	73%	11%
canola oil	8%	64%	28%
shortening	25%	45%	26%
margarine	18%	39%	39%
butter	63%	29%	3%
lard	39%	45%	11%
salmon	28%	33%	28%

why these compositions?

saturation and temperature

- organisms prefer storing energy as saturated fat whenever possible
 - energy required to create unsaturated fats
 - unsaturated fats less dense
 - **lecture 5:** electron carrier-mediated reduction/double bond formation (dehydrogenation)
- however, fats need to remain liquid
- “warm-blooded” (**endothermic**) animals can get away with saturated fats
 - warm bodies, above melting point
 - exceptions: extremities (ends of limbs) of animals in cold climates
- tropical plants are also fine with saturated fat energy storage (e.g. palm, coconut)
 - not so much for temperate plants (e.g. peanut, olive, rapeseed, soybean)
- “cold-blooded” (**ectothermic**) animals in cold environments must use unsaturated/polyunsaturated
 - e.g. fish, exterior whale blubber



the quest for saturated fats, part 1

vegetable shortening

- pastries should be flaky
 - most bread/noodles are elastic rather than flaky because of **gluten**
 - **lecture 2:** gluten is a **protein** in flour that cross-links and forms networks
- need saturated fats to disrupt gluten cross-links
 - historically: only butter/lard, but expensive
- why don't we artificially convert unsaturated into saturated?
 - unsaturated plant oils are cheaper
 - **hydrogenation** invented by Wilhelm Normann, 1901
- thus, vegetable shortening
 - e.g. Crisco from cottonseed oil

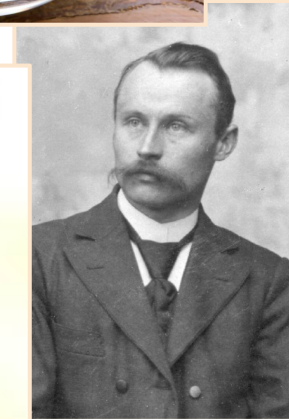
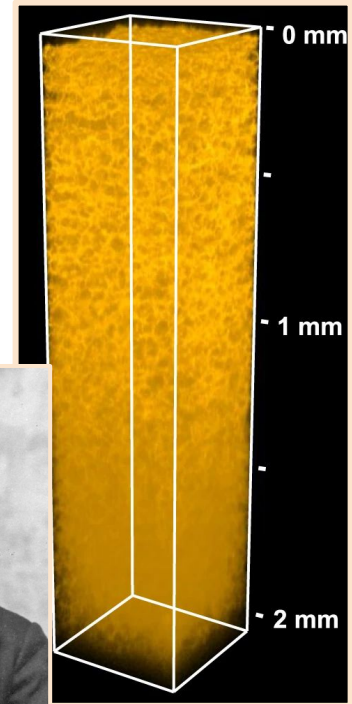


Figure from (Ogawa et al. 2021)



trans fat crisis and palm oil

- vegetable shortening was cheap, didn't go bad, and had a high **smoke point**
 - **lecture 4:** saturated fats are resistant to rancidification/free radical oxidation
- however, artificial hydrogenation processes produce **trans fats**
 - coronary artery disease and diabetes



- **solution: palm kernel oil**
 - shelf-stable; in ultra-processed foods
 - lubricant, soap, detergent, biodiesel
- **palm oil is everywhere** in consumer products
 - oil with highest production; 7.7 kg/person
- **social and environmental consequences**
 - child labor, slavery, sexual abuse
 - slash-and-burn deforestation, soil degradation, air/water pollution
 - alternatives not necessarily better (overconsumption is the problem)



essential fatty acids

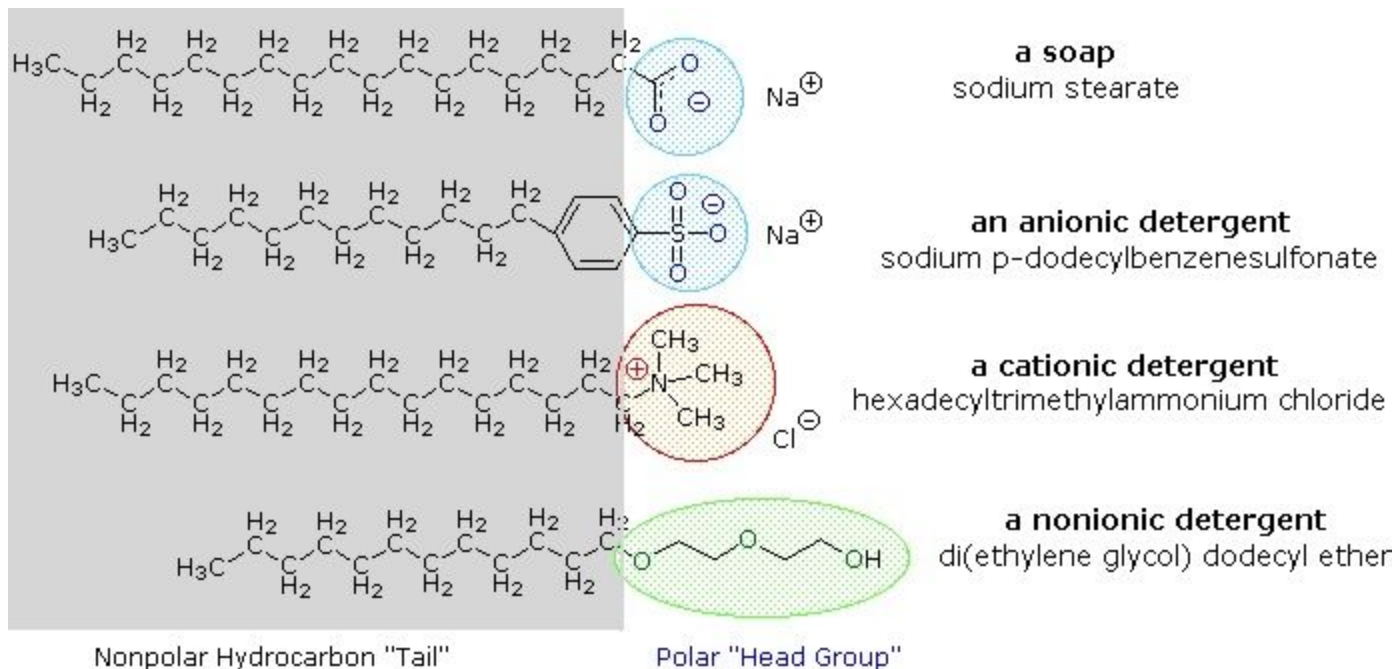
where is a fatty acid unsaturated?

- two **essential fatty acids** for humans:
alpha-linolenic acid and **linolenic acid**
 - both polyunsaturated
 - essential in diet (all other fatty acids can be synthesized from these two)
- precursors for all **omega-3** and **omega-6** fatty acids, respectively
 - omega-3 means that the double bond that's *furthest* from the oxygen is located 3 carbons away from the end
 - omega-3 deficiency common

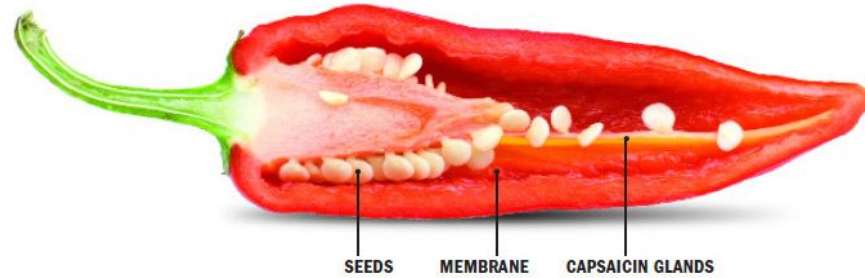
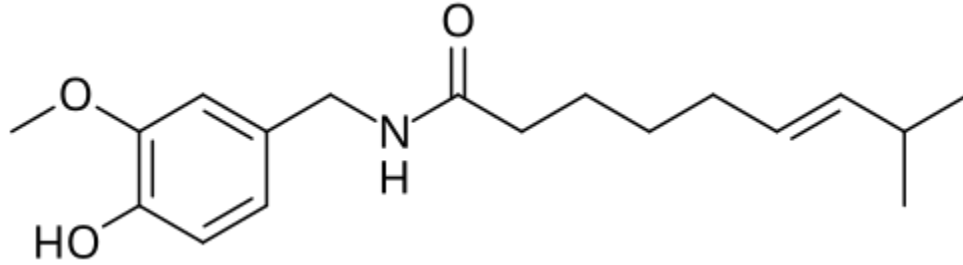
Note: This slide wasn't covered in class; we'll be covering this in lesson 6

update: we didn't, in fact, explicitly cover this in lecture 6, but the location of the double bond affects the specific steps that are taken in fatty acid oxidation (which we did cover)

soaps & detergents



capsaicin in peppers



<https://en.wikipedia.org/wiki/Capsaicin>

<https://www.culturehotsauce.com/blogs/educate-yourself/capsaicin>

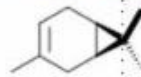
terpenes & terpenoids in spices



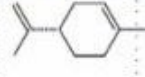
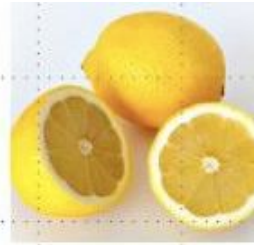
Pinene
(Pines)



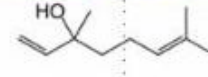
Caryophyllene
(Peppercorns)



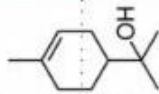
Carene
(Cedar, Rosemary)



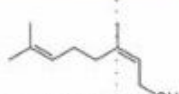
Limonene
(Citrus Lemon)



Linalool
(Mints, Lavender)



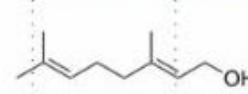
Terpineols
(Junipers, Orange Peel)



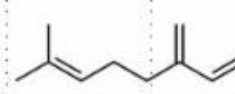
Nerol
(Lemon Grass)



Humulene
(Hops)



Geraniol
(Roses & Wine Grapes)



Myrcene
(Myrtles & Cannabis)

food (bio)chemistry!
lecture 2
polarity and emulsification,
amino acids

sovannjet lim and boheng cao
march 7, 2026



Boheng Cao <lysine@mit.edu>
to S16427-students, S16427-teachers ▾

10:22 AM ☆ ⋮

🔔 Send scheduled for 10:22 AM

Cancel send

tl;dr lecture notes/links to slides/faqs will be at [this link](#) from now on; last week's slides are [here](#); submit feedback/questions/suggestions at [this link](#) (please please please use the form if you want to ask us anything at all)

hi everyone,

hope you're having a fun saturday so far! as a reminder, this week's lecture will be at **3 to 4 pm in 3-133**, and we'll be doing the emulsification demo that we didn't have time for last week + a lot of new things!

moving forward, we've decided to put all our lecture notes at this link:

https://docs.google.com/document/d/1aNVEKZYDac3acFXKLxAs_SMPpM_5sAhywgUh4t3gU-8/edit?usp=sharing. this will probably have a disorganized medley of notes/thoughts/diagrams/links for all the lectures from now on; we'll also have answers to commonly asked questions (whether in class or through the google form). be sure to notify us (by email or through the form) if there's anything missing from this document :)

last week's slides are at this link: https://docs.google.com/presentation/d/1kjUc-2TffH7VJb-YA2b-P_so0zRHX1sJkNtxH61prFU/edit?slide=id.g3acff5356ab_0_1441#slide=id.g3acff5356ab_0_1441. we highly recommend that you look through it, even if just to skim it, since we did have to go really quickly through the slides. a few other tidbits about the slides that we didn't have time to cover last week:

- trans fats are much, much healthier than 'conventional' (cis) saturated fats found in nature. saturated fats are already linked to heart disease, but trans fats even more so — for each increase of 2% in the amount of calories from trans fat you consume, your risk for coronary artery disease [doubles](#) (yes, doubles!). in the united states, the food and drug administration (fda) [banned](#) trans fats in 2018.
- the reason that you can still buy crisco (and other hydrogenated vegetable fats) despite the ban is that they switched to a different and more complicated method for hydrogenating fats that reduces the amount of trans fat byproducts. nowadays, a lot of manufacturers start off with a small amount of already solid vegetable fat (like palm oil) and use that as a 'starting crystal' that helps make the rest of the liquid vegetable oil crystallize and become saturated.
- another way of making a solid vegetable fat product is by *emulsifying* the oil with water to create margarine. we'll be covering how that's done today :)

last (but possibly most importantly), our feedback/questions form is at https://docs.google.com/forms/d/e/1FAIpQLSdhnXxzyYm6dKxy3_P3LszxmcZufo5azsFP10RPrBzc2hBg/viewform?usp=send_form. besides email, this will be our primary form of communication for the class; if you have anything you want to ask us about the class, any requests for next lecture, or any feedback whatsoever, please don't hesitate to send us your thoughts!

check your inbox!

you should do the
worksheet :D

(or like we can't force you to)
(but sovannjet spent like 4
hours last night drawing out all
the chemical reactions and
arrow-pushing in the software)
(it's really time-consuming)



slides from last week

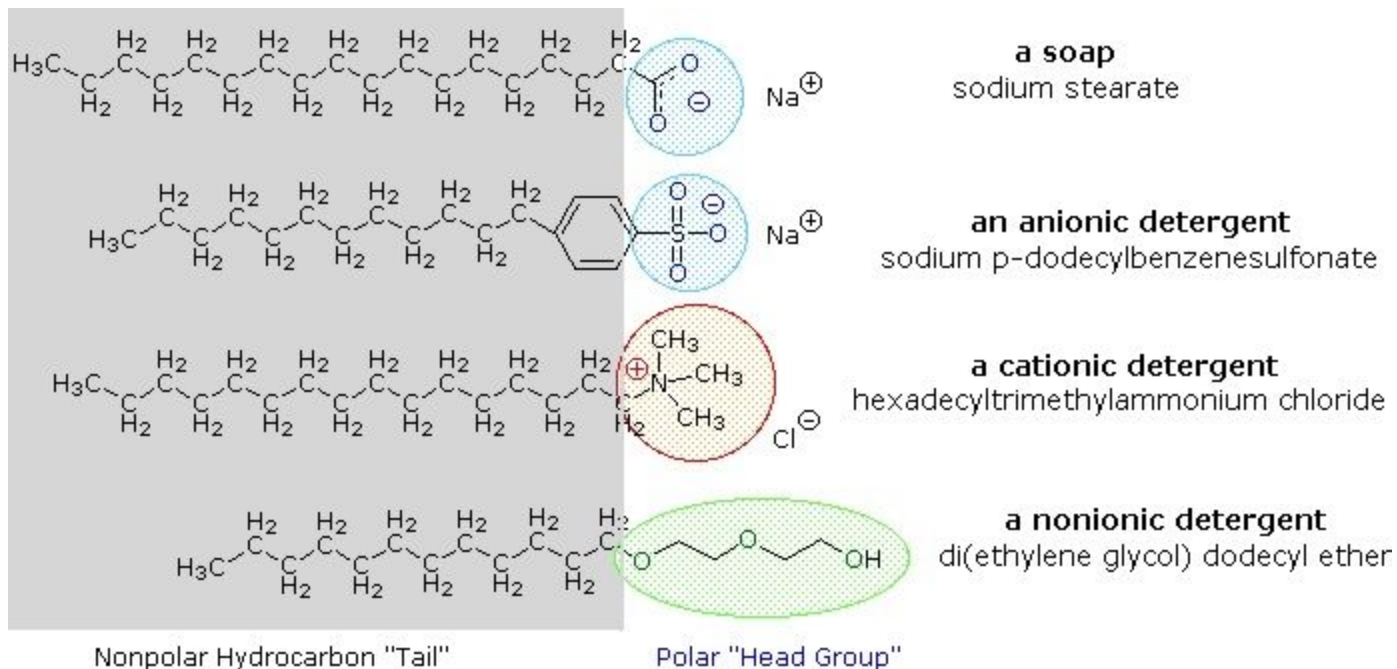


lecture notes

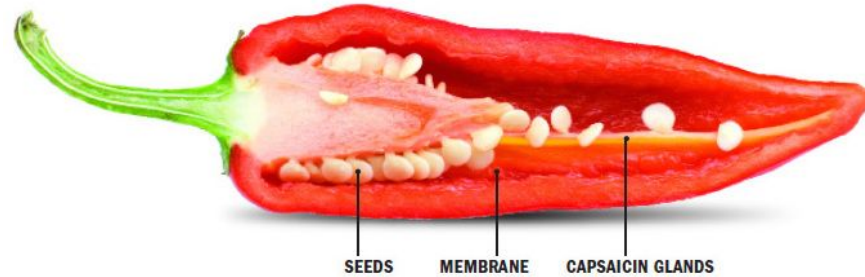
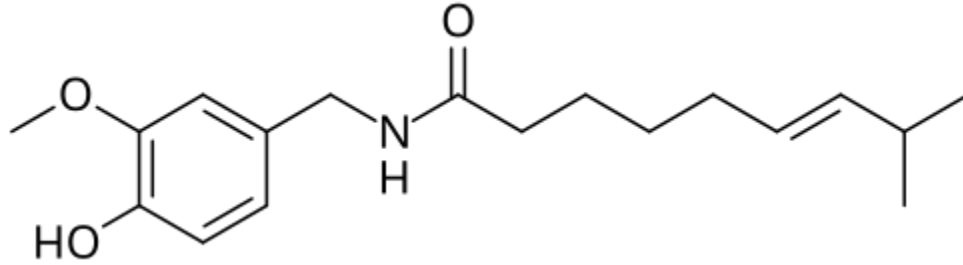


feedback form

recap: soaps & detergents



recap: capsaicin in peppers



<https://en.wikipedia.org/wiki/Capsaicin>

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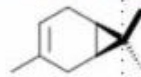
recap: terpenes & terpenoids in spices



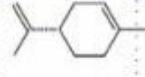
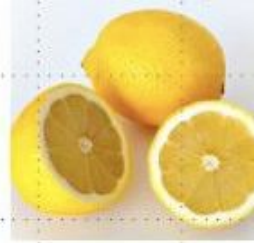
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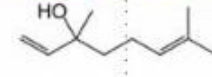
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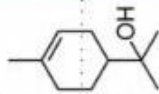
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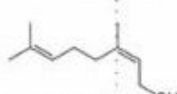
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Linalool
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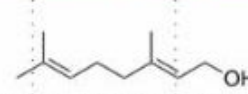
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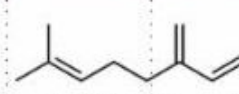
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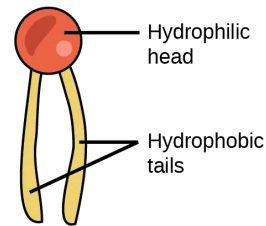
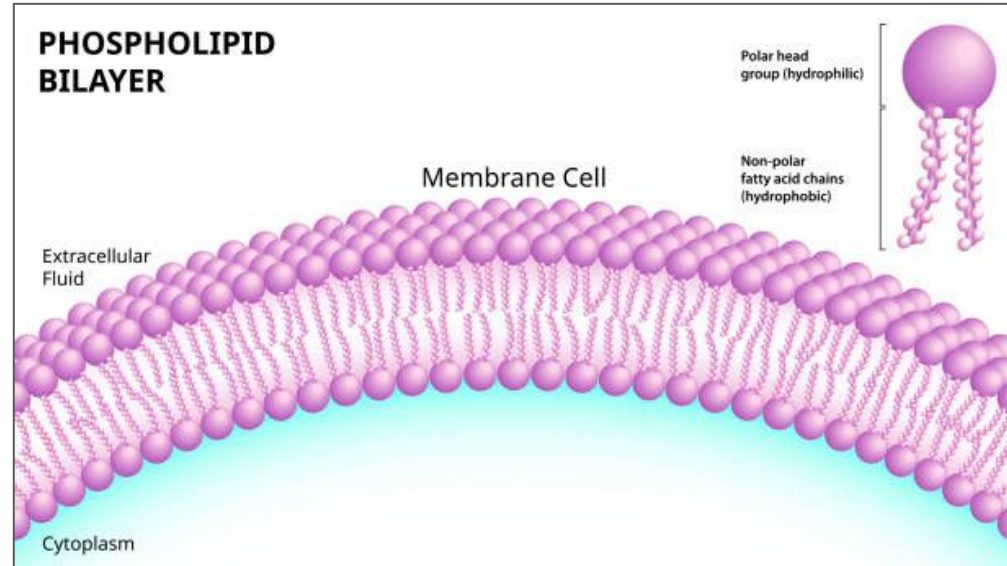
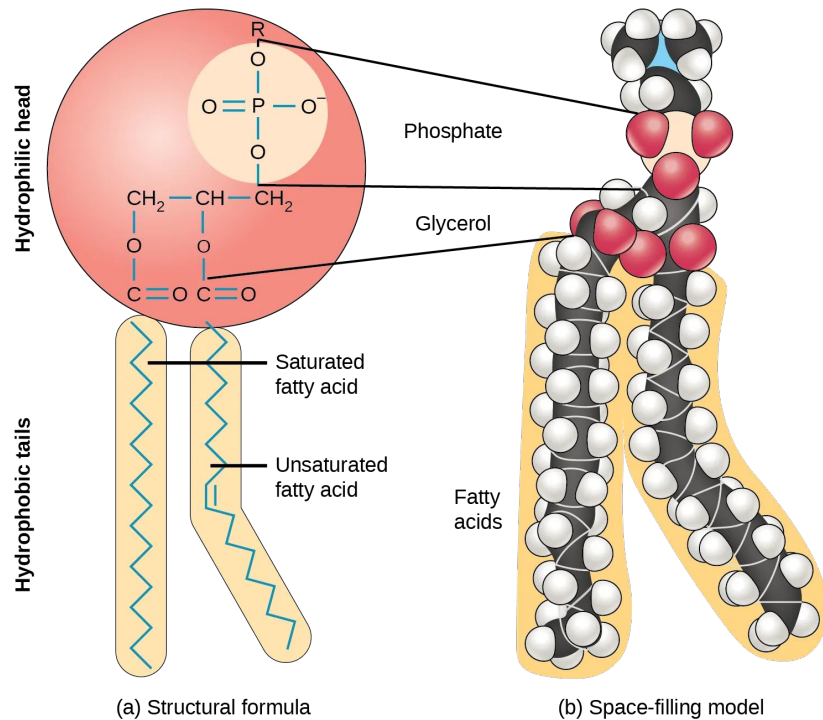
Geraniol
(Roses & Wine Grapes)



Myrcene
(Myrtles & Cannabis)

phospholipids and amphipathic molecules

both hydrophobic and hydrophilic

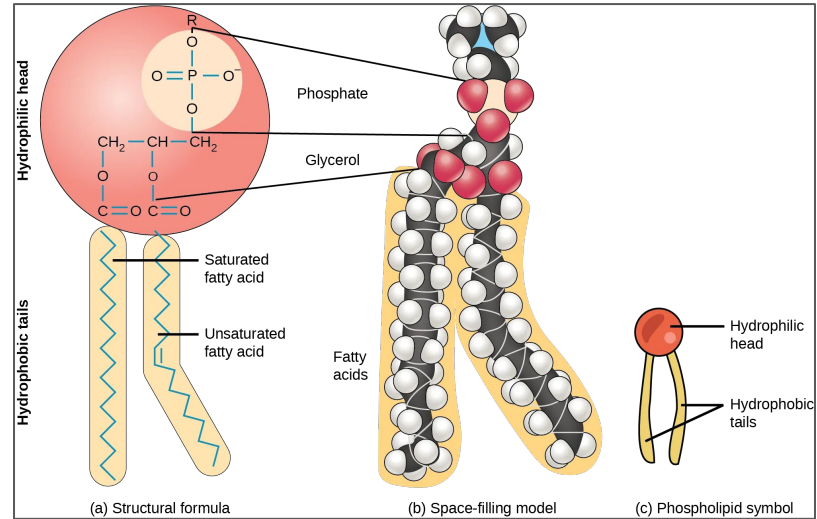
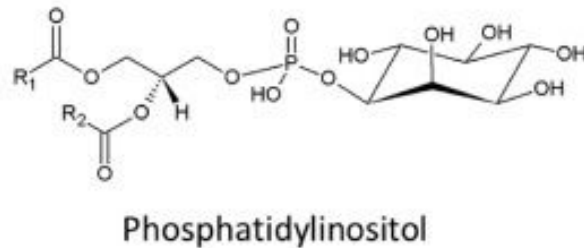
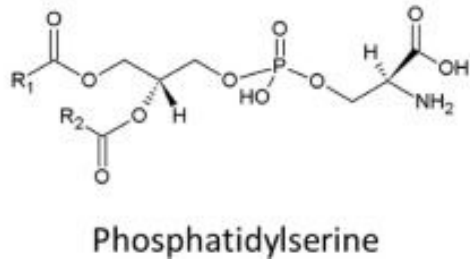
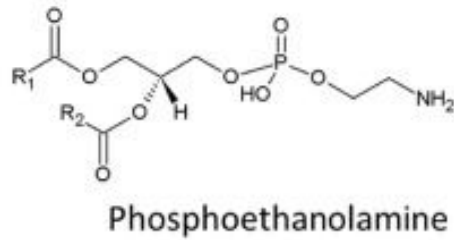
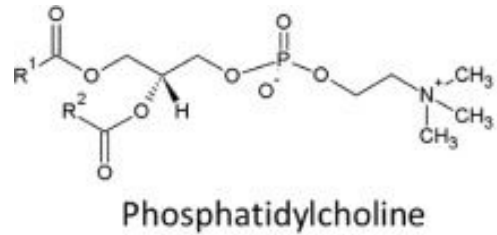


(c) Phospholipid symbol

phospholipids and amphipathic molecules

both hydrophobic and hydrophilic

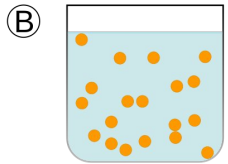
- **mayonnaise** is a water-oil emulsion using egg yolk as the emulsifying agent
 - lecithin (a mixture of phospholipids) in egg has both hydrophobic and hydrophilic parts



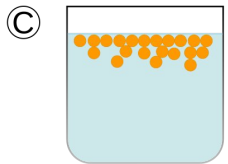
demo time :)



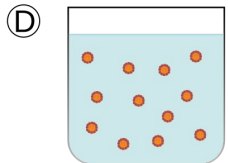
(a) initial state: oil and water separated; oil is less dense and floats at the top



(b) oil stirred/agitated and forms droplets spreading throughout water



(c) without added surfactant/emulsifying agent, oil and water separate again



(d) emulsifying agents (like egg yolk or starch) can keep oil and water mixed

- oil is **hydrophobic** because it's (mostly) **nonpolar** and has few polar bonds with large electronegativity difference/partial charges
 - mostly fatty acid **hydrocarbon** chains (carbon-hydrogen or carbon-carbon bonds)
- water and acetic acid is **hydrophilic** because it's highly **polar**
 - oxygen is very **electronegative** (likes to pull electrons in the covalent bonds towards itself)
 - hydrogen is **electropositive** (doesn't like electrons)
 - oxygen has a negative **partial charge**

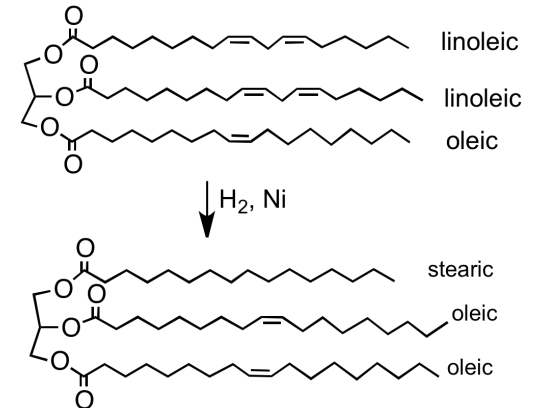
food products and emulsification

the quest for solid fats, continued

- **butter** is a naturally occurring **emulsion** of small amounts of water in fat
 - not purely fat; vegetable oil and tallow have much less water
 - water content makes it soft, so that you can spread it with a knife
 - can't leave out at room temperature for long, unlike vegetable oil (microbes need *aqueous* environment)

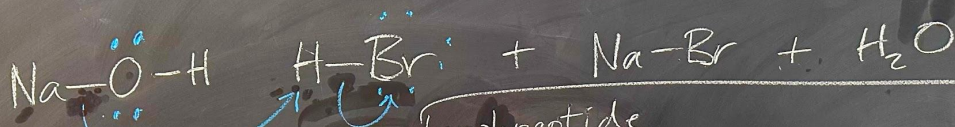


- **margarine** is an artificial **emulsification** of water and oil, made cheaply
 - 'opposite' of what we did (small amount of oil in water)
 - made with **hydrogenated** vegetable oil or **palm oil (lecture 1)** for cheap saturated/solid alternative to animal fat
 - historically: tallow/coal paraffin
 - beta-carotene for color



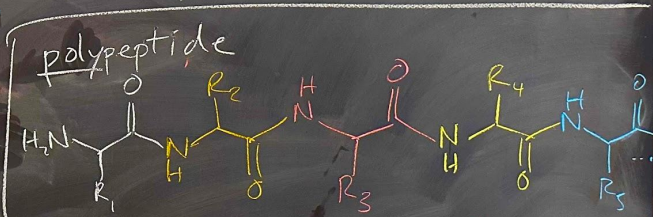
arrow pushing
curved arrow

represents movement of 2 e⁻s



base

acid

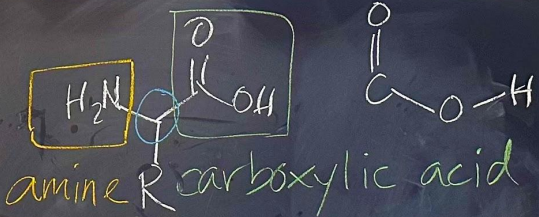


Brønsted-Lowry definition: acid donates H⁺
base accepts H⁺

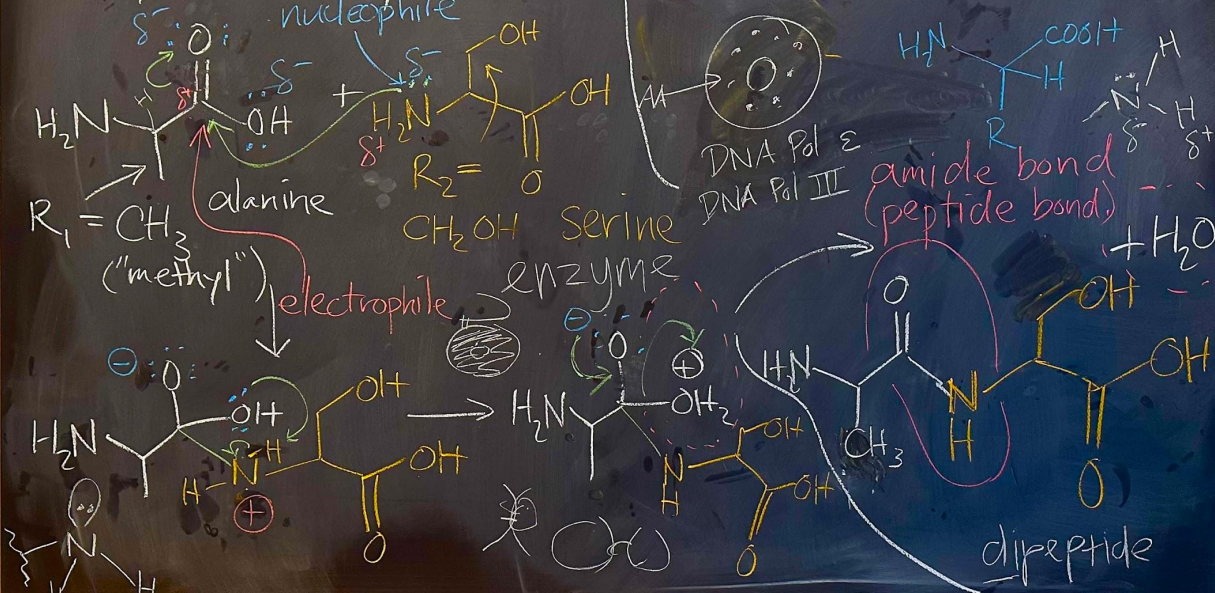
(the box that says "polypeptide" was drawn after class and isn't relevant to arrow pushing.)

proteins

- monomers (building blocks):



- dehydration synthesis



(see previous slide for a longer polypeptide. ignore "enzyme", "DNA Pol ϵ ", "DNA Pol III", and the cell above it.)

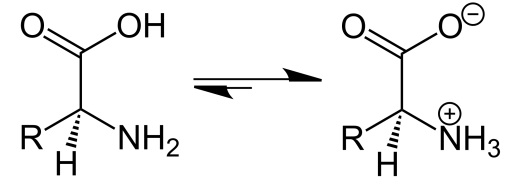
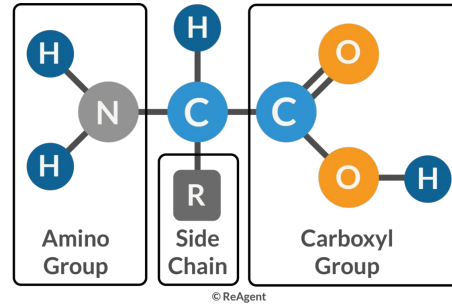
food (bio)chemistry!
lecture 3
amino acids and proteins

sovannjet lim and boheng cao
march 21, 2026

amino acids, part 1

a brief introduction

- components of an amino acid
 - central (alpha) carbon
 - **carboxylic acid** group (-COOH)
 - **amino group** (-NH₂)
 - hydrogen
 - **side chain** (determines what amino acid it is; determines properties; sticks out from polypeptide backbone)
- 20 different amino acids in humans*
 - 9 **essential amino acids** that you need in your diet: valine, isoleucine, leucine, methionine, phenylalanine, tryptophan, threonine, histidine, and lysine
 - your body can synthesize all others



- behavior of amino acids inside cells
 - amino group (NH₂) is **basic**;
 - carboxyl group (COOH) is **acidic**
 - amino group generally becomes NH₃⁺;
 - carboxyl group generally becomes COO⁻ group generally loses a hydrogen ion
 - becomes **zwitterionic** (one positive side, one negative side)

amino acids, part 2

side chain classification

- classification based on chemistry of side chain
 - ignore the non-side chain part (shared among all)
 - **hydrophobic:** no polar bonds in side chain; mostly hydrocarbons
 - **hydrophilic uncharged:** often a carbon-oxygen or carbon-nitrogen polar bond
 - **positively/negatively charged (and hydrophilic)**

TWENTY-ONE PROTEINOGENIC α -AMINO ACIDS

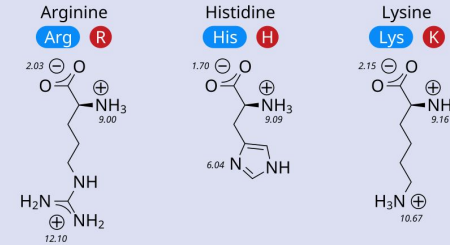
Side chain charge at physiological pH 7.4

pK_a values shown italicized

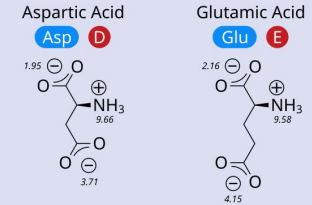
⊕ Positive
⊖ Negative

A. Amino Acids with Electrically Charged Side Chains

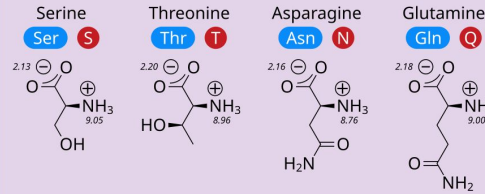
Positive



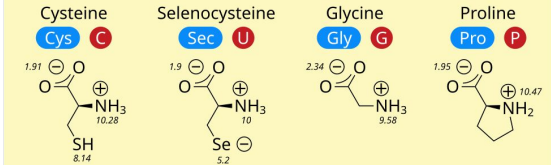
Negative



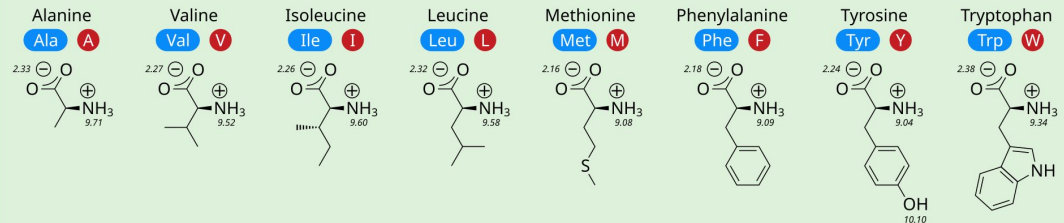
B. Amino Acids with Polar Uncharged Side Chains



C. Special Cases



D. Amino Acids with Hydrophobic Side Chains



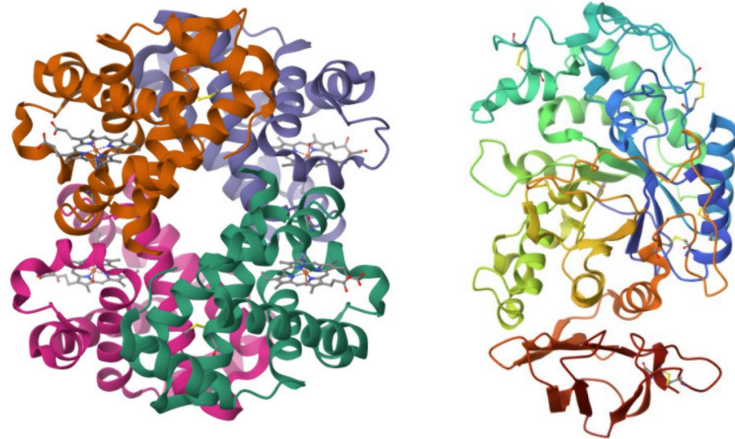
amino acids and proteins

folding molecules

- amino acids linked together via **dehydration reactions** to form long chains (**polypeptides**)
 - carboxyl group of one amino acid bonds to the amino group of another amino acid
 - the alpha carbons, carboxyl groups, and amino groups form long, straight **backbone**
 - side chains stick out of this backbone
 - hundreds of amino acids long



- polypeptides **fold** into **proteins**
 - polypeptide backbone bends, spirals, and twists to form **helices**, **sheets**, **globules**, etc.
 - protein shape stabilized by interactions *between* the side chains of amino acids, often on far away parts of the polypeptide
 - these interactions aren't covalent bonds (what holds up the polypeptide); they're **hydrogen bonds**, **ionic bonds**, etc.

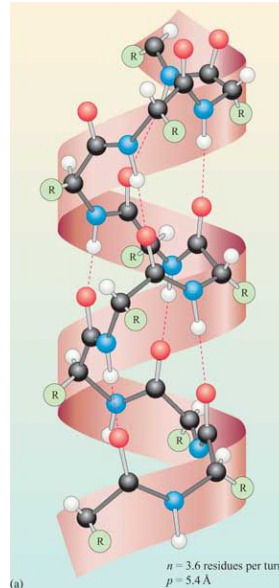


protein and structure

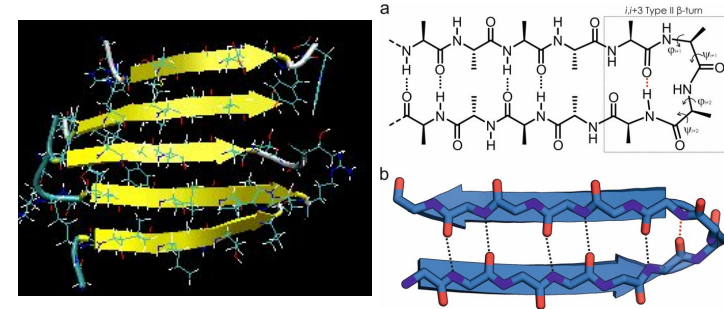
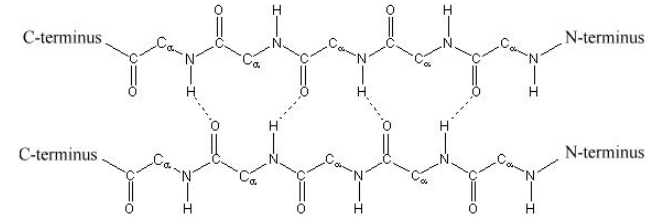
why proteins are the most important biological macromolecule

- the order of amino acids in a protein determines the shape it folds into; the shape of a protein determines its function
- proteins are everywhere and responsible for everything
 - almost *all* chemical reactions in your body are being **catalyzed** by proteins (**enzymes**)
 - some are structural or **signalling** (communicate between cells)
 - proteins execute DNA instructions
 - proteins are *fundamental* for life

- secondary structure (**alpha helices** and **beta sheets**) held together by hydrogen bonds
 - **lecture 1:** hydrogen bonds are relatively weak non-covalent bonds due to partial charges in polar molecules
 - two polar side chains can form a hydrogen bond and stabilize helices/sheets



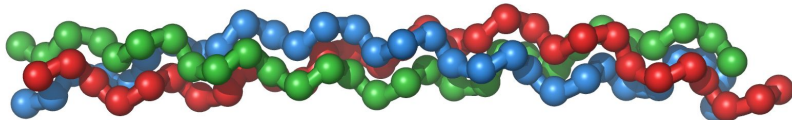
Parallel β Sheet



structural proteins in food

shape determines function

- **collagen** composed of three long intertwined alpha helices (triple helix)
 - found in skin, cartilage, bones, tendons, ligaments
 - fibrous/stretchy due to helices
- **gelatin** made of collagen
 - gelatinous/bouncy texture: jello, gummies, marshmallows
 - stabilizer/thickener in dairy products (tastes like emulsified fat)
 - harvested from leather/fish
 - gelatinous layer after refrigerating chicken stock/broth



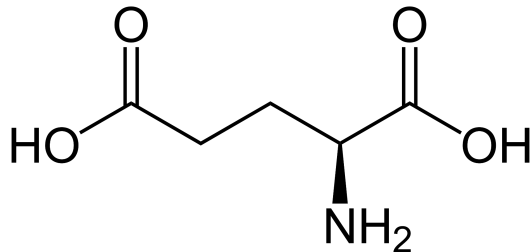
- **gluten (lecture 1)** in wheat adheres flour/makes dough elastic and chewy
 - **disulfide bridge** cross-linking (cysteine)
 - 'hard' bread flour higher in gluten; soft cake flour lower in gluten to crumble
 - shortening/saturated fats inhibit cross-linking responsible for chewiness



the taste of proteins

origins of umami

- proteins have a vast range of tastes and often don't taste like anything
- amino acids (building blocks of proteins), however, often taste **savory**
 - especially **glutamate**
 - **umami** (taste of glutamate) is synonymous to savory
 - animals evolved to like savory/umami foods so they would enjoy the taste of protein and not be protein deficient



- soybeans don't taste very savory, but if you ferment them, its proteins break down into amino acids, creating **soy sauce**
 - rich in glutamate and umami flavor
 - proteins are broken down through **hydrolysis** (opposite of dehydration)
 - dehydration joins amino acids and produces water; hydrolysis consumes water to unlink amino acids
 - **enzymatic browning** (lecture 4)

artificial savoriness

and controversy?

- cheap soy sauce is not fermented, but contains artificially **hydrolyzed vegetable protein**
 - breaks down soybean/corn protein in the same way, producing free amino acids like glutamate and umami
 - uses acid/enzymes extracted from mold to accelerate process
 - also in snacks, soups, canned/frozen foods, seasoning as additive
 - tastes a bit different, but not especially unhealthy
- monosodium glutamate (MSG) is composed of sodium ionically bonded to glutamate; salty and savory seasoning



- MSG controversy/Chinese restaurant syndrome?
 - started with letter by Kwok to *New England Journal of Medicine* reporting headaches
 - later revealed to be a prank
 - popular culture persistence, xenophobia
 - generally has no side effects
 - MSG found naturally in tomatoes, cheese
 - some evidence for **excitotoxicity** after very high consumption (interference with neurotransmitters)



these slides

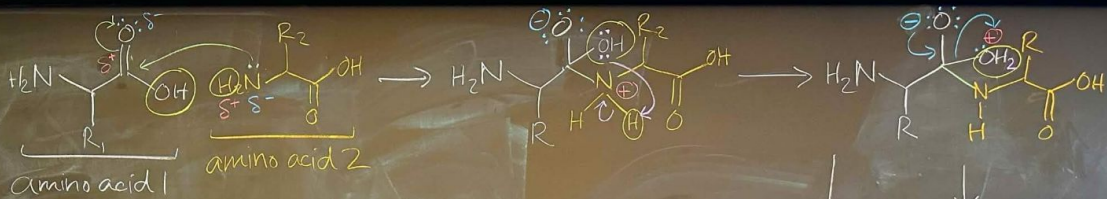


lecture notes



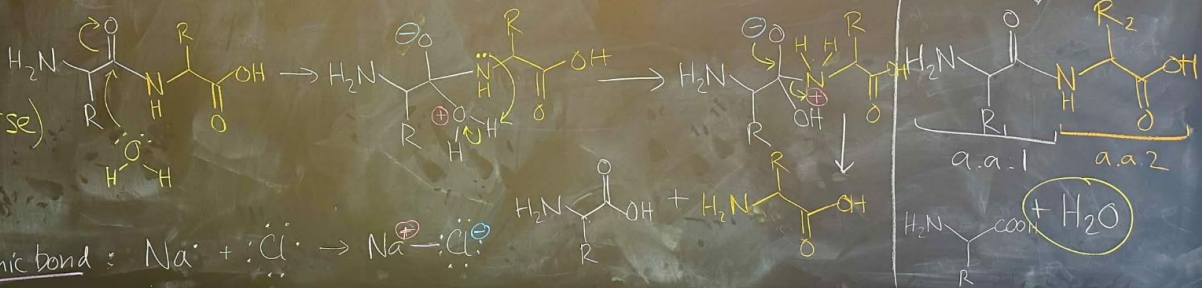
feedback form

peptide bond
formation:
dehydration reaction

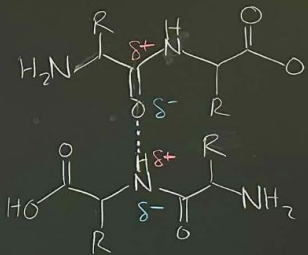


peptide bond
breakage:
hydrolysis (reverse)

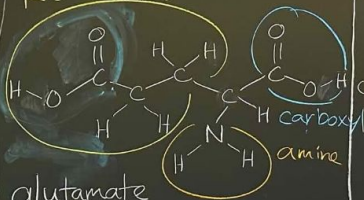
break with water



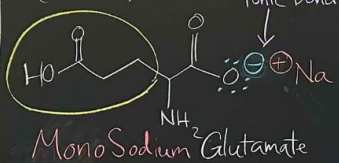
a.a. hydrogen bonding



R (side chain)

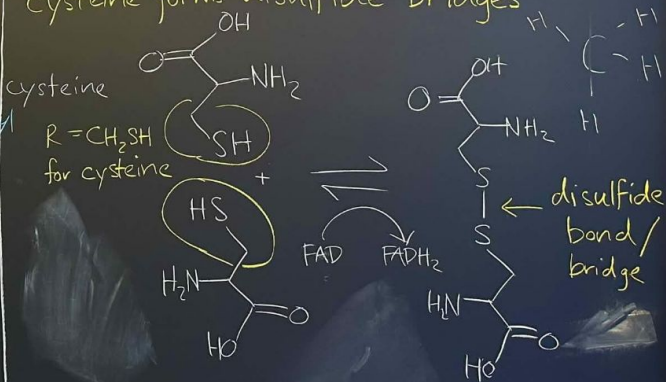


glutamate
(an a.a.)



Mono Sodium² Glutamate

cysteine forms disulfide bridges



food (bio)chemistry!
lecture 4
carbohydrates

sovannjet lim and boheng cao
march 28, 2026

carbohydrates, part 1

a brief introduction

- the term '**carbohydrate**' refers to what we would call **sugars** in everyday life, along with many other related molecules
- all **carbohydrates** have **carbon**, **hydrogen**, and **oxygen**; some also have other elements
 - *carbohydrates* is a somewhat misleading term — all molecules we've covered so far (fats and proteins) also have carbon, hydrogen, and oxygen, so carbohydrates aren't special in this regard
 - carbohydrates must have these atoms arranged in a *specific way*, which is what distinguishes them (next slide)



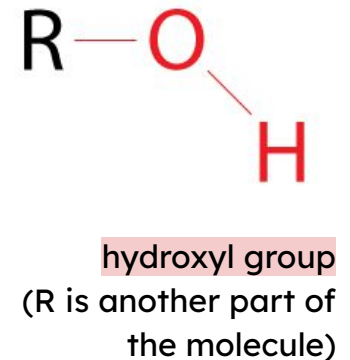
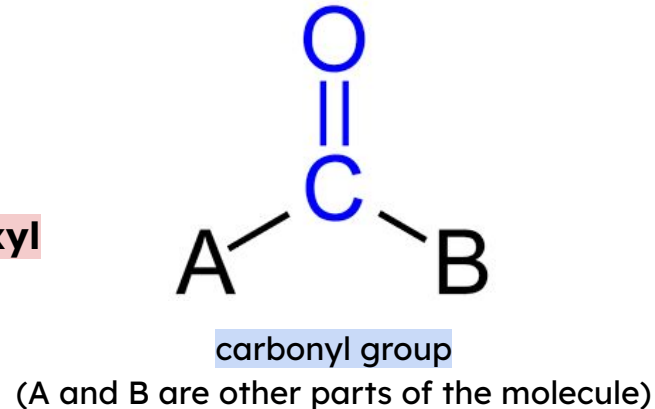
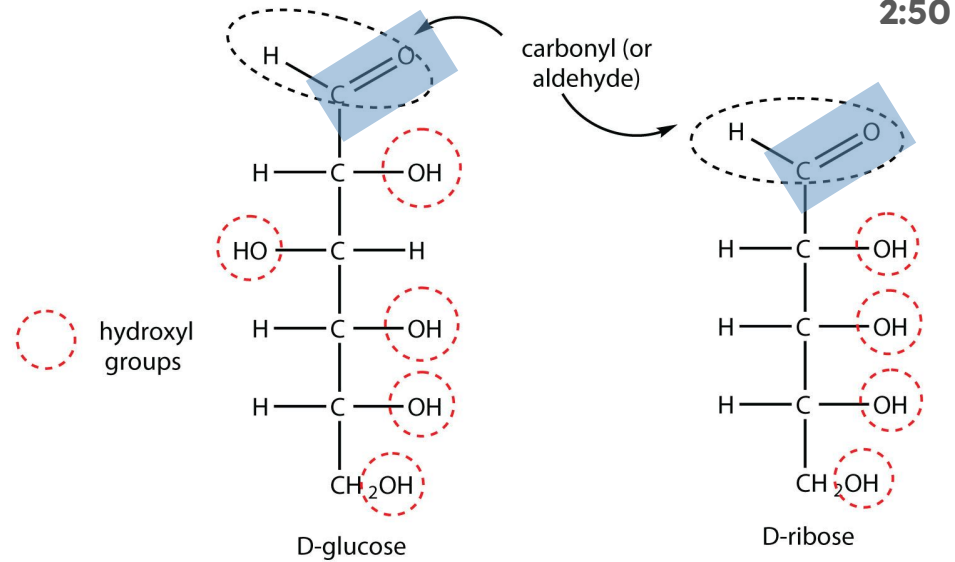
Source: Wikipedia

- carbohydrates come in many sizes:
 - **monosaccharides** are the smallest
 - **disaccharides** are made of two monosaccharides joined together by a **dehydration reaction**
 - **lecture 2:** same reaction joins amino acids into polypeptides
 - **polysaccharides** are longer chains composed of *many* (3 or more) monosaccharides joined together by dehydration reactions

monosaccharides, part 1

building blocks of carbohydrates

- **monosaccharides** are the smallest carbohydrates, and their chemical formula is always $C_nH_{2n}O_n$ for some n
 - e.g. monosaccharides include $C_2H_4O_2$, $C_3H_6O_3$, $C_4H_8O_4$, and so on
 - this is because of the way in which all the atoms are connected + octet rule
- all monosaccharides have:
 - one **carbonyl group** (a carbon double-bonded to an oxygen); and
 - all other carbons are bonded to **hydroxyl groups** (oxygen single-bonded to a hydrogen)



monosaccharides, part 2

molecules big and small

- most common monosaccharides:

$n = 5$ ($C_5H_{10}O_5$, **pentoses**) and

$n = 6$ ($C_6H_{12}O_6$, **hexoses**)

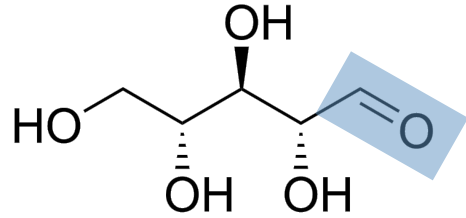
- **-ose** suffix means ‘monosaccharide’
 - **pentoses** found in DNA and RNA (**nucleic acids**)
 - **hexoses** are everywhere!
- properties of monosaccharides
 - **polar, hydrophilic, and soluble in water**
 - polar covalent bonds between oxygen and carbon (**lecture 1**: different electronegativity between C and O)
 - what we would call ‘sugars’ in everyday life
 - some are **sweet**; all are **crystalline**

- many monosaccharides have the *same* chemical formula, but have these atoms connected in different ways (**structural isomers**) and have different properties
 - e.g. all hexoses have the formula $C_6H_{12}O_6$, yet there are many varieties
 - these varieties have their carbonyl group (C=O) attached in different places, or their hydroxyl groups (O-H) in different orientations



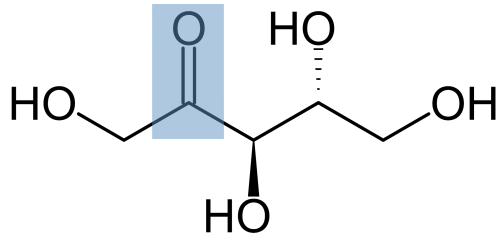
Source: Wikipedia

pentose and hexose gallery



ribose (pentose)

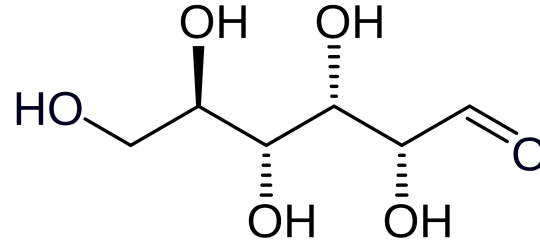
part of RNA; mildly sweet (0.3)
deoxygenated form (deoxyribose)
found in DNA



ribulose (pentose)

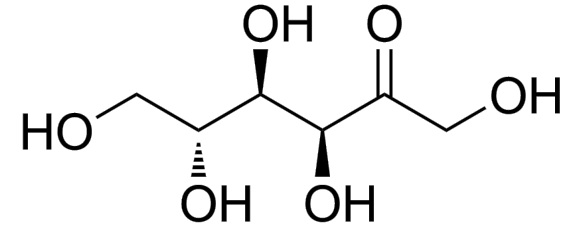
intermediate of many biochemical
pathways (e.g. photosynthesis)

all sugars represented as line structures; recall implied (not drawn) presence of **carbons at each vertex** and hydrogens **whenever necessary** to make sure that each carbon has 4 total bonds



glucose (hexose, aldose)

ubiquitous in biology; direct
product of photosynthesis;
sweetener (0.74)

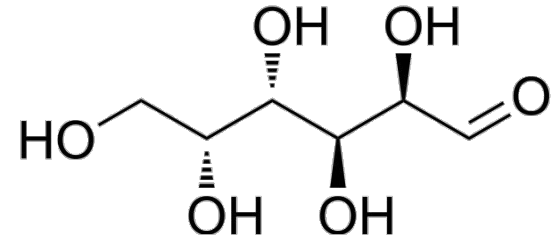


fructose (hexose, ketose)

common in fruits, root vegetables, flowers,
sugarcane; in artificial high-fructose corn
syrup; very sweet (~1.5)

note that **ribose** has its carbonyl
group at the *end* of the carbon
chain, whereas **ribulose** has the
carbonyl group in the *middle*

as a result, ribose is an **aldose**;
ribulose is a **ketose**

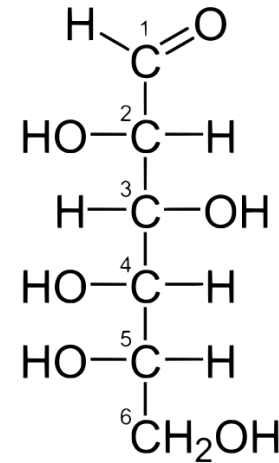


galactose (hexose, aldose)

intermission: chirality

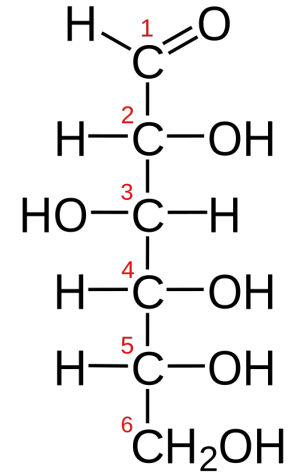
when molecules have left and right

- some molecules have an evil twin
 - almost all glucose in nature is **D-glucose**, or **right-handed** glucose (figure on the right)
 - in the laboratory, however, you can make **L-glucose**, or **left-handed** glucose (figure on the left)
 - exactly the same, but *everything* is reflected as if in a mirror; e.g. hydroxyl (OH) groups that were on the left are now on the right, and vice versa
- these molecules are different for the same reason that your left and right hands are different
 - your left and right hands are mirror images of each other, but if you chopped them off, you'd always be able to tell which is which
 - this is because your hands have a front and back, just like these molecules!
 - not all molecules behave like this, but all monosaccharides and amino acids are like this because they have **asymmetric carbons** (carbons attached to 4 different things)



L-glucose

left-handed; from laboratory



D-glucose

right-handed; in nature

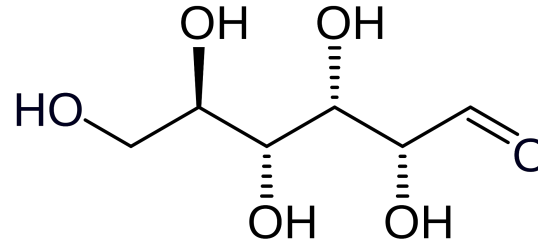
- invert sugar syrup in processed food
 - has left-handed (laboratory) version of glucose
 - about the same as normal sugar syrup, but a bit sweeter
 - in honey, jam, fondant, candies, wine, kombucha



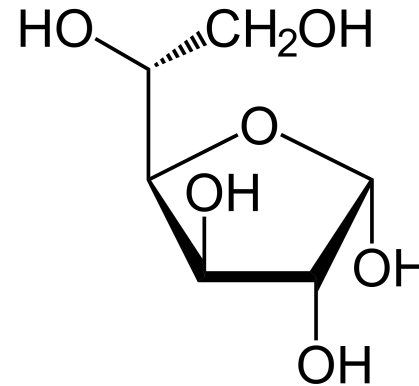
rings!

we lied on the last slide :(

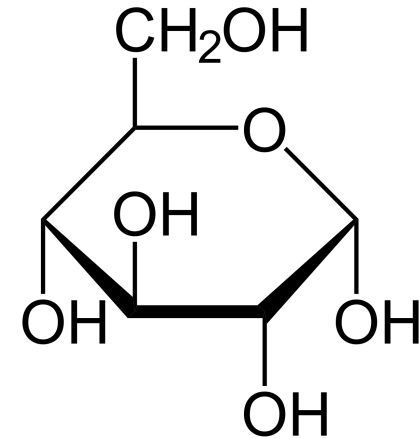
- pentoses (5-carbon) and hexoses (6-carbon) don't usually look like the structures on the previous slide in nature
- when dissolved in water, they **bond to themselves (anomerize)** and form **rings**
 - hexoses can form either **hexagonal** rings (**pyran**) or **pentagonal** rings (**furan**)
 - each vertex of a ring is a carbon, except for one vertex (the location of the carbonyl), which is an oxygen
 - hydroxyl groups attached to carbons stick up or down from the ring
 - pyran rings have 1 carbon outside the ring; furan rings have 2 carbons outside



glucose (straight chain form)
very rare in solution



glucose
(furan/pentagonal ring)
slightly rarer

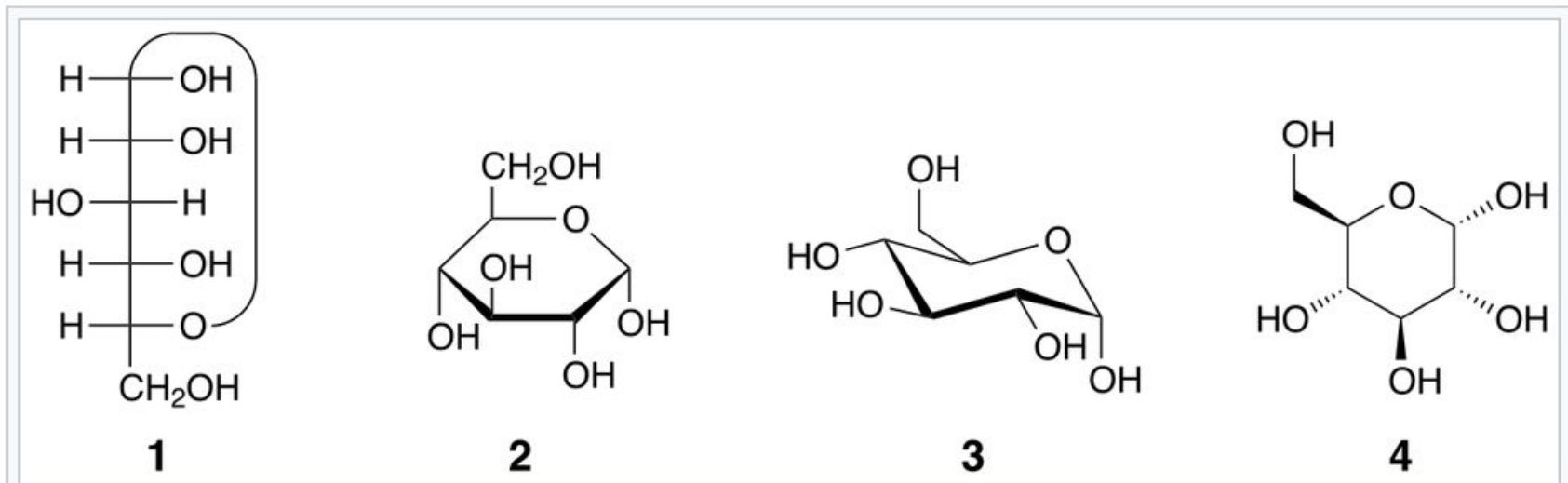



glucose
(pyran/hexagonal ring)
most common form when
dissolved in water

representations of glucose

7:30

many ways of saying the same thing

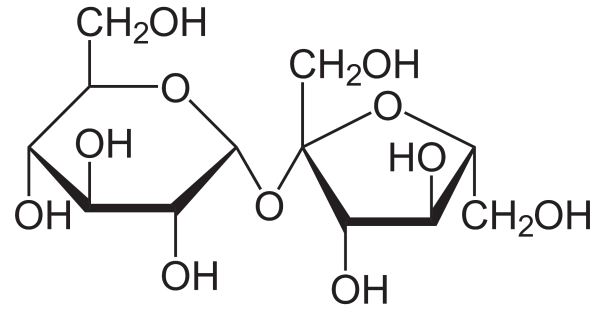


Different [projections](#) of α -D-glucopyranose. **1** = [Fischer projection](#) with C-1 at the top of the anomeric centre. C-5 is the anomeric reference atom. **2, 3** = [Haworth projections](#). **4** = [Mills projection](#). 

disaccharides

and then there were two

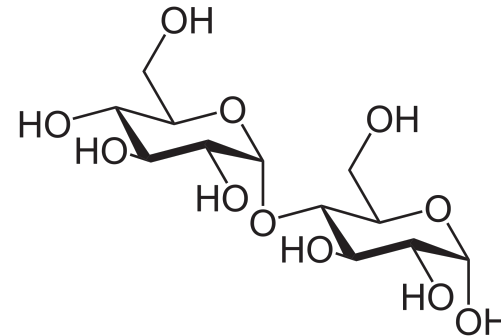
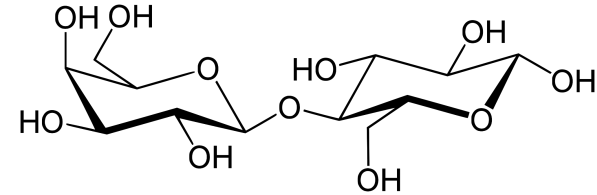
- two monosaccharides can be joined through a **dehydration reaction**
 - **lecture 2:** same reaction can join amino acids into polypeptides
 - produces water molecule as byproduct
 - after joining two hexoses, the chemical formula of the disaccharide is $C_6H_{12}O_6 + C_6H_{12}O_6 - H_2O = C_{12}H_{22}O_{11}$
- resulting covalent bond called a **glycosidic bond** and is commonly attached on either one of two different positions on ring
 - either **4' position** or **6' position**
 - 4' and 6' indicate which carbon on the ring the bond is attached to



sucrose
(glucose + fructose)

table sugar (from sugarcane or sugar beet); what “sugar” generally means in everyday life

lactose
(glucose + galactose)
found in milk; 65% of people can't digest and are lactose intolerant; not very sweet (0.16)

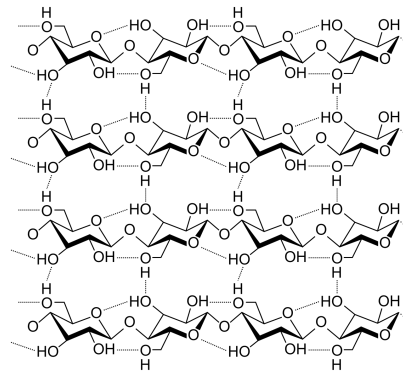


maltose
(glucose + glucose)
found in honey and hydrolyzed starch (see next slide); weakly sweet (0.3)

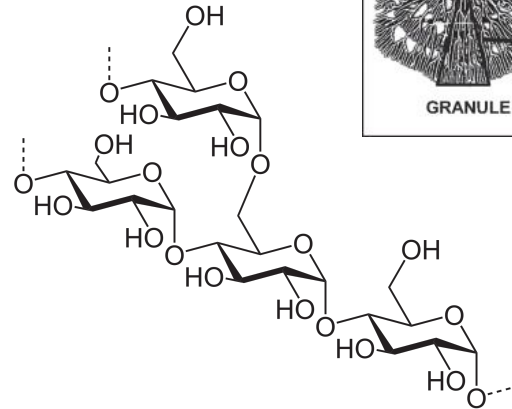
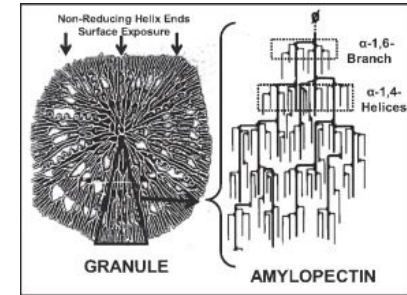
polysaccharides

and then there were many

- we can repeatedly join more and more monosaccharides using dehydration reactions to get a **polysaccharide**
- polysaccharides can be long and straight, or **branched**
 - at each branch, monosaccharide has two connections (one at 4' and one at 6')
- branched polysaccharides used for energy storage (compact; many points from which monosaccharides can be 'torn off'); straight polysaccharides are structural and rigid
- generally not sweet; taste receptors attenuated to simple (mono- or disaccharides), which are easy to digest



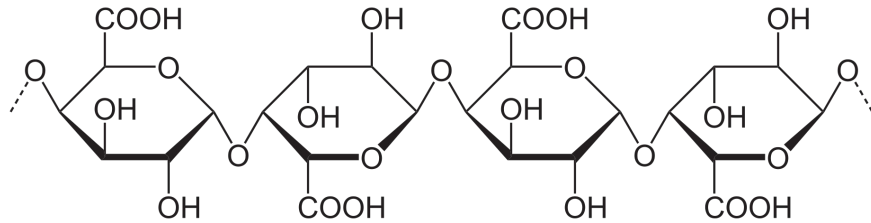
cellulose
(many glucoses)
straight, parallel
strands weakly held by
hydrogen bonds; why
wood is strong/celery is
crunchy



amylopectin
(a type of starch,
many glucoses)

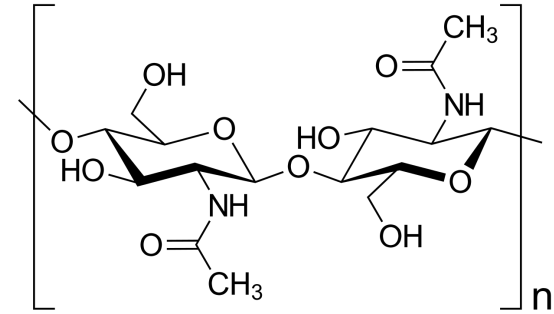
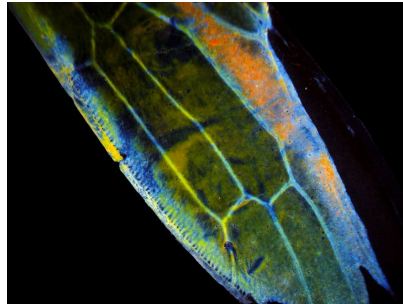
highly branched; energy
storage in plants; *most
common* carbohydrate
in food (most staples
like rice/bread)

polysaccharide gallery



pectin (many linked galacturonic acid and rhamnose; some xylose)

- mix of straight and very branched regions with methyl groups
- found in crunchy/hard fruit (apples, pears, apricots, orange peels)
- holds hard flesh of fruit together and is crunchy
- used to thicken food/create jelly-like texture, stabilize drinks, make fruit snack/gummy candies
- one type of **dietary fiber** (you can't digest it, so it passes through; cellulose is also fiber)



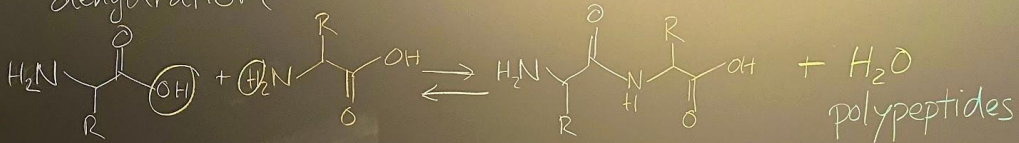
chitin (many N-acetylglucosamine)

- contains nitrogen in amine group (unusual for carbohydrates)
- very long, straight chains
- found in mushrooms/fungi, insect shells, crustacean/mollusc shells
- translucent and flexible but hard to break due to hydrogen bonding between nitrogens
- why insects and mushrooms are crunchy

protein

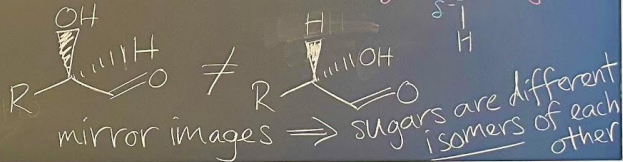
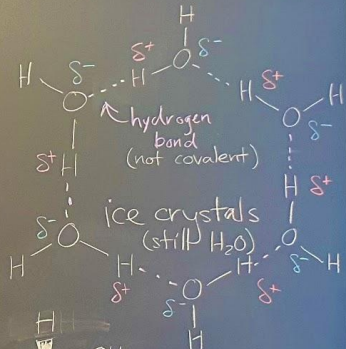
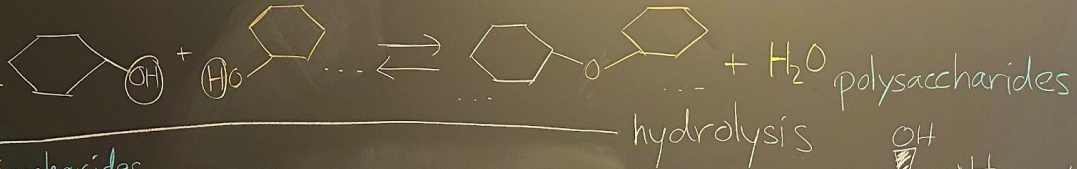
amino acids

dehydration

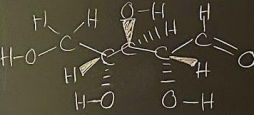


sugar

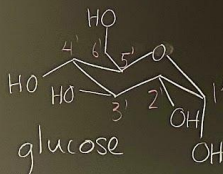
monosaccharides



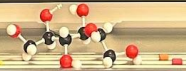
pentose & hexose gallery



ribose



glucose



CLIF CHAPLIS LEMMON INC. PAPER



recap & preview

we've covered a lot!

(as noted in the course description) for each of these molecules, we will discuss:

8:26

- their chemical **structure**
- their **reactivity** in the kitchen
- their function and **metabolism** in the body
- **what these mean** for your everyday interactions/experiences with food

food group	biological molecule	structure	reactivity	metabolism
fats				lecture 6
proteins				
grains				
fruits/ vegetables	fiber (various polysaccharides) vitamins, minerals, antioxidants	lecture 5 (ft. two demos! (hopefully))		

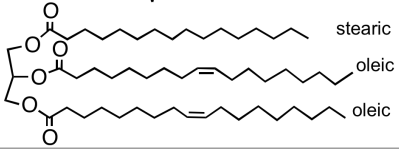
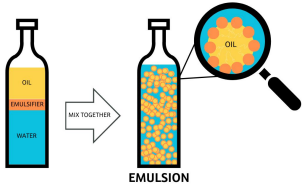
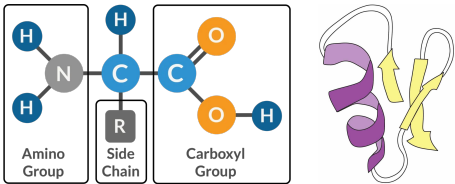
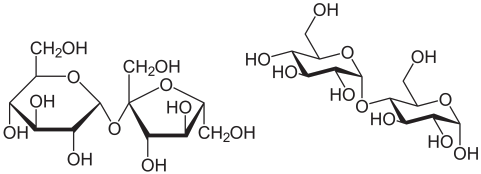

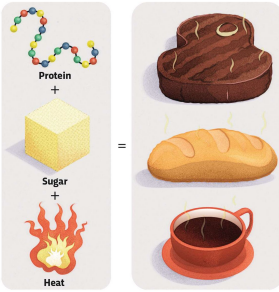
recap & preview

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- their function and **metabolism** in the body
- **what these mean** for your everyday interactions/experiences with food

food group	biological molecule	structure	reactivity	metabolism
fats	lipids	saturated, unsaturated, trans 	nonpolar/hydrophilic <u>emulsification</u> : mix nonpolar + polar via emulsifier 	lecture 6
proteins	amino acids (monomer) proteins/polypeptides (polymer)	alpha helices, beta sheets, disulfide bridges 	<u>buildup</u> : dehydration synthesis <u>breakdown</u> : hydrolysis <i>non-enzymatic browning</i> (lecture 5: enzymatic browning) <ul style="list-style-type: none"> - <u>caramelization</u>: sugars self-react - <u>Maillard reaction</u>: sugar + protein react 	
grains	carbohydrates ("sugars") fiber (various polysaccharides)	mono-, di-, polysaccharides 	 	
fruits/vegetables	fiber (various polysaccharides) vitamins, minerals, antioxidants		lecture 5 (ft. two demos! (hopefully))	

food (bio)chemistry!
lecture 5
sugar reactivity,
redox & radical reactions

sovannjet lim and boheng cao
april 4, 2026

introduction to caramelization

- to **caramelize** monosaccharides and disaccharides, we heat them for a long time
 - sometimes a few seconds; often hours
 - sugars react to form non-sugar products
 - very specific conditions to prevent burning or other cooking reactions
 - temperature depends on type of sugar, acidity, water; generally $>120^{\circ}\text{C}$ (high)
 - brown color; nutty/buttery flavor

- foods with caramelized ingredients:
 - caramel sauce (caramelized sugar + cream), in crème caramel, caramel apples
 - dulce de leche/milk sugar/dodol (caramelized milk/coconut milk)
 - caramelized onions, French onion soup
 - toffee (caramelized sugar + butter)

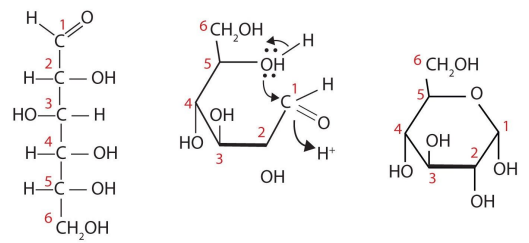
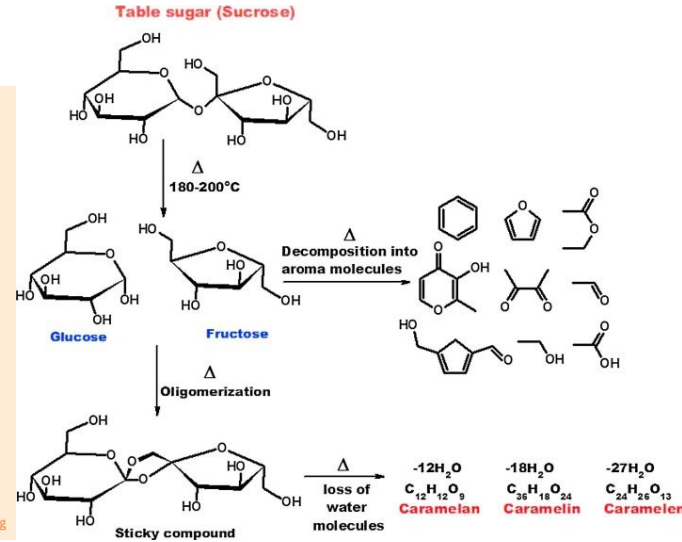
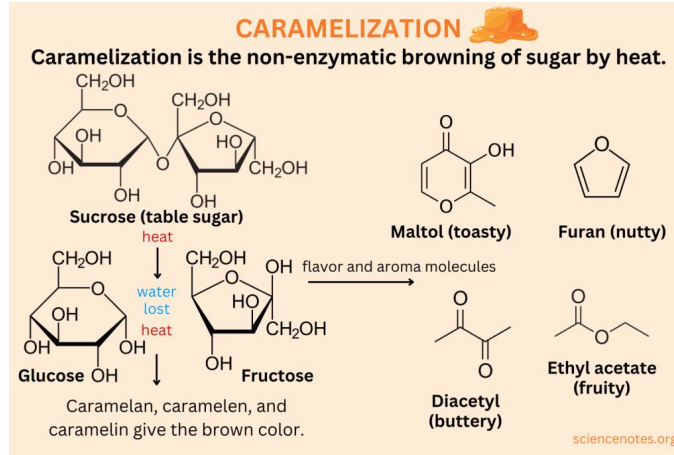


non-enzymatic browning, part 1: caramelization

reactions within/among sugars

Caramelization temperatures^[3]

Sugar ↕	Temperature ↕
Fructose	105 °C (221 °F)
Galactose	160 °C (320 °F)
Glucose	150 °C (302 °F)
Sucrose	170 °C (338 °F)
Maltose	180 °C (360 °F)



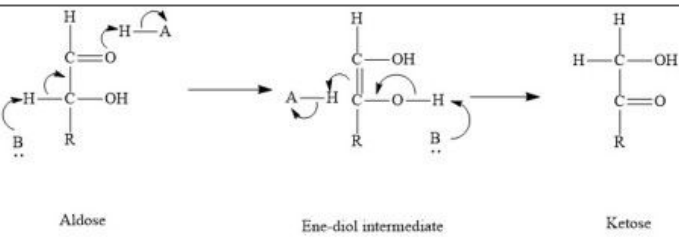
Caramelization is a complex, poorly understood process that produces hundreds of chemical products, and includes the following types of reactions:

- [equilibration](#) of [anomeric](#) and ring forms
- [sucrose inversion](#) to fructose and glucose
- [condensation reactions](#)
- intramolecular bonding
- [isomerization](#) of [aldoses](#) to [ketoses](#)
- [dehydration reactions](#)
- fragmentation reactions
- unsaturated [polymer](#) formation

← hydrolysis

← dehydration synthesis

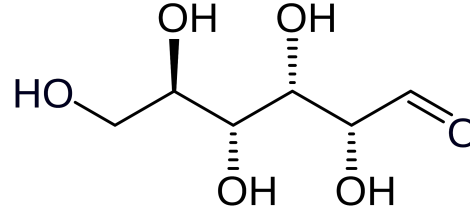
- **condensation:** combine 2 molecules
- **dehydration:** loss of H₂O



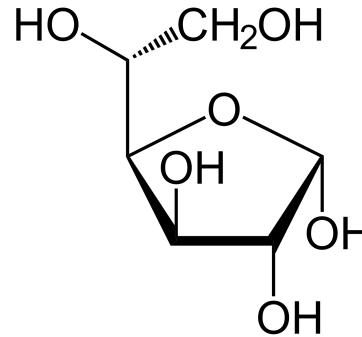
rings!

we lied on the last slide :(

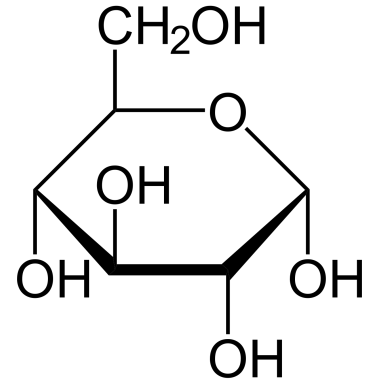
- pentoses (5-carbon) and hexoses (6-carbon) don't usually look like the structures on the previous slide in nature
- when dissolved in water, they **bond to themselves (anomerize)** and form **rings**
 - hexoses can form either **hexagonal** rings (**pyran**) or **pentagonal** rings (**furan**)
 - each vertex of a ring is a carbon, except for one vertex (the location of the carbonyl), which is an oxygen
 - hydroxyl groups attached to carbons stick up or down from the ring
 - pyran rings have 1 carbon outside the ring; furan rings have 2 carbons outside



glucose (straight chain form)
very rare in solution



glucose
(furan/pentagonal ring)
slightly rarer

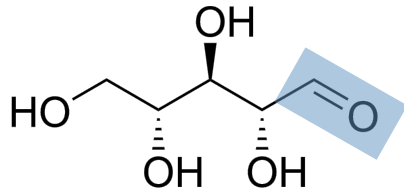


glucose
(pyran/hexagonal ring)
most common form when
dissolved in water

pentose and hexose gallery

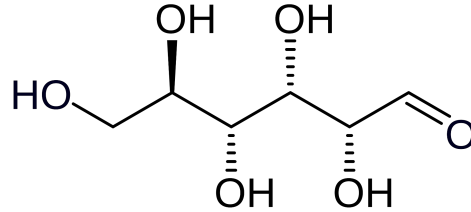
4:55

all sugars represented as line structures; recall implied (not drawn) presence of **carbons at each vertex** and hydrogens **whenever necessary** to make sure that each carbon has 4 total bonds



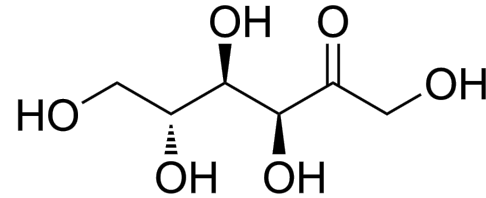
ribose (pentose)

part of RNA; mildly sweet (0.3)
deoxygenated form (deoxyribose)
found in DNA



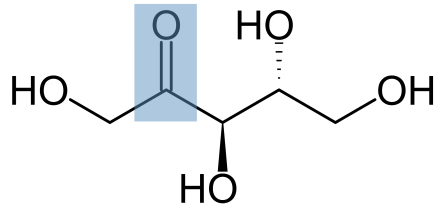
glucose (hexose, aldose)

ubiquitous in biology; direct product
of photosynthesis; sweetener (0.74)



fructose (hexose, ketose)

common in fruits, root vegetables, flowers,
sugarcane; in artificial high-fructose corn
syrup; very sweet (~1.5)

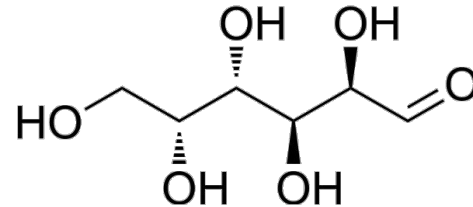


ribulose (pentose)

intermediate of many biochemical
pathways (e.g. photosynthesis)

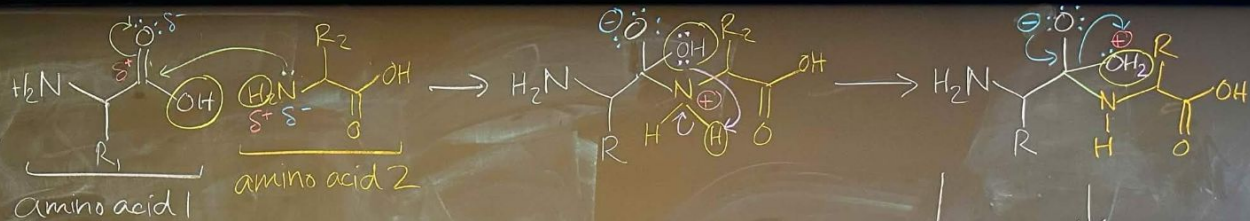
note that **ribose** has its carbonyl group at the *end* of the carbon chain, whereas **ribulose** has the carbonyl group in the *middle*

as a result, ribose is an **aldose**;
ribulose is a **ketose**



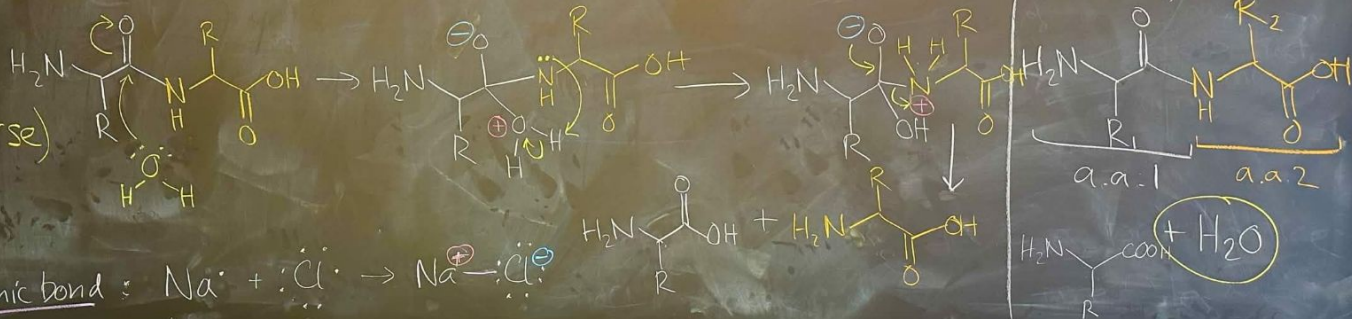
galactose (hexose, aldose)

peptide bond
formation:
dehydration reaction



peptide bond
breakage:
hydrolysis (reverse)

break with water



introduction to Maillard reactions

non-enzymatic browning, cont.

- the **Maillard reaction** occurs when searing, grilling, baking, frying from 145 to 160 °C
 - ubiquitous in cooking: “the most widely practiced chemical reaction in the world”
 - hundreds of different **volatile** flavor compounds and long colorful compounds
 - completely different from caramelization, but effects may seem similar at first sight

- effects of the Maillard reaction:
 - brown crust on baked goods (e.g. bread)
 - bread/cracker-like flavor in baked goods
 - golden color of fried foods
 - darkening/browning of grilled meats
 - aroma of roasted foods
 - color and taste of chocolate and coffee
 - acrylamide formation (possibly carcinogenic?) at very high temperatures for fried foods (e.g. French fries)



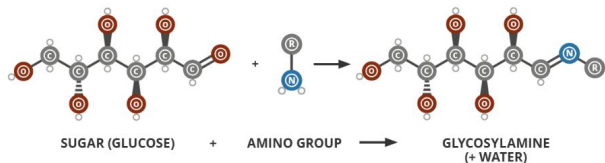
non-enzymatic browning, part 2: Maillard reaction

reaction between sugar + protein

A GUIDE TO THE MAILLARD

The Maillard reaction occurs during cooking, and it is responsible for the non-enzymatic browning of food. It is a series of reactions, and can occur at room temperature, but is optimal between 140-165°C. The Maillard reaction is a chemical reaction between a sugar and an amino acid.

- 1** The carbonyl group on a sugar reacts with a protein or amino acid's amino group, producing an N-substituted glycosylamine.



- 2** The glycosylamine compound generated in the first step isomerises, by undergoing Amadori rearrangement, to give a ketosamine.



- 3** The ketosamine can react in a number of ways to produce a range of different products, which themselves can react further.



Classes of



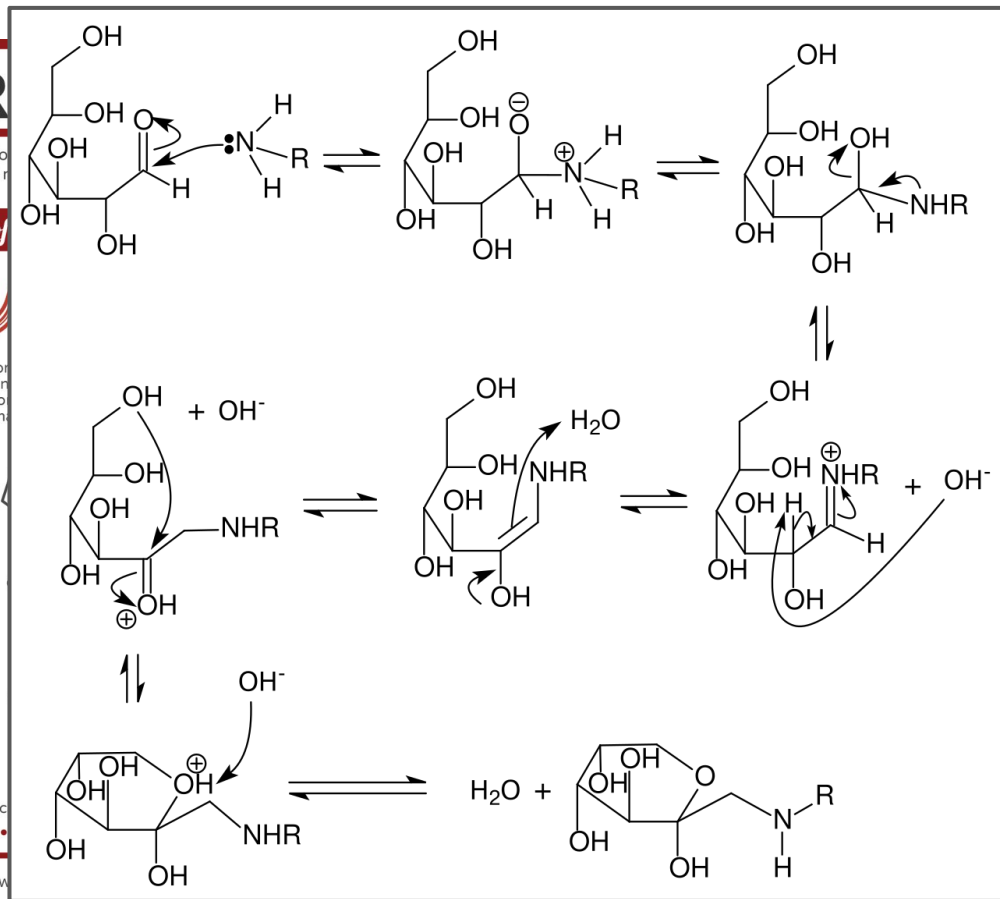
The Maillard reaction products contribute to flavour and colour. Melanoidins are also formed, contributing to the colouration of many foods.



PYRAZINES
cooked
roasted
toasted

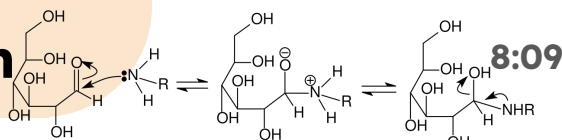


FURANONES
sweet
caramel
burnt



non-enzymatic browning, part 2: Maillard reaction

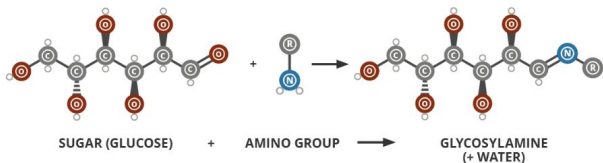
reaction between sugar + protein



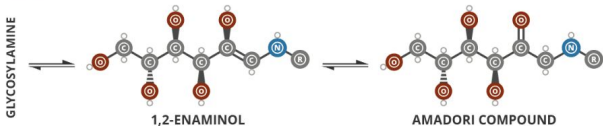
A GUIDE TO THE MAILLARD REACTION

The Maillard reaction occurs during cooking, and it is responsible for the non-enzymatic browning of foods when cooked. It actually consists of a number of reactions, and can occur at room temperature, but is optimal between 140-165°C. The Maillard reaction occurs in three stages, detailed here.

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Classes of Maillard Reaction Products



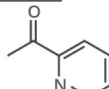
cooked
roasted
toasted



bitter
cereal-like
nutty



bitter
burnt
astringent



cracker-like
cereal



sweet
caramel
burnt



meaty
burnt
caramel-like

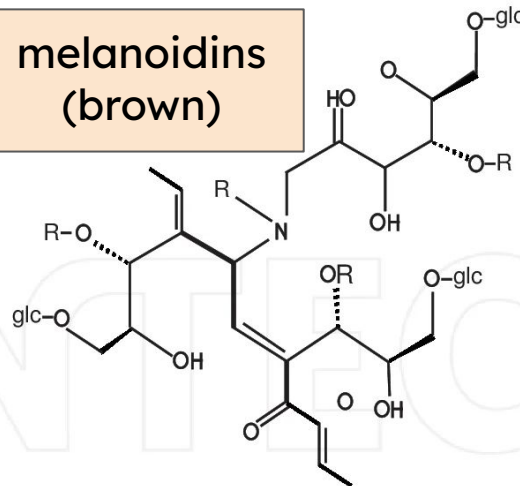


green
nutty
sweet



meaty
roasted

melanoidins (brown)



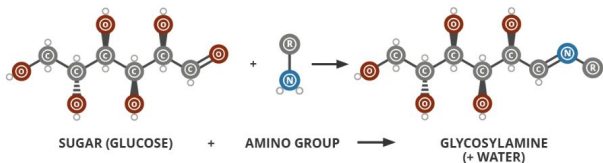
non-enzymatic browning, part 2: Maillard reaction

reaction between sugar + protein

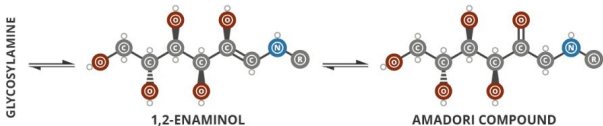
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Classes of Maillard Reaction Products



The Maillard reaction contributes to the flavor of these products. Melanoidins contribute to the color of these products.

flavor compounds



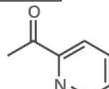
PIRAZINES
cooked
roasted
toasted



PYRROLES
cereal-like
nutty



ALKYLPYRIDINES
bitter
burnt
astringent



ACYLPYRIDINES
cracker-like
cereal



FURANONES
sweet
caramel
burnt



FURANS
meaty
burnt
caramel-like



OXAZOLES
green
nutty
sweet



THIOPHENES
meaty
roasted

reactants

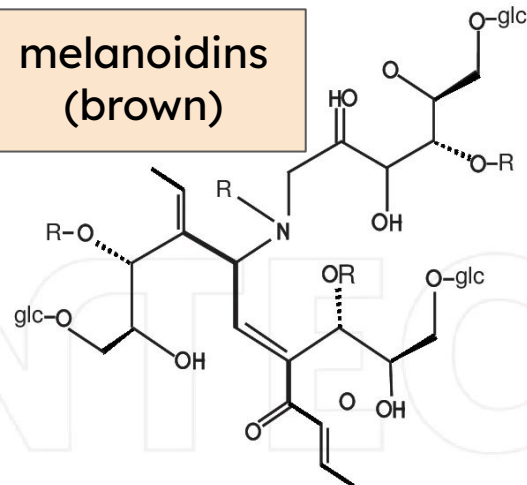
- sugar
 - protein (amino acid)
- (eventual) products

- flavor compounds
- melanoidins (brown)

accelerated by

- heat
- alkalinity (why?)

melanoidins
(brown)



R: H; glc: (glc)_n

non-enzymatic browning, part 2: Maillard reaction

reaction between sugar + protein

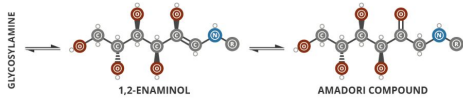
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3 The ketosamine can react in a number of ways to produce a range of different products, which themselves can react further.



Classes of Maillard Reaction Products



The Maillard reaction produces hundreds of products; a small subset of these contribute to flavour and aroma, some groups of which are described below. Melanoidins are also formed, brown, polymeric substances which contribute to the colouration of many cooked foods.



PYRAZINES
cooked
roasted
toasted



PYRROLES
cereal-like
nutty



ALKYLPYRIDINES
bitter
burnt
astringent



ACYLPYRIDINES
cracker-like
cereal



FURANONES
sweet
caramel
burnt



FURANS
meaty
burnt
caramel-like



OXAZOLES
nutty
sweet



THIOPHENES
meaty
roasted

reactants

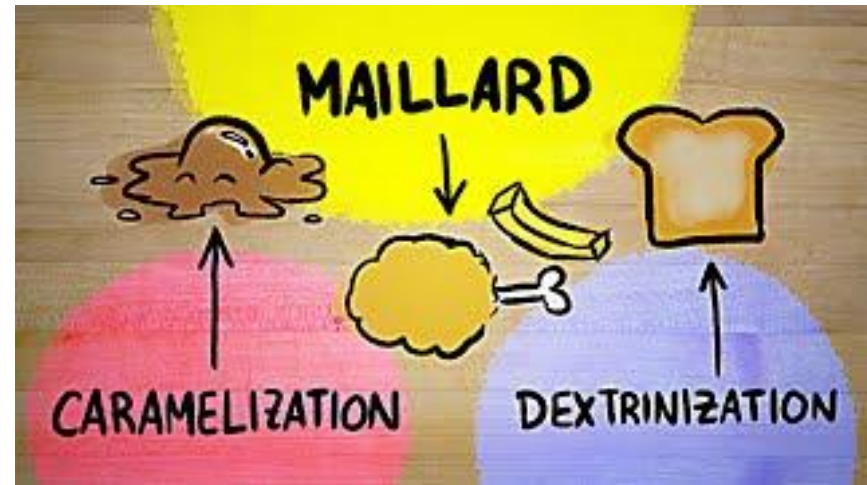
- sugar
- protein (amino acid)

(eventual) products

- flavor compounds
- melanoidins (brown)

accelerated by

- heat
- alkalinity (why?)



recommended viewing: [MinuteFood](#)



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recap & preview

we've covered a lot!

(as noted in the course description) for each of these molecules, we will discuss:

8:26

- their chemical **structure**
- their **reactivity** in the kitchen
- their function and **metabolism** in the body
- **what these mean** for your everyday interactions/experiences with food

food group	biological molecule	structure	reactivity	metabolism
fats				lecture 6
proteins				
grains				
fruits/ vegetables	fiber (various polysaccharides) vitamins, minerals, antioxidants		lecture 5: redox and radical reactions	

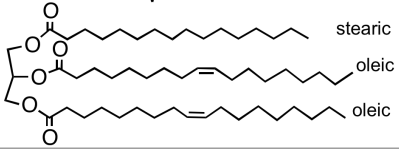
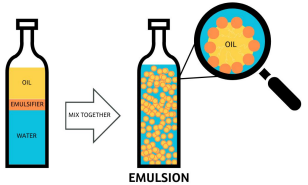
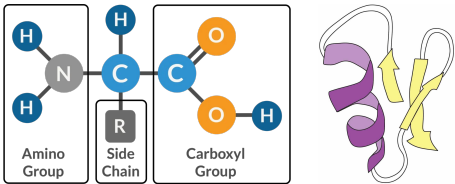
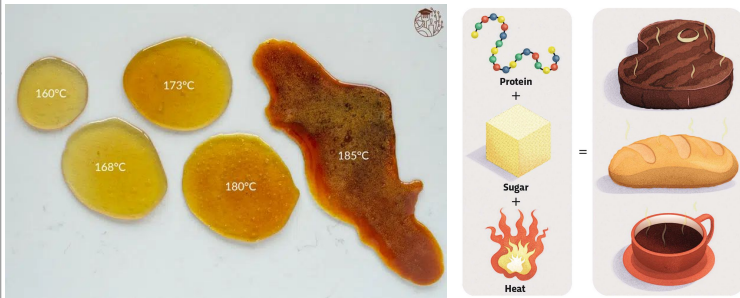
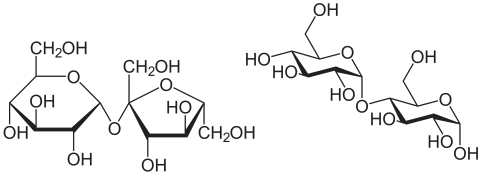
recap & preview

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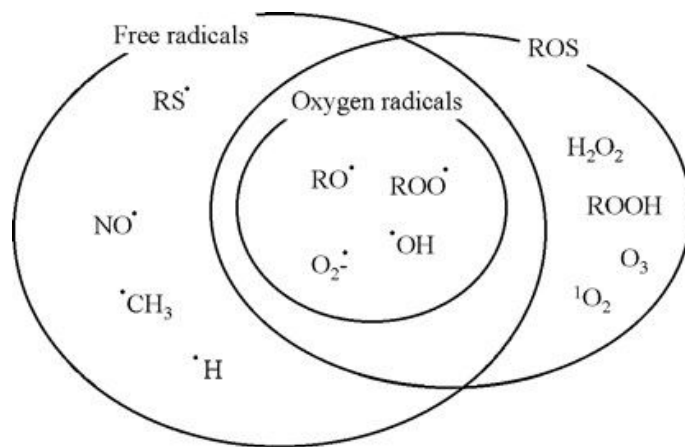
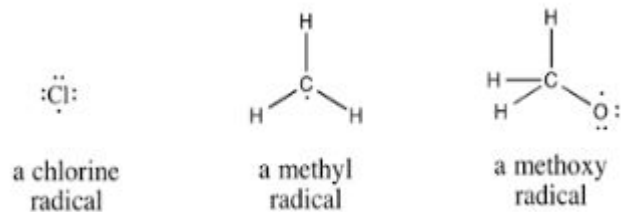
food group	biological molecule	structure	reactivity	metabolism
fats	lipids	saturated, unsaturated, trans 	nonpolar/hydrophilic <u>emulsification</u> : mix nonpolar + polar via emulsifier 	lecture 6
proteins	amino acids (monomer) proteins/polypeptides (polymer)	alpha helices, beta sheets, disulfide bridges  <p>lecture 6: taste receptors as examples of proteins</p>	<u>buildup</u> : dehydration synthesis <u>breakdown</u> : hydrolysis non-enzymatic browning (lecture 5: enzymatic browning) <ul style="list-style-type: none"> - <u>caramelization</u>: sugars → flavors + caramels/caramelens/caramelins - <u>Maillard reaction</u>: sugar + protein → flavors + melanoidins 	
grains	carbohydrates ("sugars") fiber (various polysaccharides)	mono-, di-, polysaccharides 		
fruits/vegetables	fiber (various polysaccharides) vitamins, minerals, antioxidants		lecture 5: redox and radical reactions	

ANTIOXIDANT	SOURCES	BENEFITS
Vitamin C	Citrus fruits, berries, bell peppers	Boosts immune system, promotes collagen production
Vitamin E	Nuts, seeds, vegetable oils	Protects cell membranes, supports cardiovascular health
Beta-carotene	Carrots, sweet potatoes, spinach	Converted to vitamin A in the body, supports eye health
Lycopene	Tomatoes, watermelon, pink grapefruit	Protects skin from UV damage

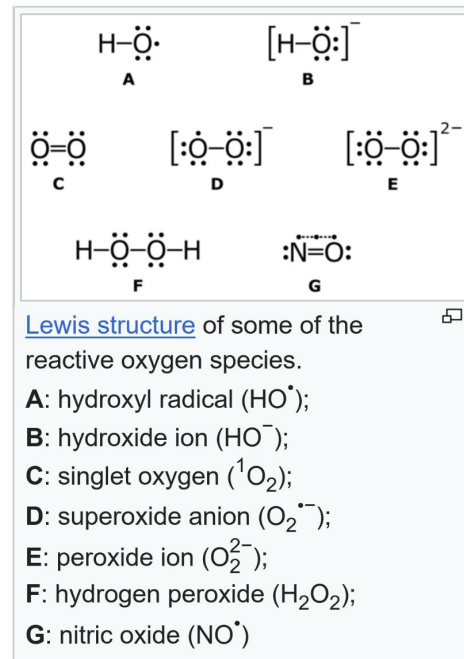
free radicals & reactive oxygen species (ROS)

unpaired e^- is unstable & reactive

free radicals



Reactive Oxygen Species

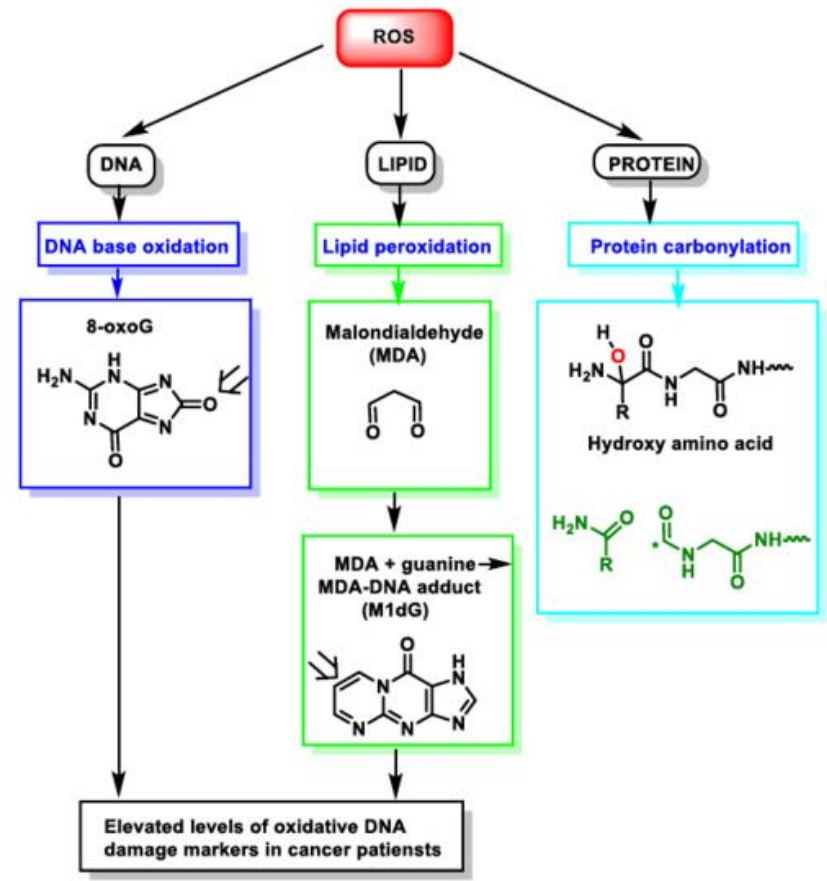
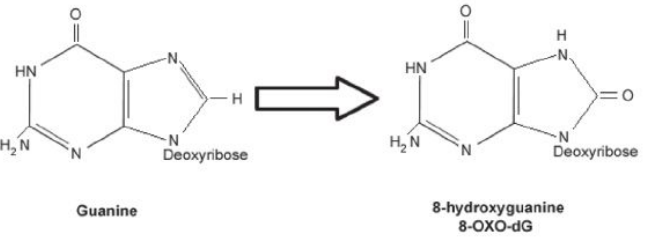
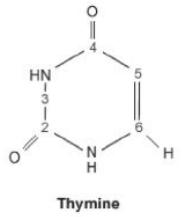
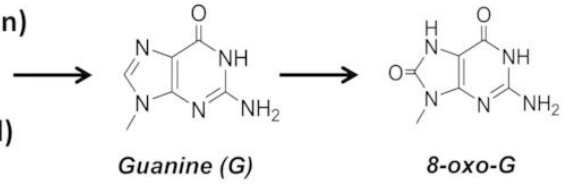


free radicals & reactive oxygen species (ROS)

→ oxidative cell damage

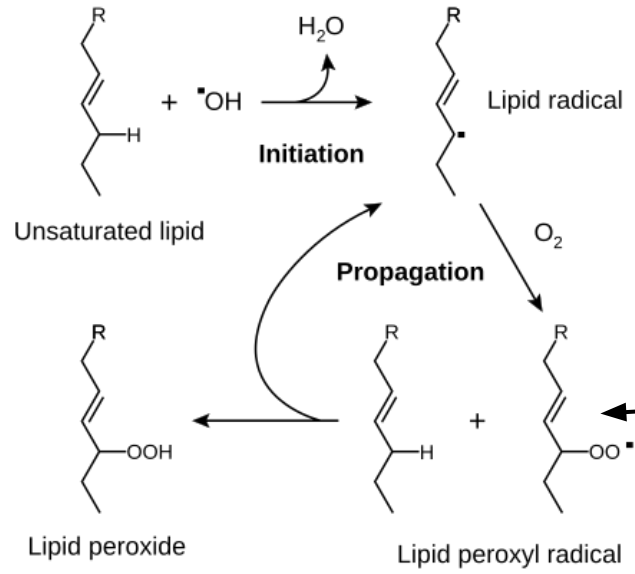
Reactive Oxygen Species (ROS)

- O_2^- (Superoxide anion)
- O_2^{2-} (Peroxide)
- $\cdot OH$ (Hydroxyl radical)
- OH^- (Hydroxide)

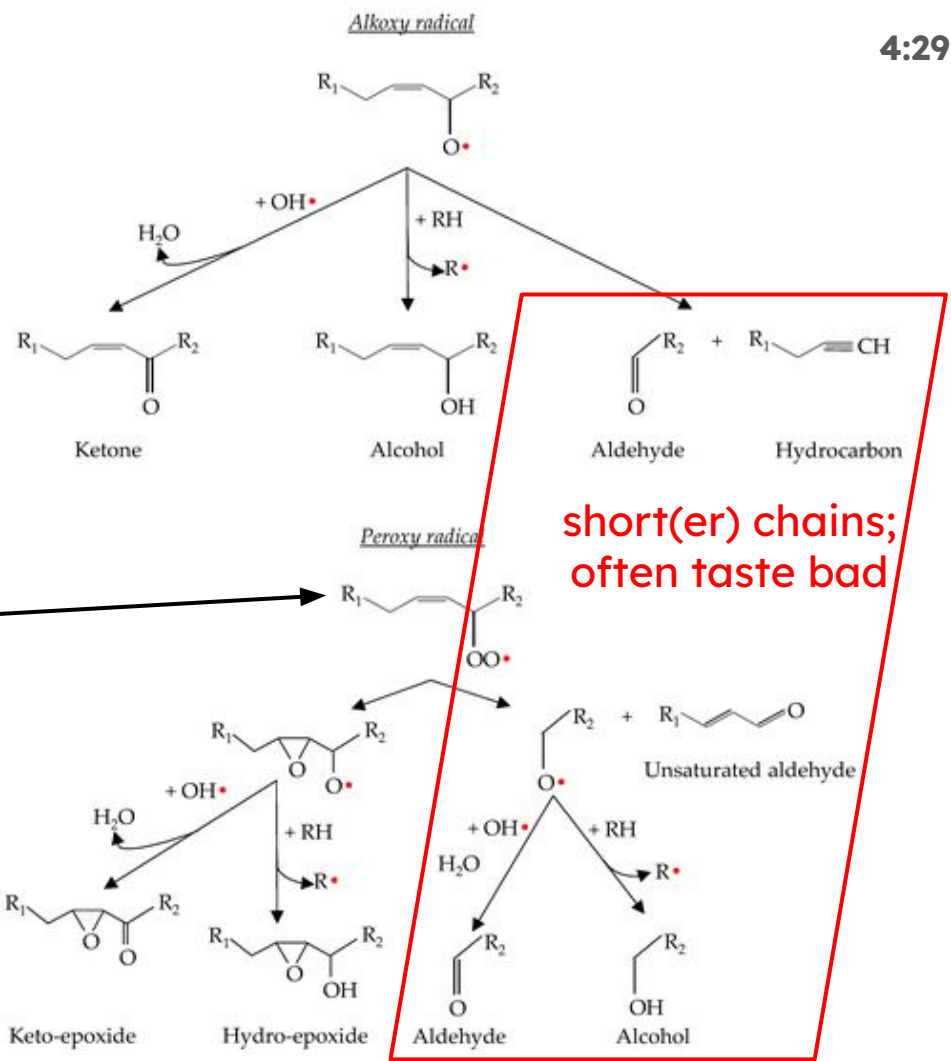


(oxidative) rancidification

radical oxidation of fats

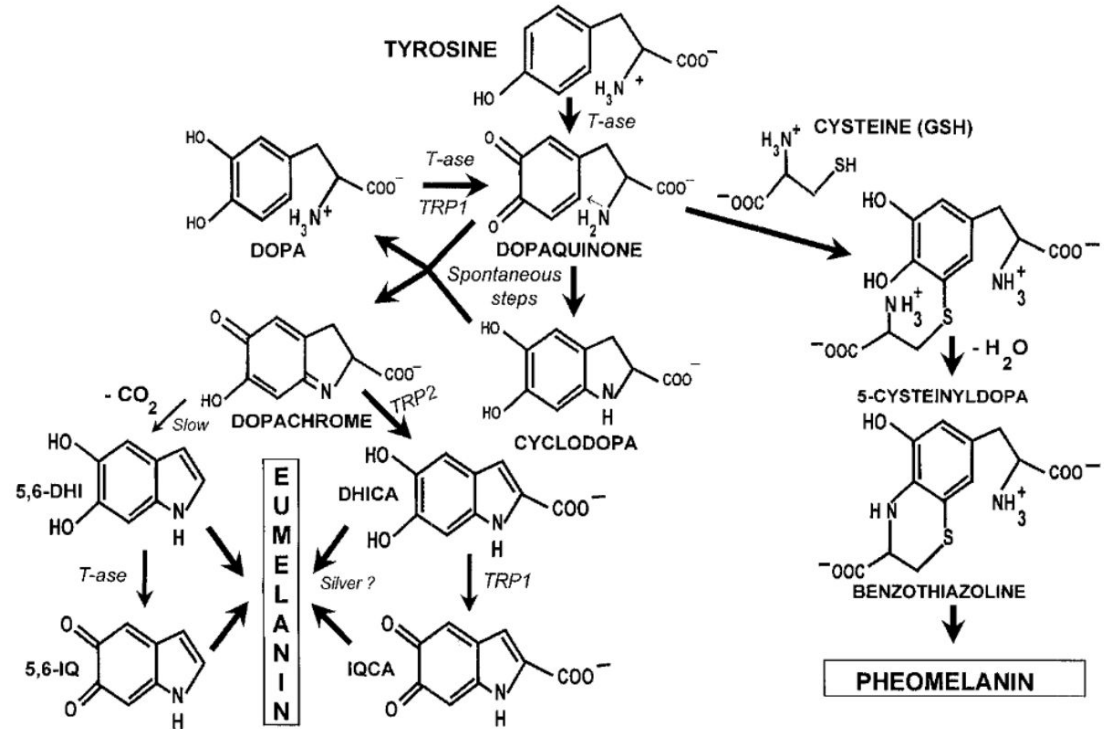
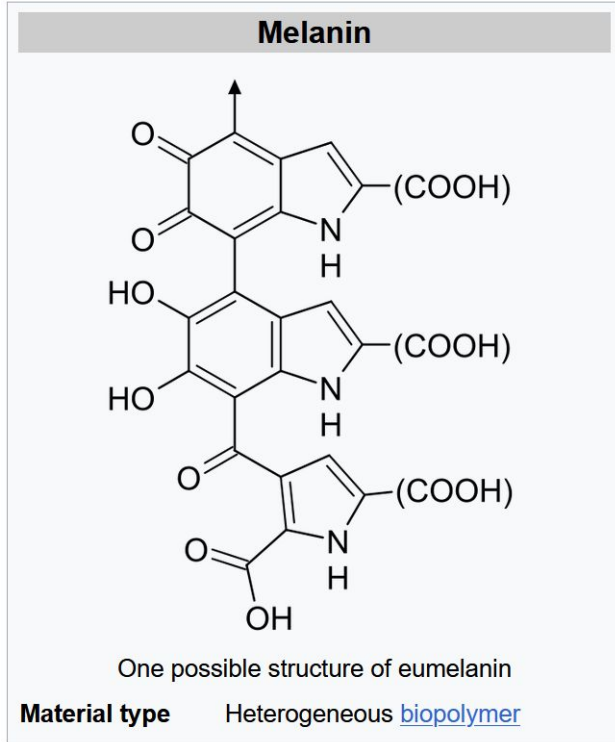


oxygen absorber

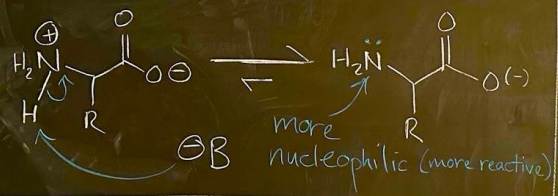


melanin structure & production

a brown pigment

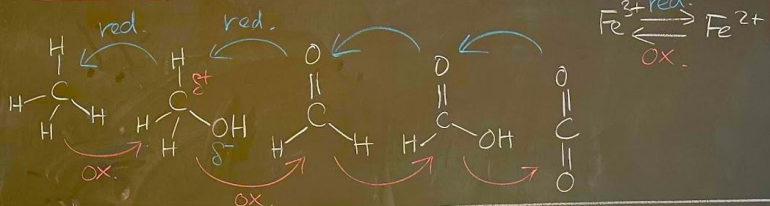


Maillard reaction accelerated by alkalinity

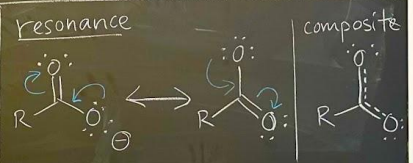


redox vocabulary/terminology

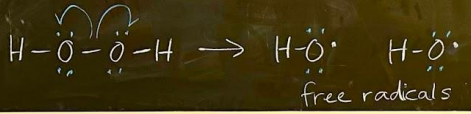
Oxidation Is Loss, Reduction Is Gain ('OIL RIG')



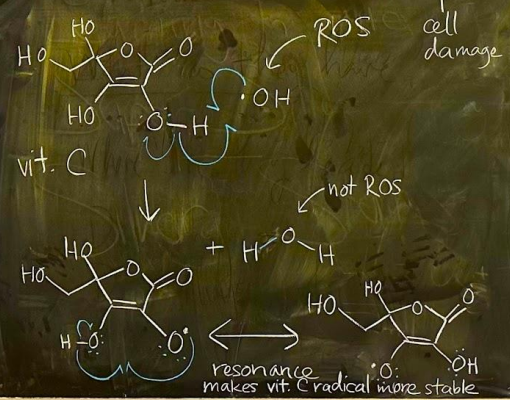
oxidant causes oxidation
 reductant causes reduction
 antioxidant? prevent ox.



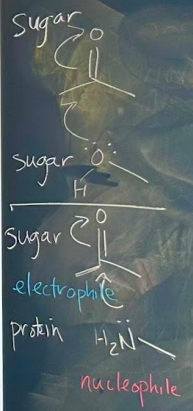
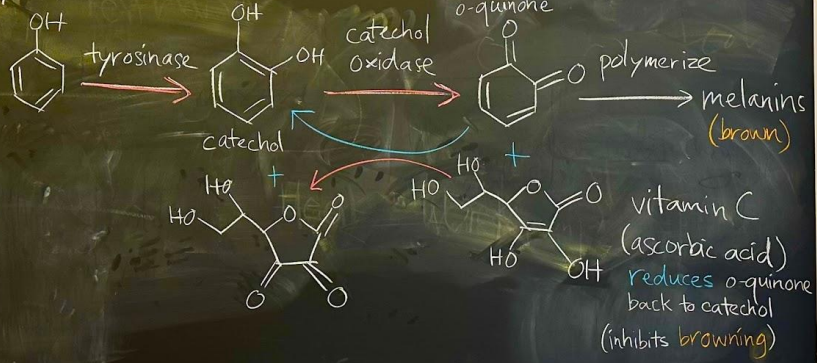
H₂O₂ as Reactive Oxygen Species (ROS)



vit. C (antioxidant) gets rid of ROS (oxidants)



polyphenol oxidases

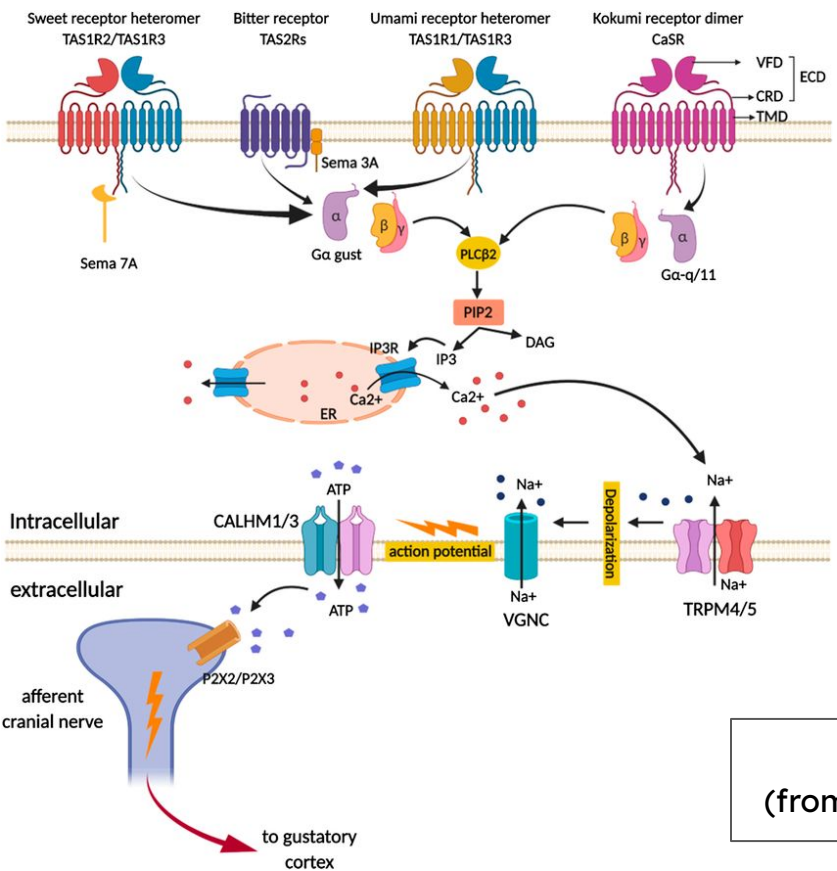


food (bio)chemistry!
lecture 6
biology:
taste receptors, metabolism

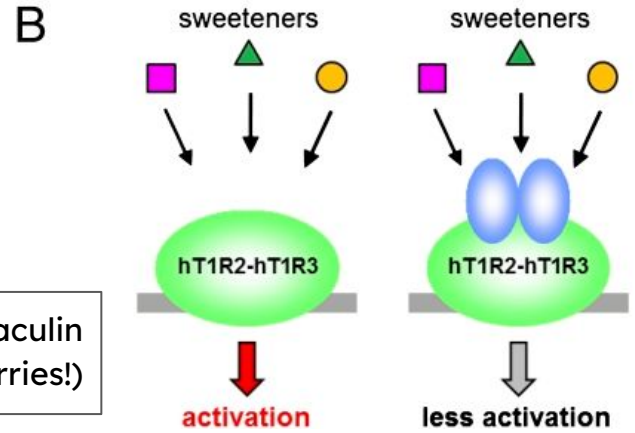
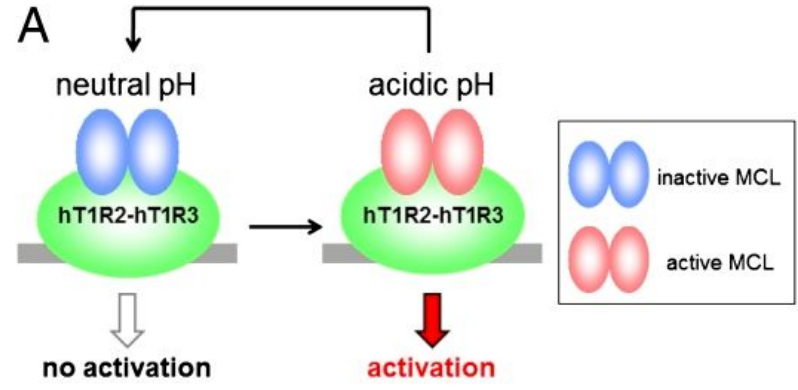
sovannjet lim and boheng cao
april 11, 2026

taste receptors

taste molecules bind → send signal to cell



MCL = miraculin (from the Ledidi berries!)

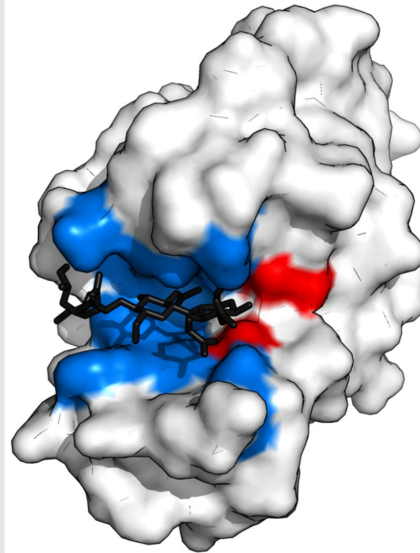


active sites

where enzymes catalyze reactions

PROTEIN STRUCTURE

Scaffold to support and position active site



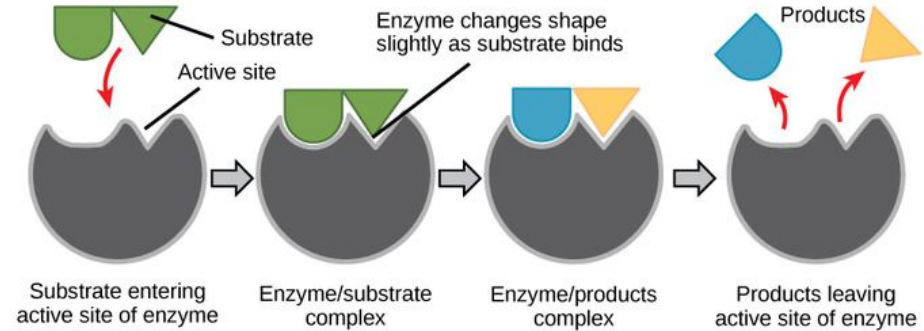
ACTIVE SITE

BINDING SITES

Bind and orient substrate(s)

CATALYTIC SITE

Reduce chemical activation energy

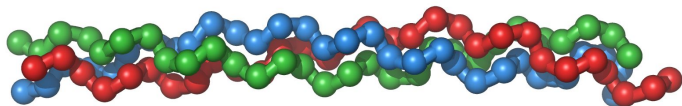


structural proteins in food

6:48

shape determines function

- **collagen** composed of three long intertwined alpha helices (triple helix)
 - found in skin, cartilage, bones, tendons, ligaments
 - fibrous/stretchy due to helices
- **gelatin** made of collagen
 - gelatinous/bouncy texture: jello, gummies, marshmallows
 - stabilizer/thickener in dairy products (tastes like emulsified fat)
 - harvested from leather/fish
 - gelatinous layer after refrigerating chicken stock/broth



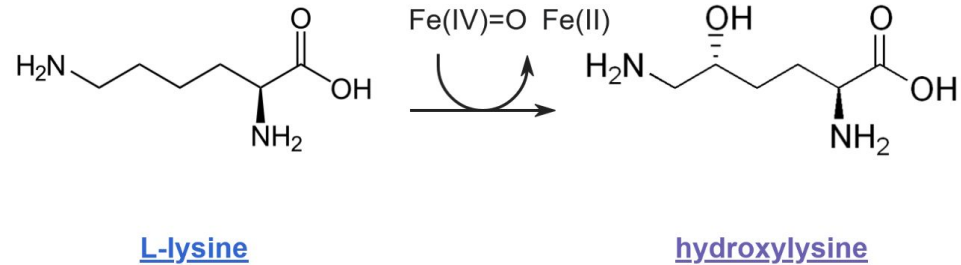
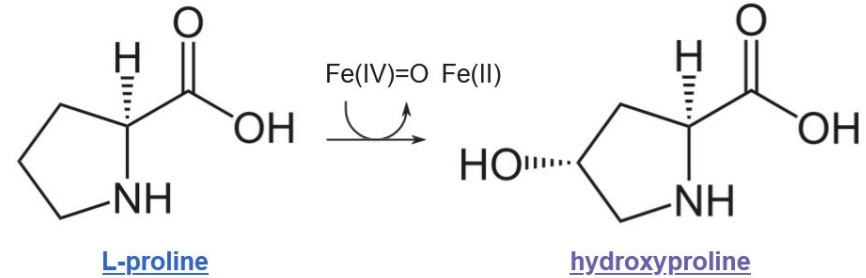
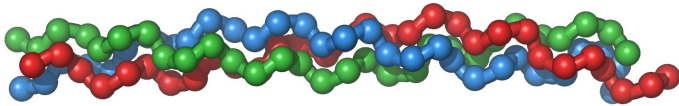
- **gluten (lecture 1)** in wheat adheres flour/makes dough elastic and chewy
 - **disulfide bridge** cross-linking (cysteine)
 - 'hard' bread flour higher in gluten; soft cake flour lower in gluten to crumble
 - shortening/saturated fats inhibit cross-linking responsible for chewiness



prolyl hydroxylase & lysyl hydroxylase

en route to collagen

- **collagen** composed of three long intertwined alpha helices (triple helix)
 - found in skin, cartilage, bones, tendons, ligaments
 - fibrous/stretchy due to helices
 - **in order to make tight helices, need *hydroxyproline* and *hydroxylysine*!**



cofactors

enzyme assistants

now

metabolism (rest of lecture 6)

previously mentioned (lecture 3 "faq")

you've probably heard of these

Non-vitamins [edit]

Cofactor	Chemical group(s) transferred	Distribution
Adenosine triphosphate ^[43]	Phosphate group	Bacteria, archaea and eukaryotes
S-Adenosyl methionine ^[44]	Methyl_group	Bacteria, archaea and eukaryotes
Coenzyme B ^[45]	Electrons	Methanogens
Coenzyme M ^{[46][47]}	Methyl_group	Methanogens
Coenzyme Q ^[48]	Electrons	Bacteria, archaea and eukaryotes
Cytidine triphosphate ^[49]	Diacylglycerols and lipid head groups	Bacteria, archaea and eukaryotes
Glutathione ^{[50][51]}	Electrons	Some bacteria and most eukaryotes
Heme ^[52]	Electrons	Bacteria, archaea and eukaryotes
Lipoamide ^[5]	Electrons, acyl groups	Bacteria, archaea and eukaryotes
Methanofuran ^[53]	Formyl_group	Methanogens
Molybdopterin ^{[54][55]}	Oxygen atoms	Bacteria, archaea and eukaryotes
Nucleotide sugars ^[56]	Monosaccharides	Bacteria, archaea and eukaryotes
3'-Phosphoadenosine-5'-phosphosulfate ^[57]	Sulfate group	Bacteria, archaea and eukaryotes
Pyroloquinoline quinone ^[58]	Electrons	Bacteria
Tetrahydrobiopterin ^[59]	Oxygen atom and electrons	Bacteria, archaea and eukaryotes
Tetrahydromethanopterin ^[60]	Methyl_group	Methanogens

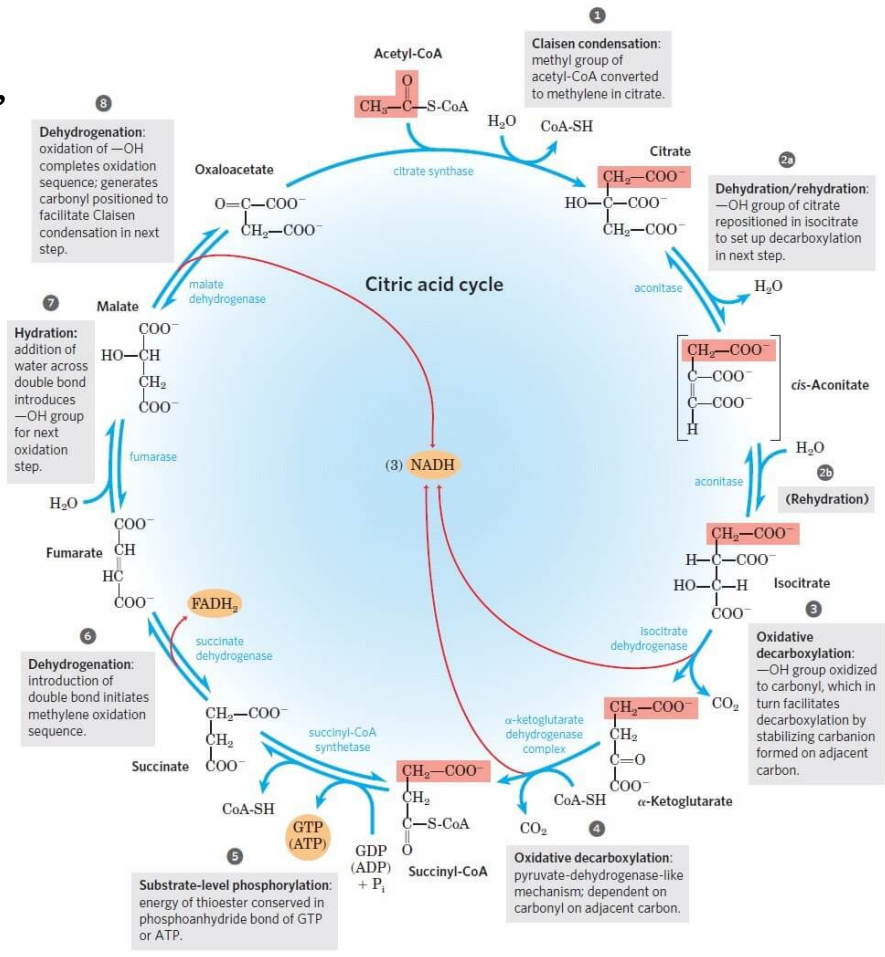
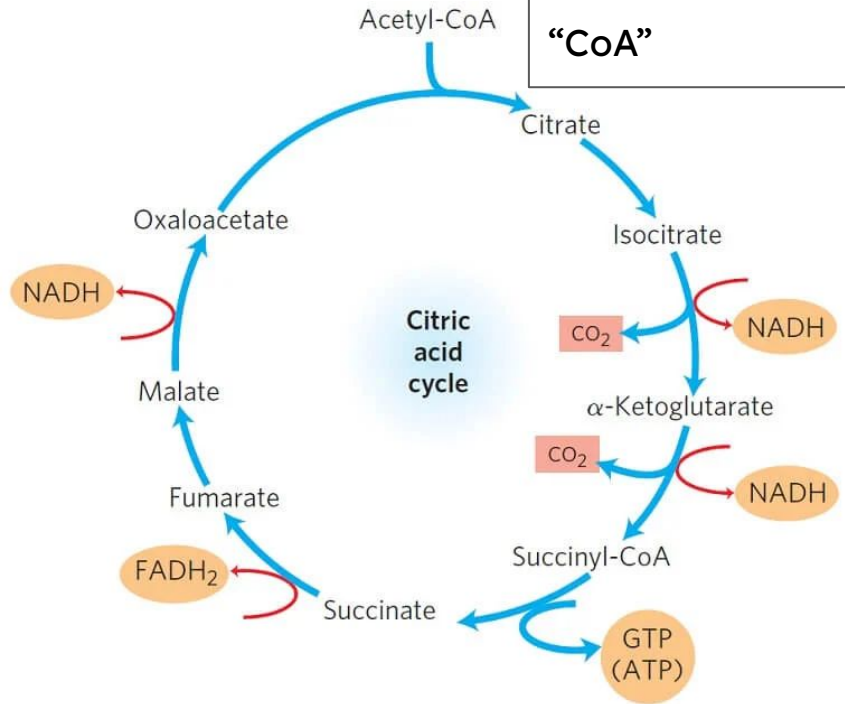
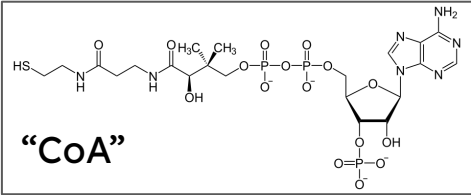
Vitamins and derivatives [edit]

Cofactor / Prosthetic group	Vitamin	Additional component	Chemical group(s) transferred	Distribution
Thiamine pyrophosphate ^[32]	Thiamine (B ₁)	pyrophosphate	2-carbon groups, α cleavage	Bacteria, archaea and eukaryotes
NAD ⁺ and NADP ⁺ ^[33]	Niacin (B ₃)	ADP	Electrons	Bacteria, archaea and eukaryotes
Pyridoxal phosphate ^[34]	Pyridoxine (B ₆)	None	Amino and carboxyl groups	Bacteria, archaea and eukaryotes
Methylcobalamin ^[35]	Vitamin B ₁₂	Methyl group	acyl groups	Bacteria, archaea and eukaryotes
Cobalamin ^[5]	Cobalamin (B ₁₂)	None	hydrogen, alkyl groups	Bacteria, archaea and eukaryotes
Biotin ^[36]	Biotin (H)	None	CO ₂	Bacteria, archaea and eukaryotes
Coenzyme A ^[37]	Pantothenic acid (B ₅)	ADP	Acetyl_group and other acyl groups	Bacteria, archaea and eukaryotes
Tetrahydrofolic acid ^[38]	Folic acid (B ₉)	Glutamate residues	Methyl, formyl, methylene and formimino groups	Bacteria, archaea and eukaryotes
Menaquinone ^[39]	Vitamin K	None	Carbonyl_group and electrons	Bacteria, archaea and eukaryotes
Ascorbic acid ^[40]	Vitamin C	None	Electrons	Bacteria, archaea and eukaryotes
Flavin mononucleotide ^[41]	Riboflavin (B ₂)	None	Electrons	Bacteria, archaea and eukaryotes
Flavin adenine dinucleotide ^[41]	Riboflavin (B ₂)	ADP	Electrons	Bacteria, archaea and eukaryotes
Coenzyme F420 ^[42]	Riboflavin (B ₂)	Amino acids	Electrons	Methanogens and some bacteria

TriCarboxylic Acid/citric acid/Krebs cycle

making NADH and FADH₂ in mitochondria

- “the mitochondria are the powerhouse of the cell”
- key input: **Acetyl-CoA**



electron transport chain/oxidative phosphorylation

making ATP in mitochondria

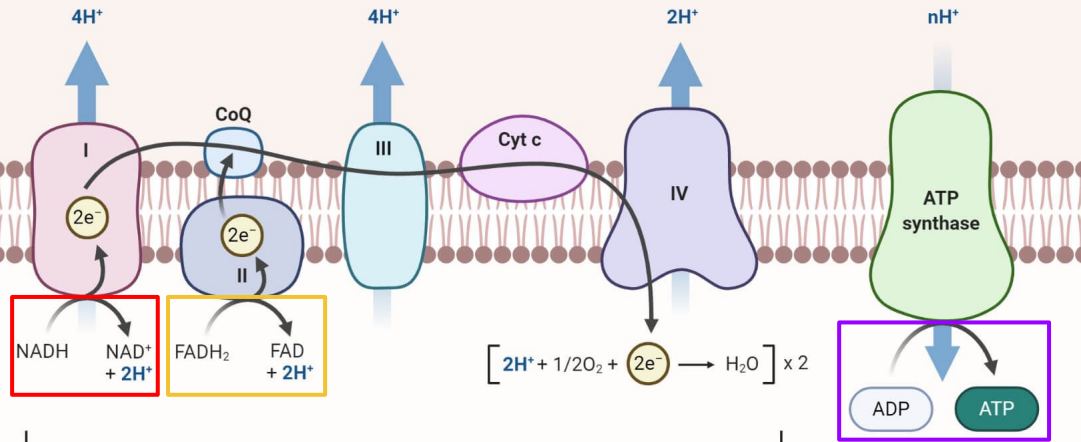
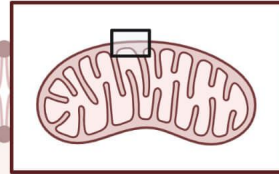
Cytoplasm

Outer membrane

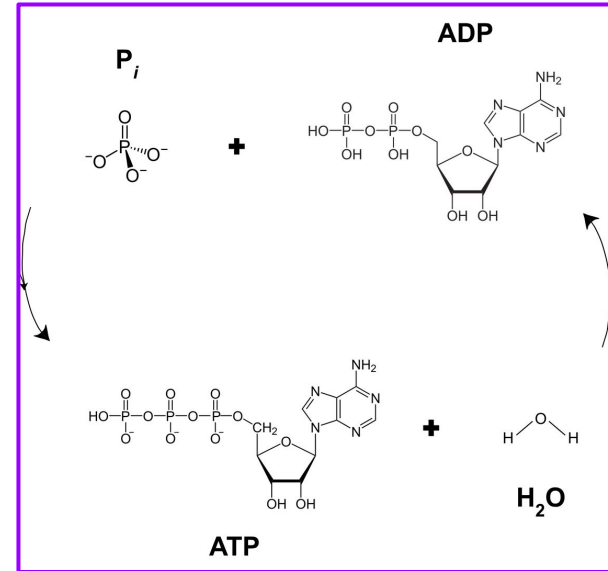
Intermembrane space

Inner membrane

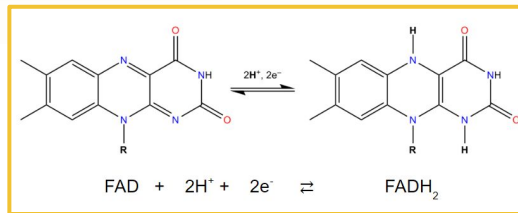
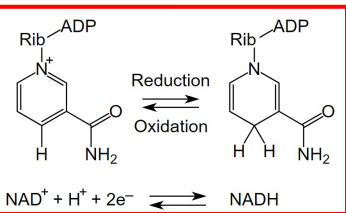
Mitochondrial matrix



- uses NADH & FADH₂ from TCA cycle
- “ATP is the energy currency of the cell”
- “the mitochondria are the powerhouse of the cell”

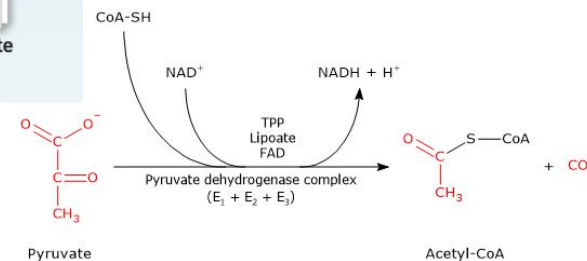
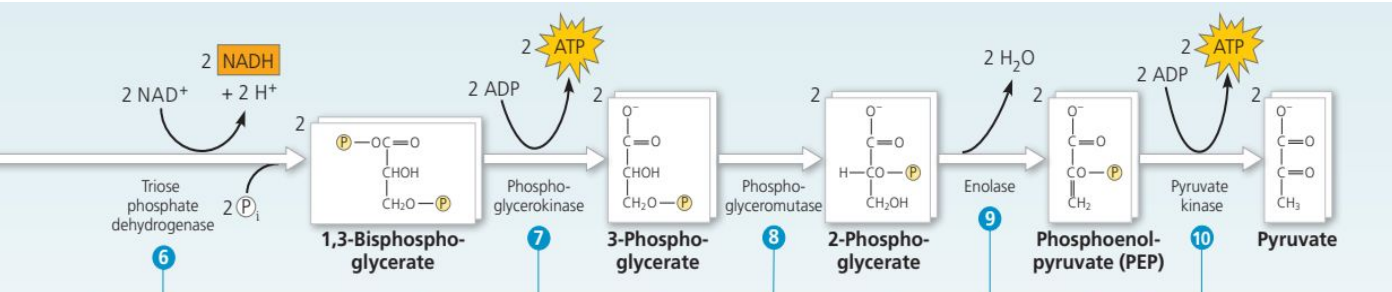
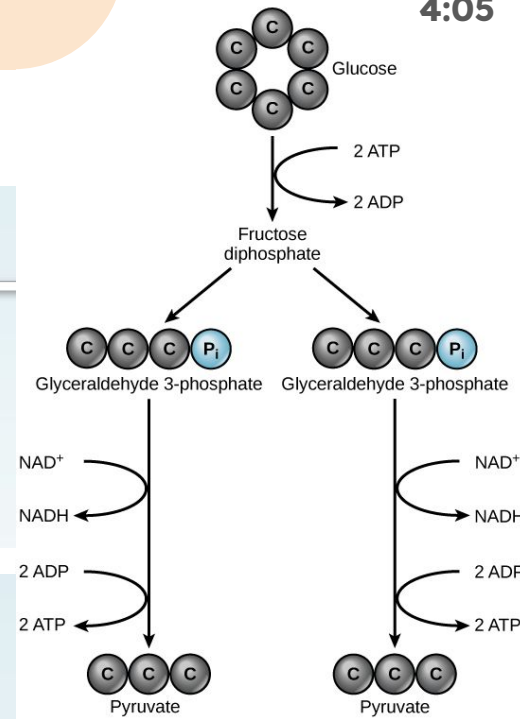
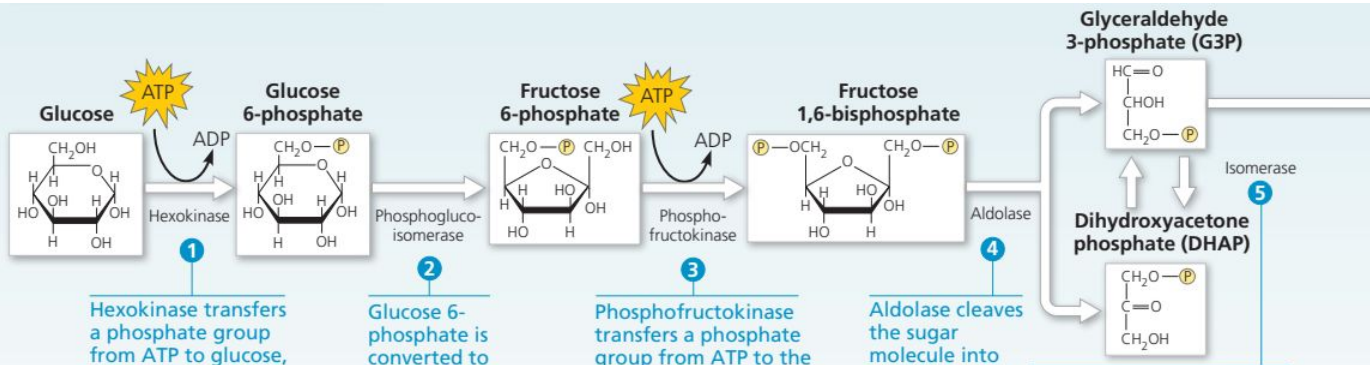


Electron Transport Chain



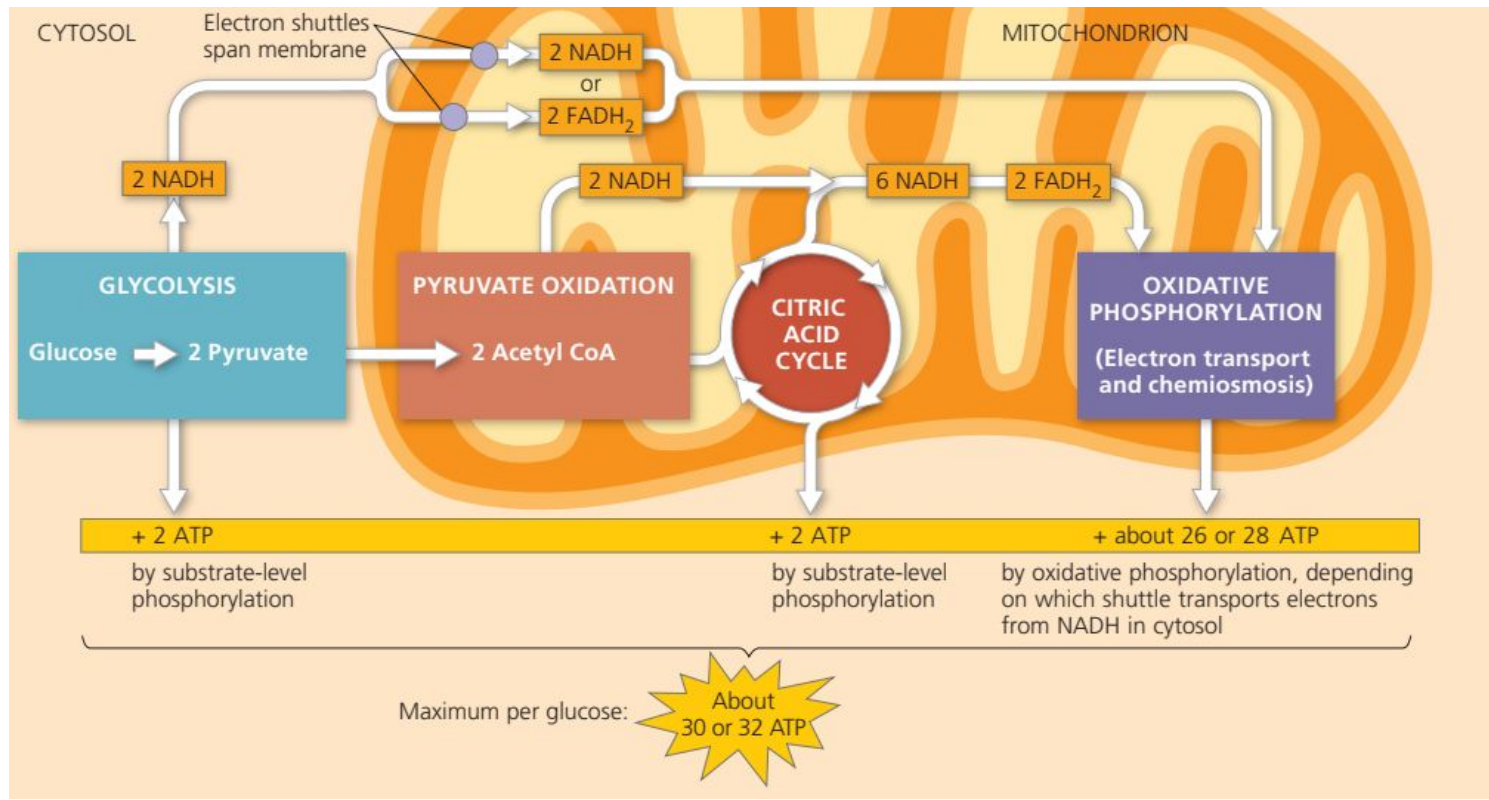
sugar breakdown: glycolysis

glucose → pyruvate → Acetyl-CoA



so far...

sugar breakdown → ... → ATP



sugar breakdown: fermentation

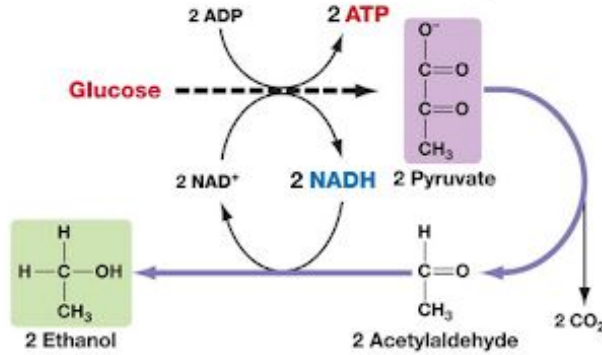
when there's no O₂

Glycolysis

Fermentation

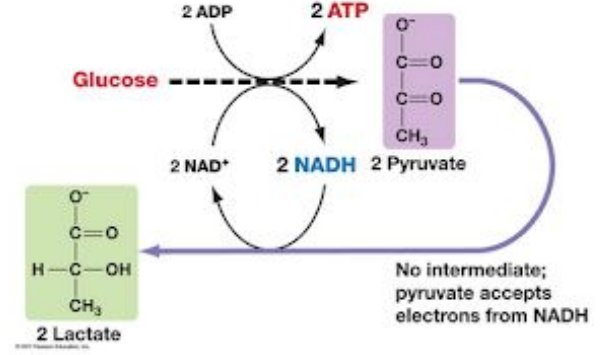
Ethanol pathway

Alcohol fermentation occurs in yeast.



Lactate pathway

Lactic acid fermentation occurs in humans.



GLUCOSE
↓
Pyruvic acid

Anaerobic bacteria

Yeast

Lactic acid fermentation

Alcohol fermentation

Aspergillus

Lactobacillus

Saccharomyces

Lactic acid
i.e. Soy Sauce

Lactic acid
i.e. Cheese & Yoghurt

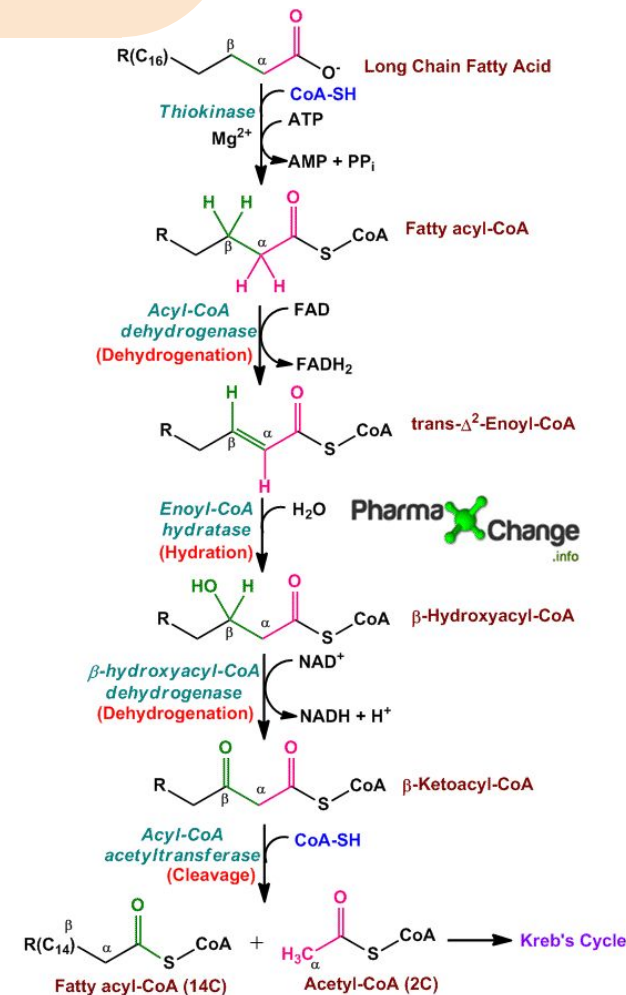
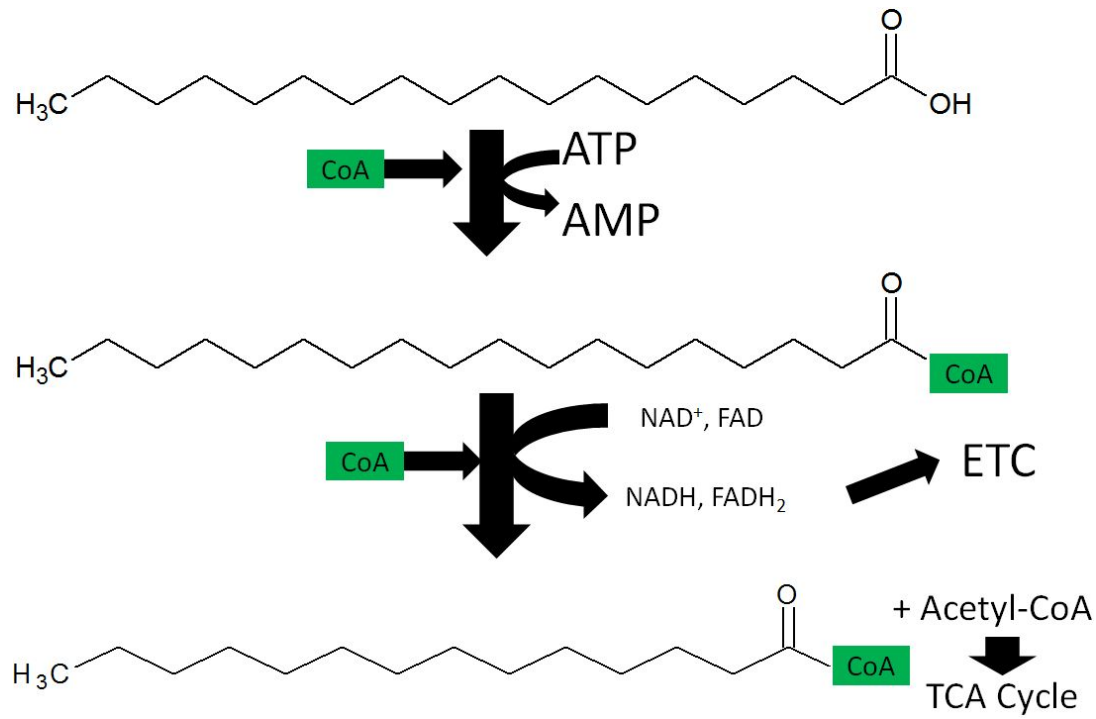
Ethanol + CO₂
i.e. Beer

Ethanol
i.e. Wine

CO₂
i.e. Bread

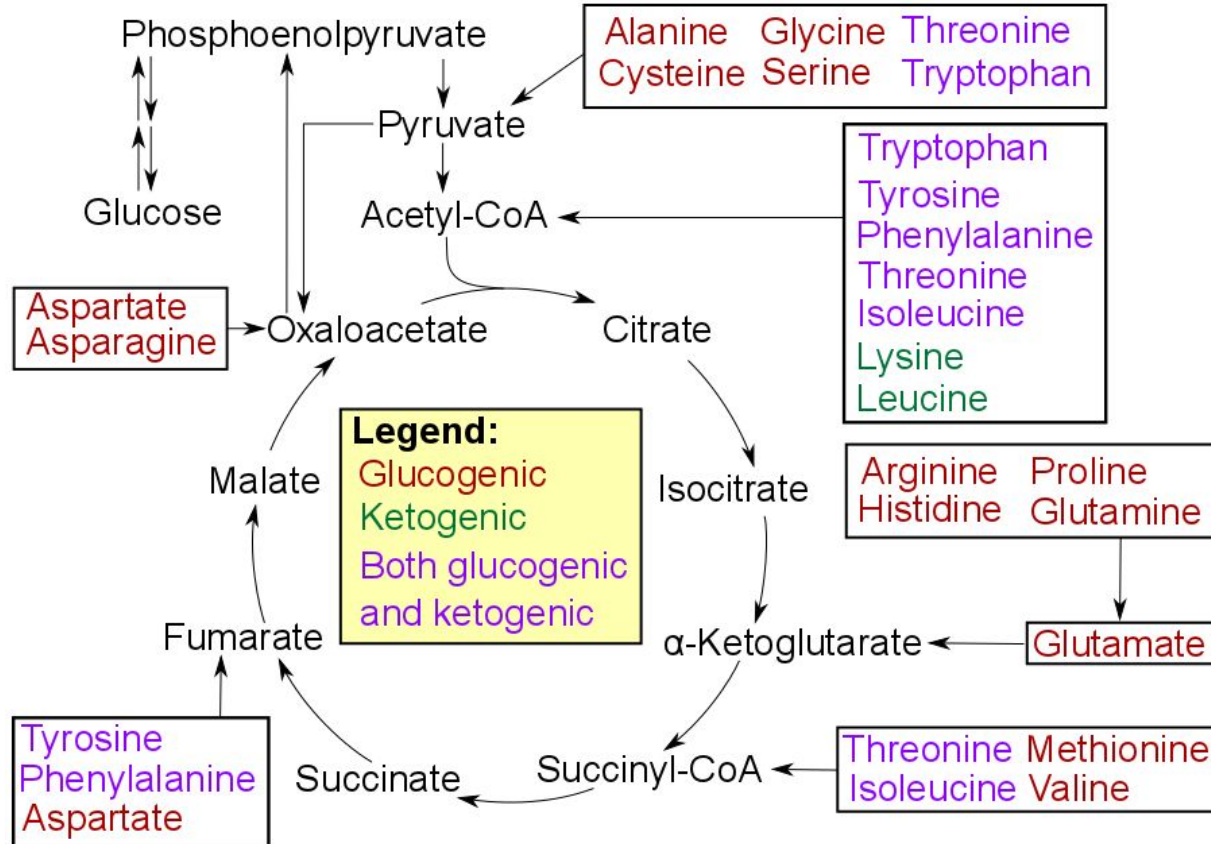
fatty acid breakdown: fatty acid oxidation

-2 carbons at a time



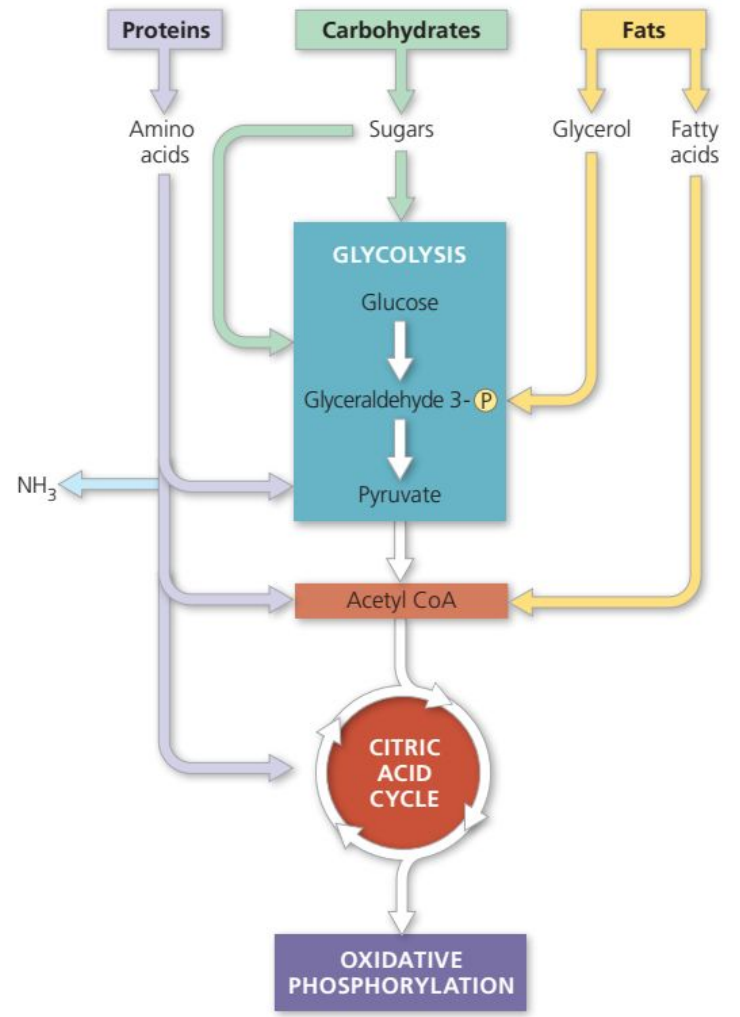
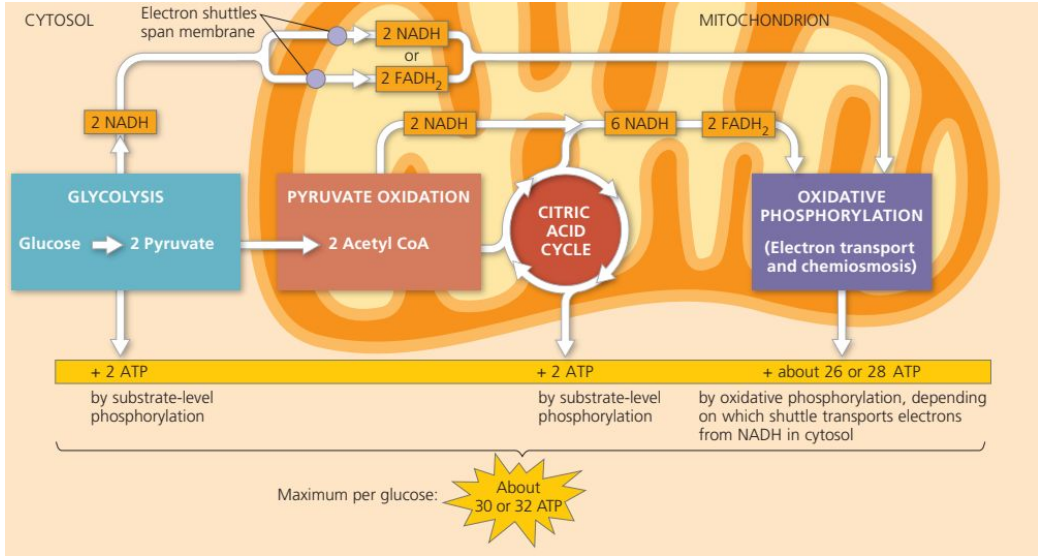
amino acid breakdown

products go to TCA cycle



summary: breakdown

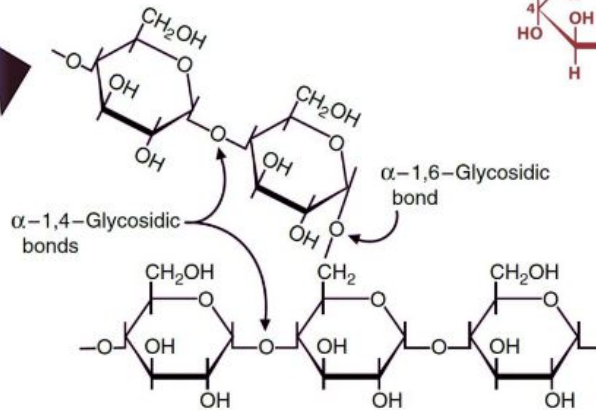
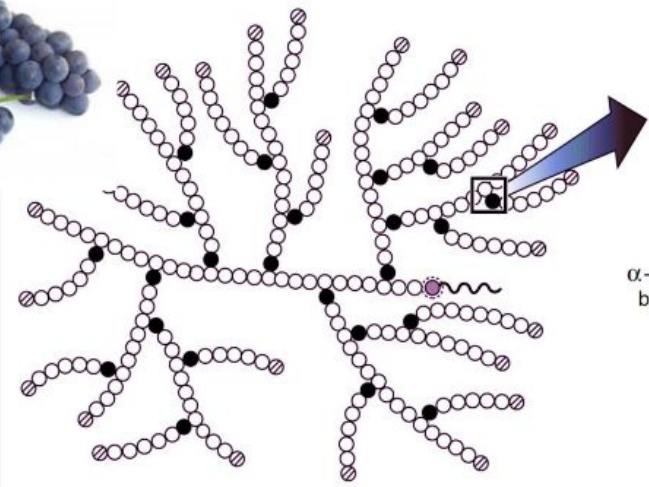
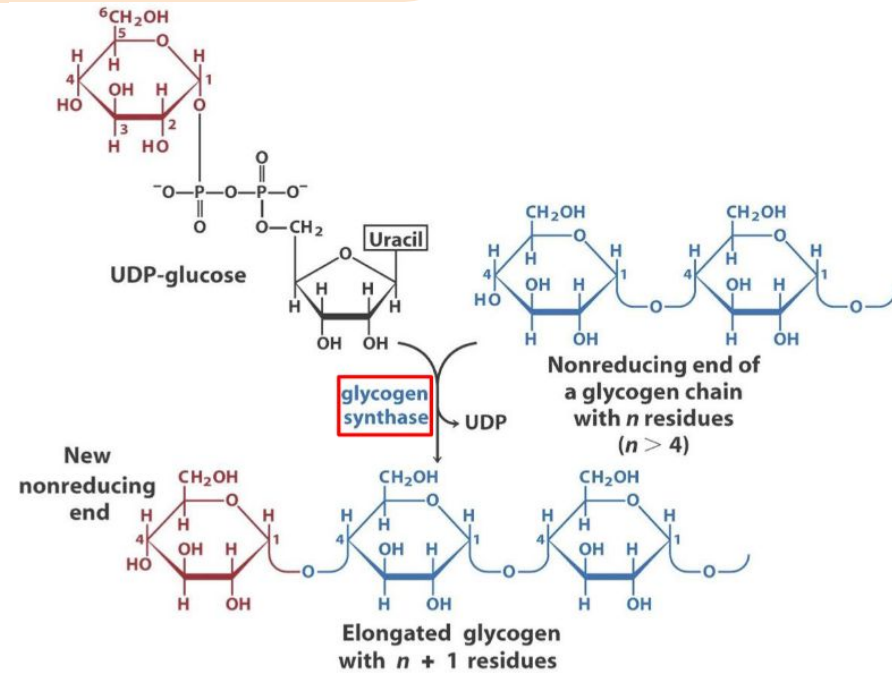
of sugars, amino acids, fats



sugar buildup: glycogen synthesis

energy storage

- breaking these bonds later releases energy
 - **saving energy for later!**
- cf. dehydration synthesis



amino acid buildup: protein synthesis

amino acids and proteins

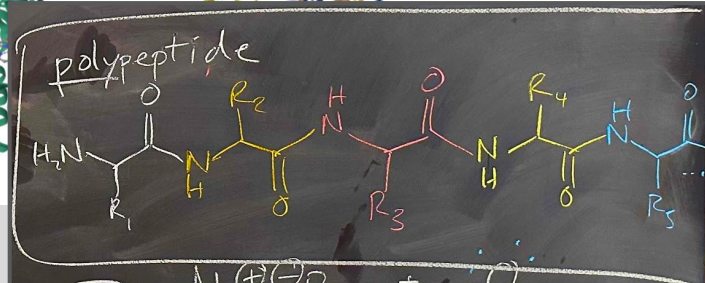
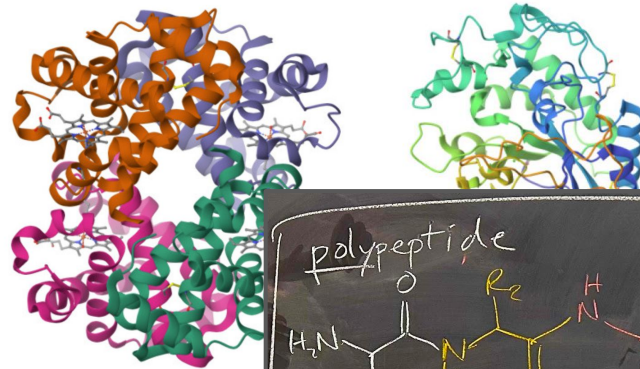
5:53

folding molecules

- amino acids linked together via **dehydration reactions** to form long chains (**polypeptides**)
 - carboxyl group of one amino acid bonds to the amino group of another amino acid
 - the alpha carbons, carboxyl groups, and amino groups form long, straight **backbone**
 - side chains stick out of this backbone
 - hundreds of amino acids long



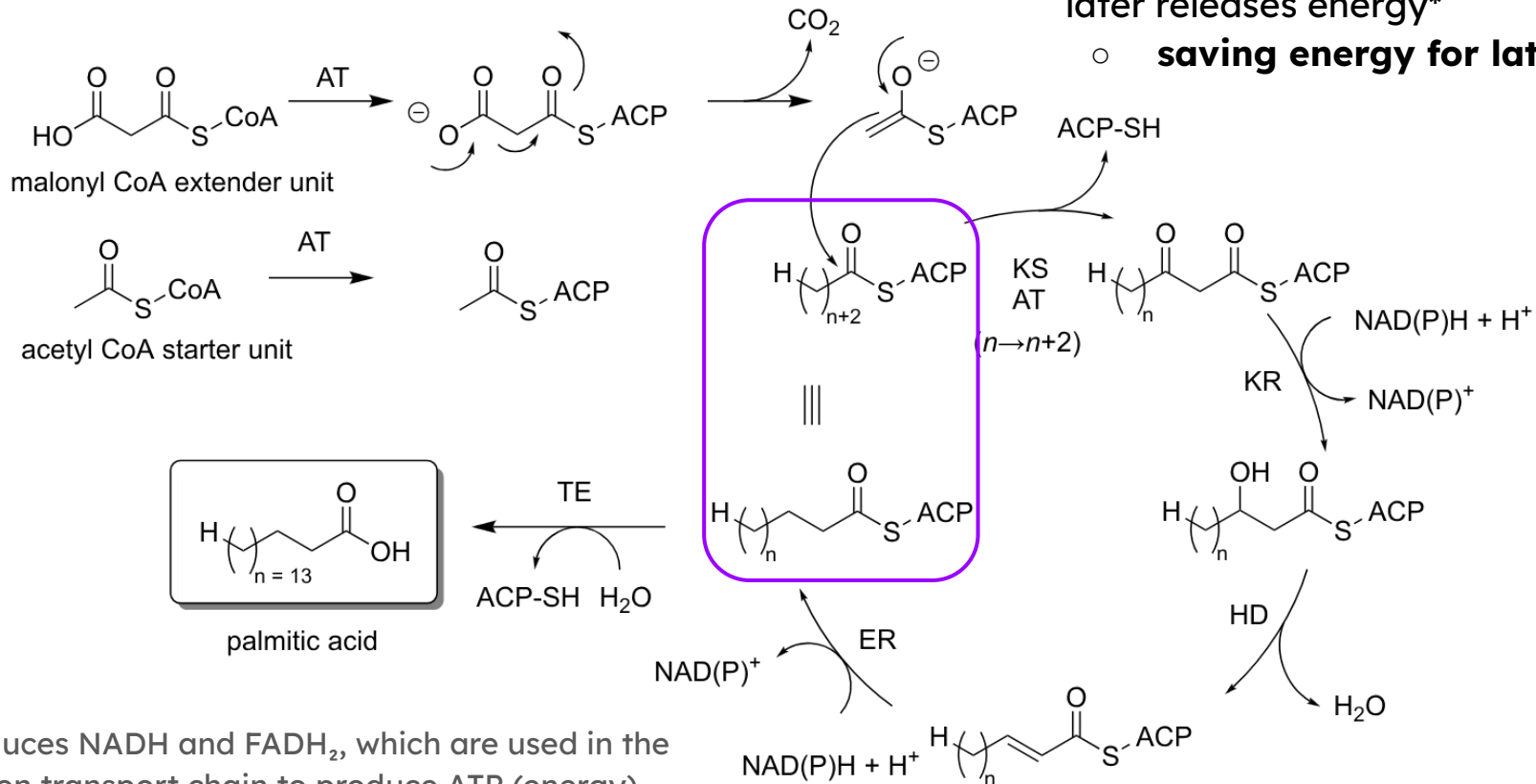
- polypeptides **fold** into **proteins**
 - polypeptide backbone bends, spirals, and twists to form **helices, sheets, globules**, etc.
 - protein shape stabilized by interactions *between* the side chains of amino acids, often on far away parts of the polypeptide
 - these interactions aren't covalent bonds (what holds up the polypeptide); they're **hydrogen bonds, ionic bonds**, etc.



fatty acid buildup: fatty acid synthesis

energy storage

- breaking these bonds (FA oxidation) later releases energy*
 - **saving energy for later!**



* produces NADH and FADH₂, which are used in the electron transport chain to produce ATP (energy)

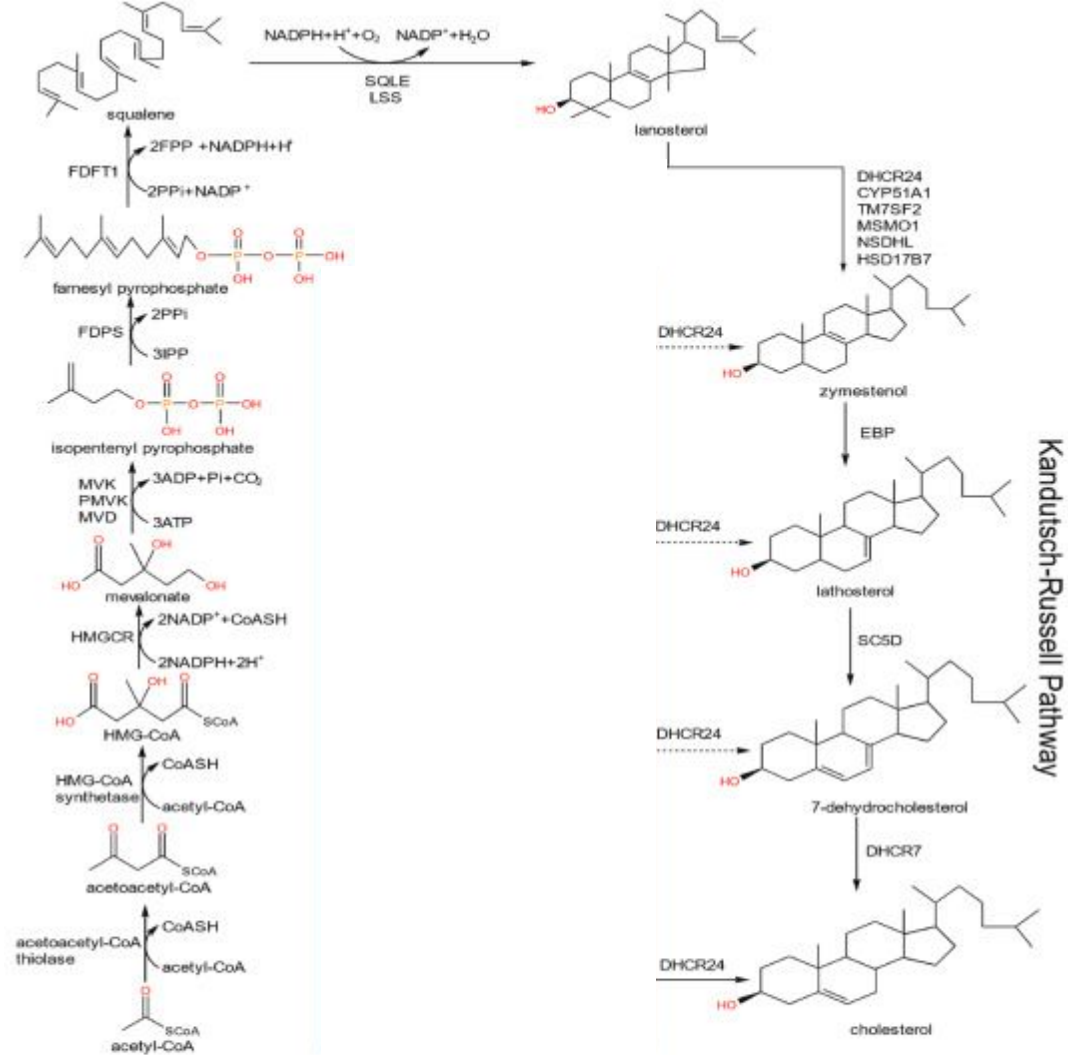
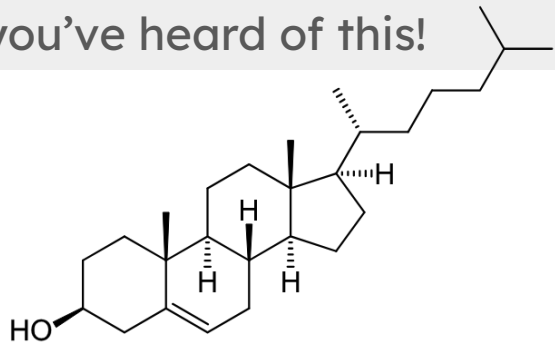
summary: **buildup**

of sugars, amino acids, fats

- glucose: **glycogen synthesis**
 - saving energy for later
- amino acids: **protein synthesis**
 - proteins Do Things in cells
- fats: **fatty acid synthesis**
 - saving energy for later

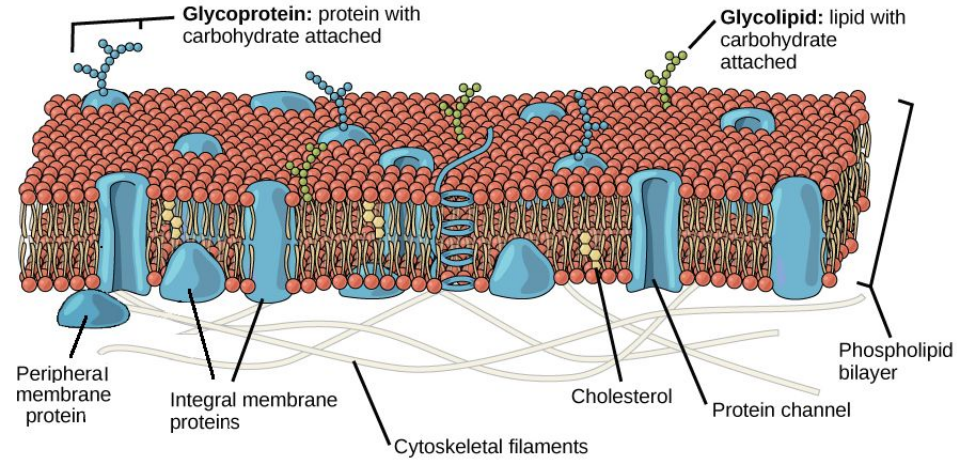
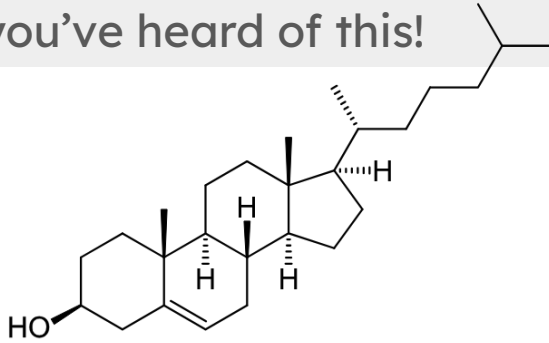
cholesterol

you've heard of this!



cholesterol

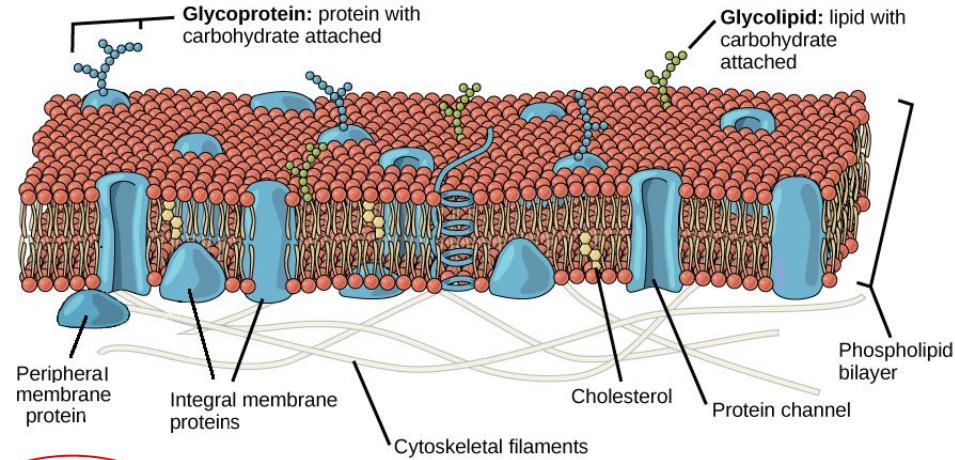
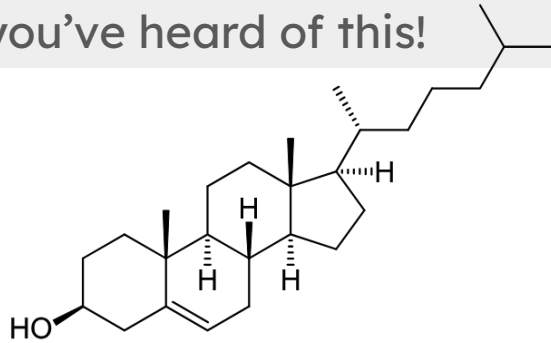
you've heard of this!



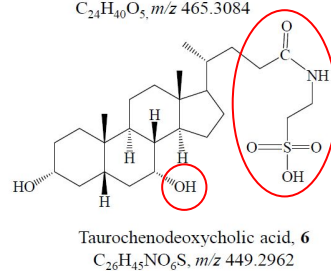
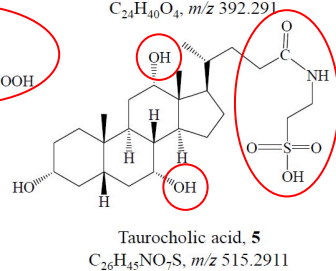
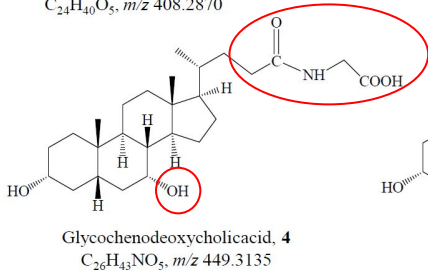
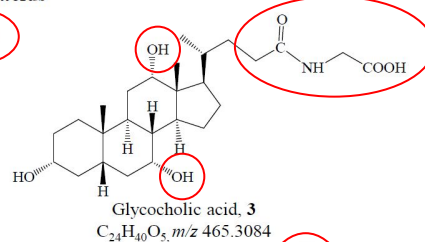
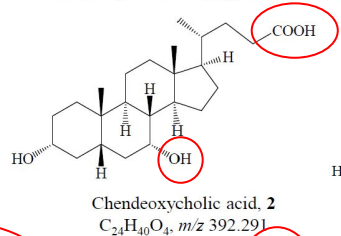
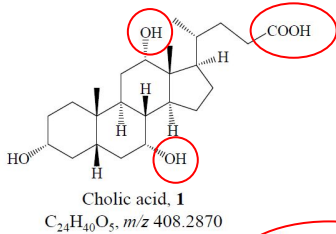
- Acetyl-CoA → ... → cholesterol
- makes cell membranes more fluid

cholesterol

you've heard of this!



Primary and conjugated bile acids



- Acetyl-CoA → ... → cholesterol
- makes cell membranes more fluid
- cholesterol → bile acids (in bile), which *emulsify* dietary fats
 - does this make sense, in terms of polarity?

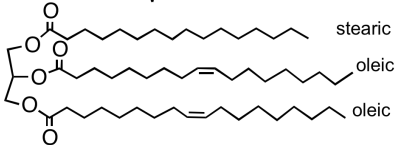
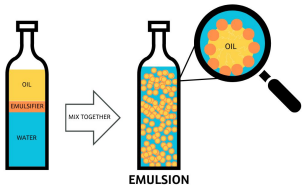
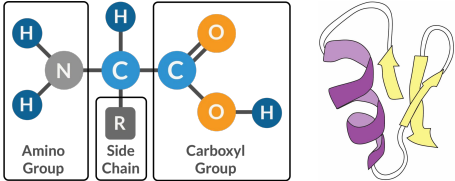
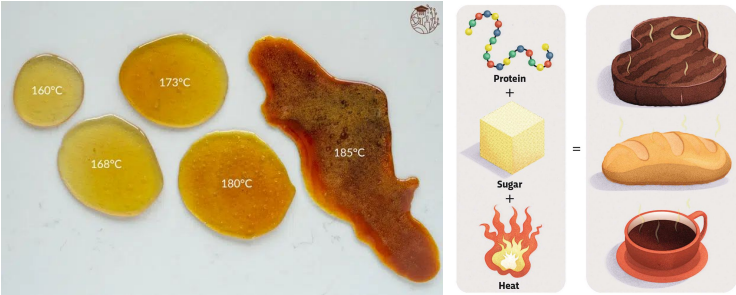
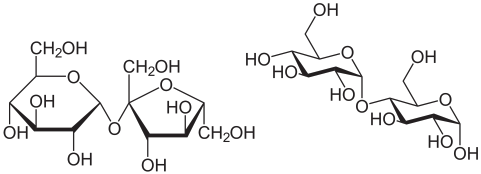
RECAP

we've covered a lot—thanks!

(as noted in the course description) for each of these molecules, we will discuss:

8:26

- their chemical **structure**
- their **reactivity** in the kitchen
- their function and **metabolism** in the body
- **what these mean** for your everyday interactions/experiences with food

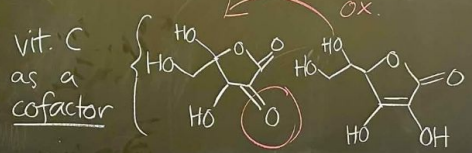
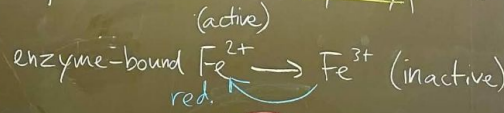
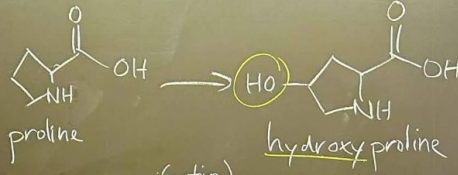
food group	biological molecule	structure	reactivity	metabolism
fats	lipids	saturated, unsaturated, trans 	nonpolar/hydrophilic <u>emulsification</u> : mix nonpolar + polar via emulsifier 	lecture 6 producing energy : TCA → ETC → ATP
proteins	amino acids (monomer) proteins/polypeptides (polymer)	alpha helices, beta sheets, disulfide bridges  lecture 6: taste receptors as examples of proteins	<u>buildup</u> : dehydration synthesis <u>breakdown</u> : hydrolysis <i>non-enzymatic browning</i> (lecture 5: enzymatic browning) <ul style="list-style-type: none"> - <u>caramelization</u>: sugars → flavors + caramels/caramelens/caramelins - <u>Maillard reaction</u>: sugar + protein → flavors + melanoidins 	breakdown : glycolysis, FA oxidation, a.a.'s → TCA buildup : synthesis of glycogen, fatty acids, proteins cholesterol
grains	carbohydrates ("sugars") fiber (various polysaccharides)	mono-, di-, polysaccharides 	lecture 5: redox and radical reactions free radicals, reactive oxygen species, rancidification, enzymatic browning, antioxidants (ex. vitamin C)	
fruits/vegetables	fiber (various polysaccharides) vitamins, minerals, antioxidants			

taste receptors



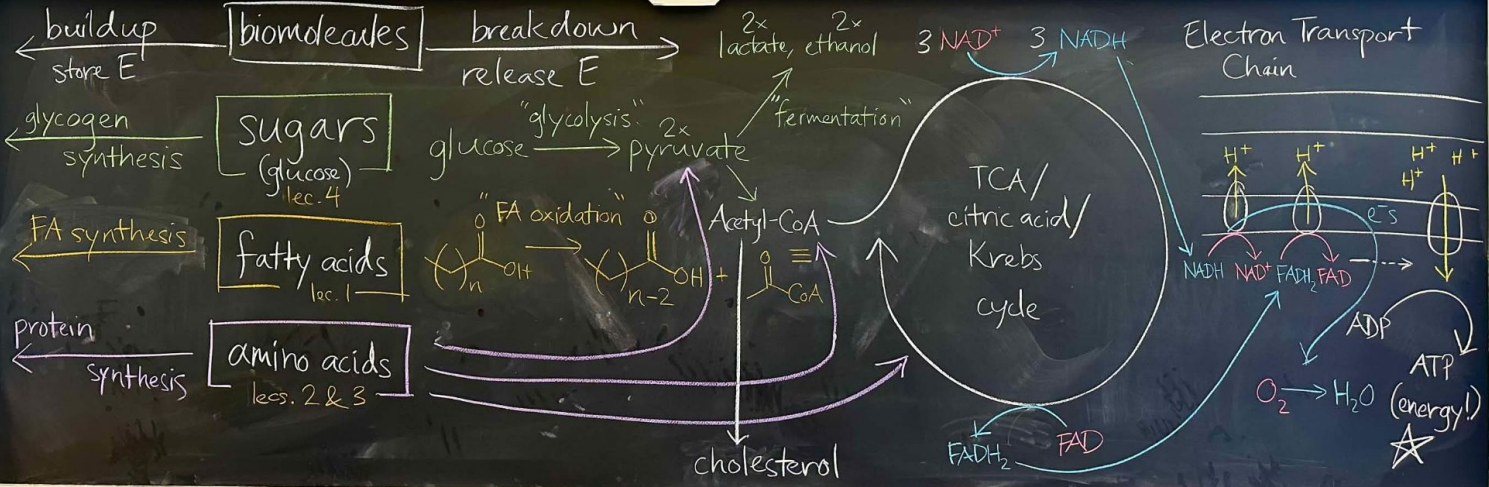
other minerals used by cells: K⁺, Ca²⁺, Cl⁻

prolyl hydroxylase



cofactor = required for enzyme to function

METABOLISM ↓





these slides



lecture notes



feedback form