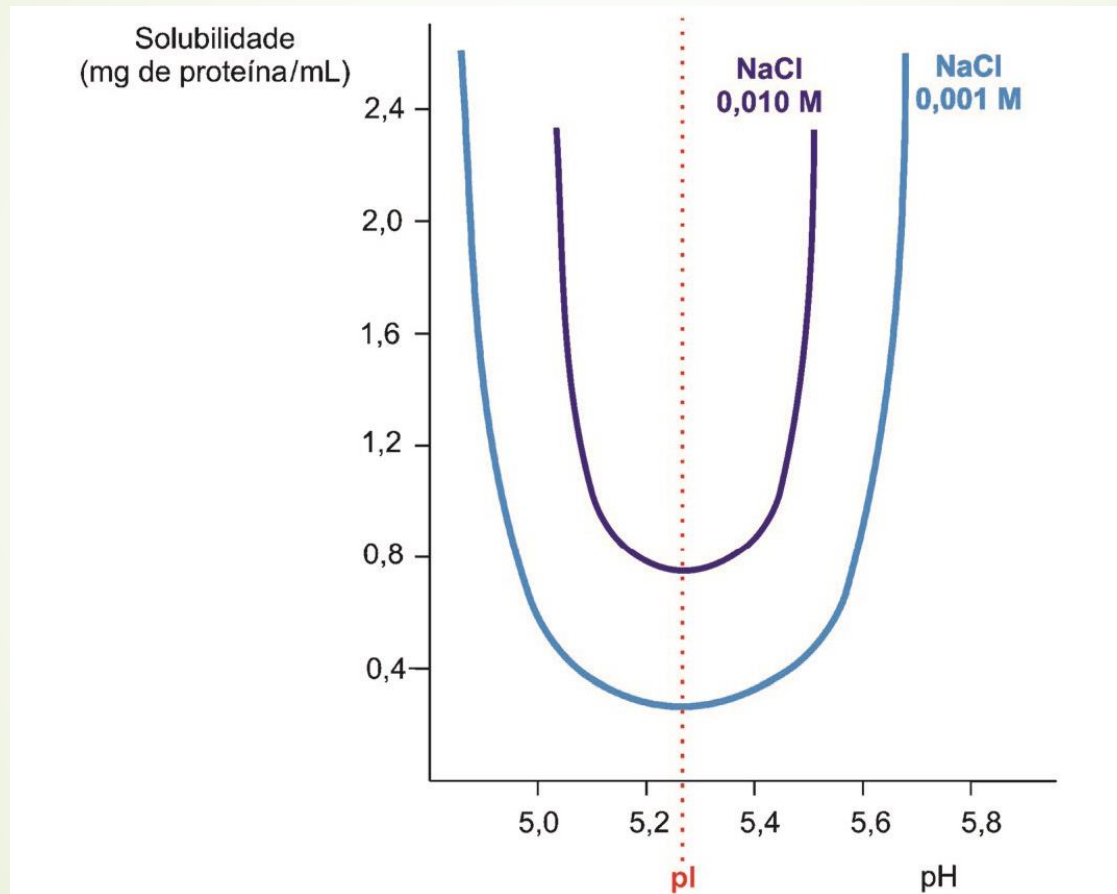


# Solubilidade de uma proteína globular em função de pH



**Fig. 2.13** Solubilidade de uma proteína globular em função do pH, em duas concentrações de NaCl. Está assinalado o pH correspondente ao pI da proteína.

# Efeito da concentração de Enzima na Velocidade da Reação

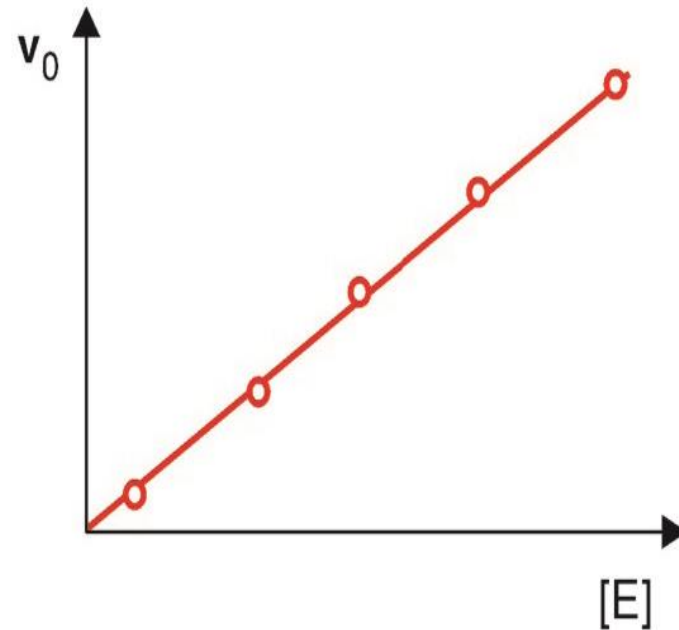


Fig. 5.11 Velocidade da reação enzimática ( $v_0$ ) em função da concentração da enzima (E).

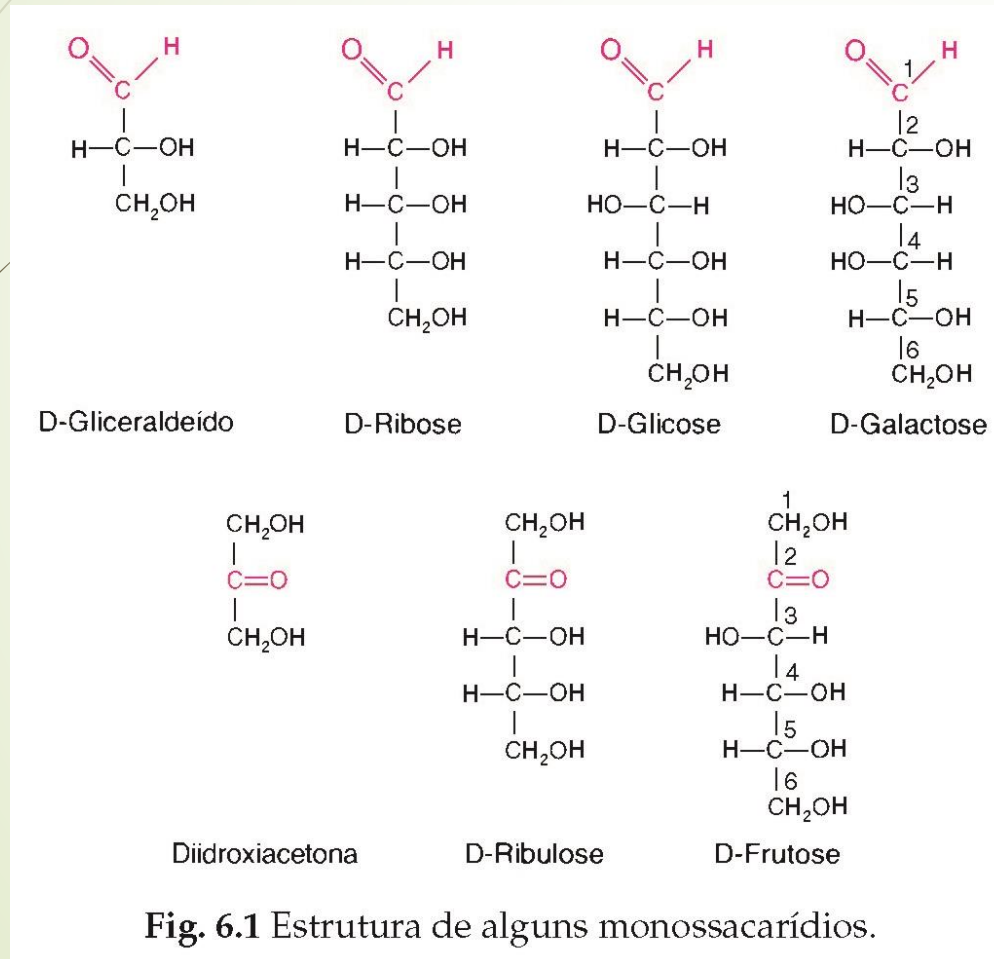


<https://www.youtube.com/watch?v=CHMY4G9gTPA>

## Definição de Carboidratos:

São compostos que, em geral, apresentam a fórmula empírica  $(\text{CH}_2\text{O})_n$ .

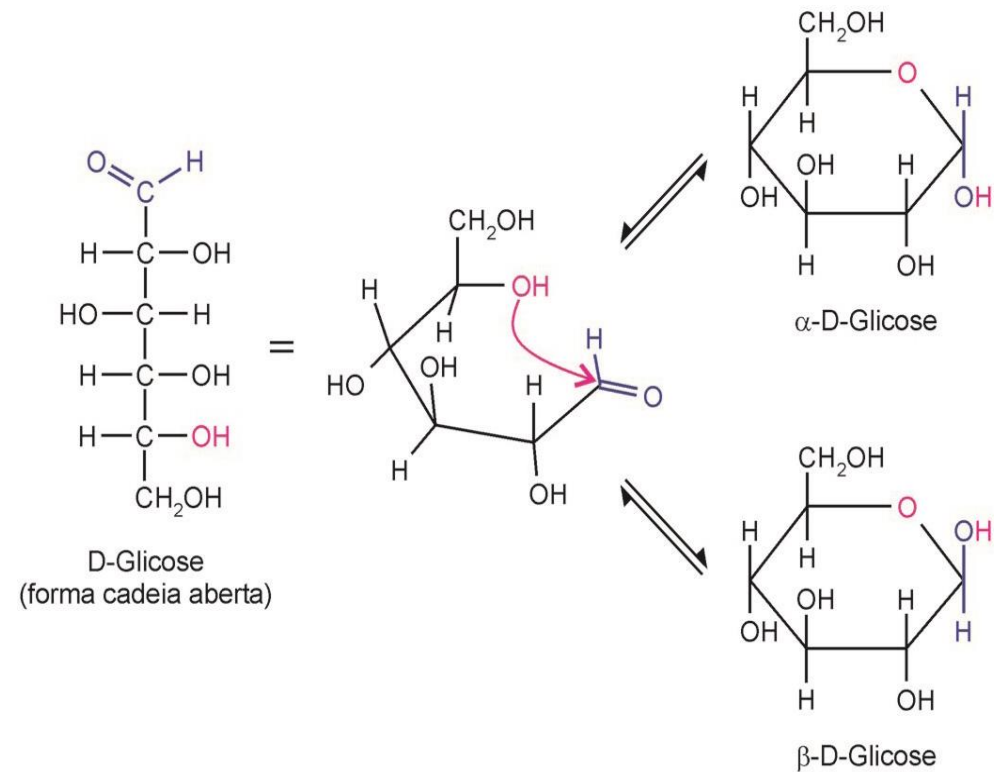
São poliidroxiáldeídos ou poliidroxicetonas ou substâncias que, hidrolisadas, liberam esses compostos.



## Estrutura de Carboidratos

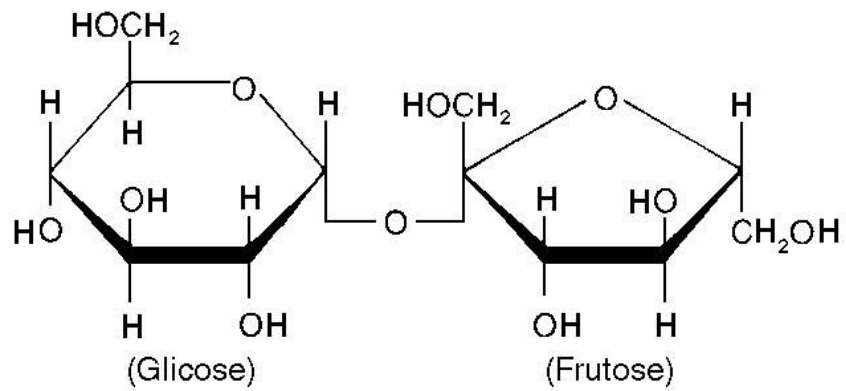
Fig. 6.1 Estrutura de alguns monossacarídeos.

# Glicose

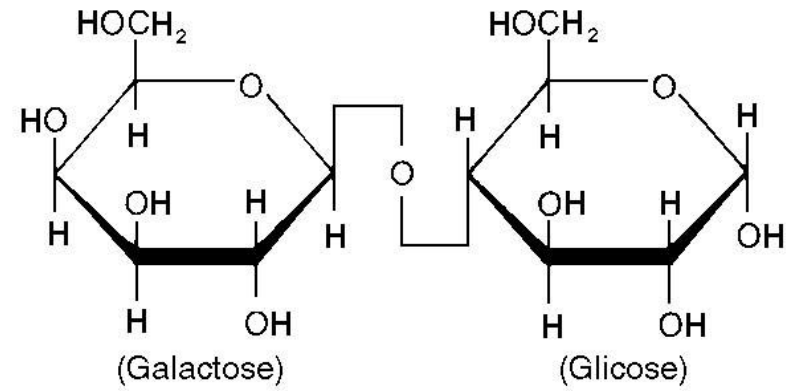


**Fig. 6.2** Conversão da forma em cadeia aberta da molécula de glicose na forma cíclica — o grupo hidroxila do carbono 5 reage com o grupo aldeído, formando um hemiacetal cíclico, que pode existir como dois isômeros,  $\alpha$  e  $\beta$ .

# Sacarose e Lactose



Sacarose



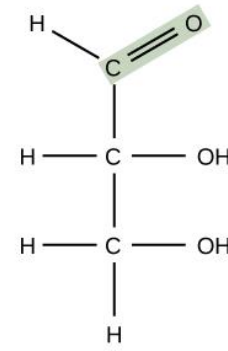
Lactose

**Fig. 6.3** Estrutura dos dois dissacarídeos mais comuns.

# Monossacarídios

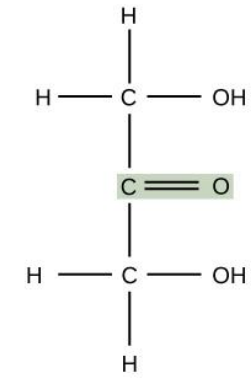
## MONOSACCHARIDES

Glyceraldehyde



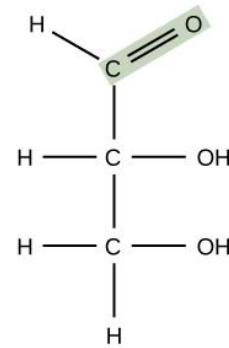
Aldose

Dihydroxyacetone



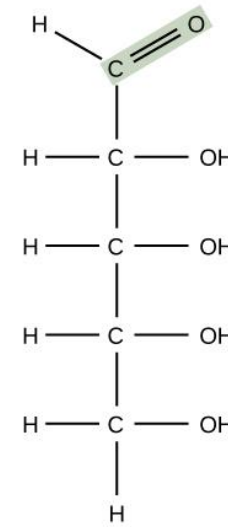
Ketose

Glyceraldehyde



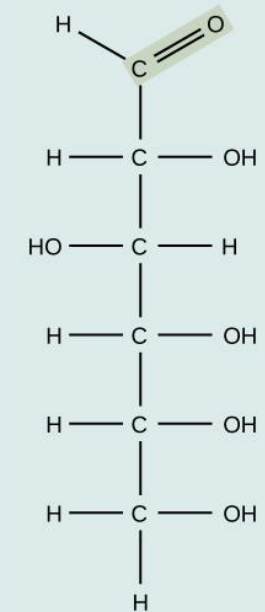
Triose

Ribose



Pentose

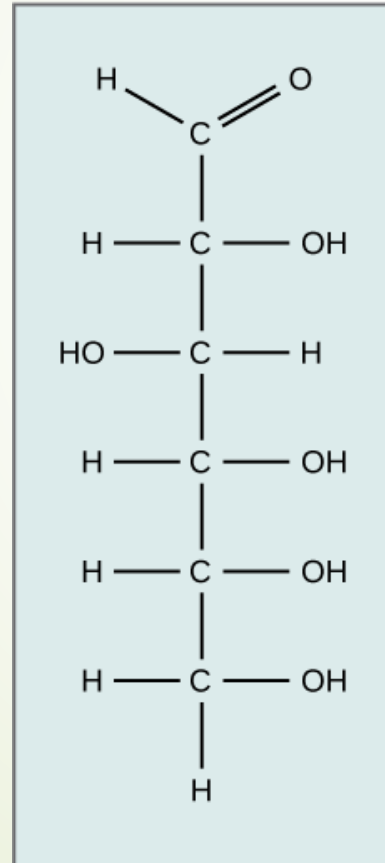
Glucose



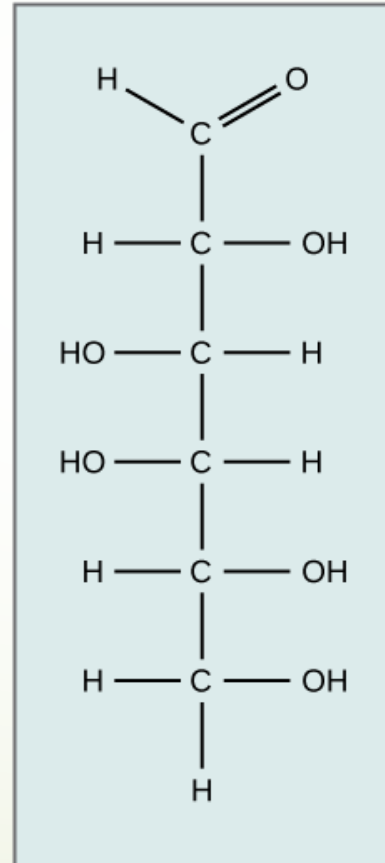
Hexose

# Glicose, Galactose e Frutose

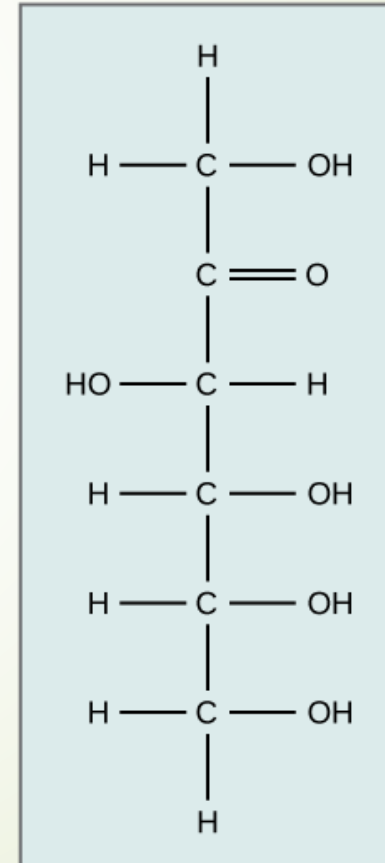
**Glucose**



**Galactose**

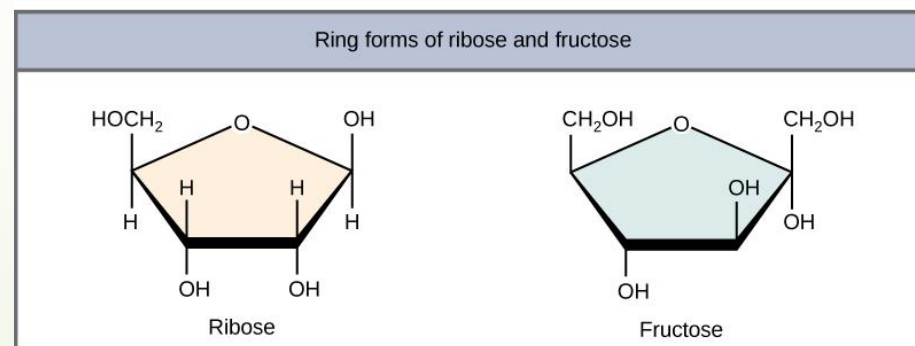
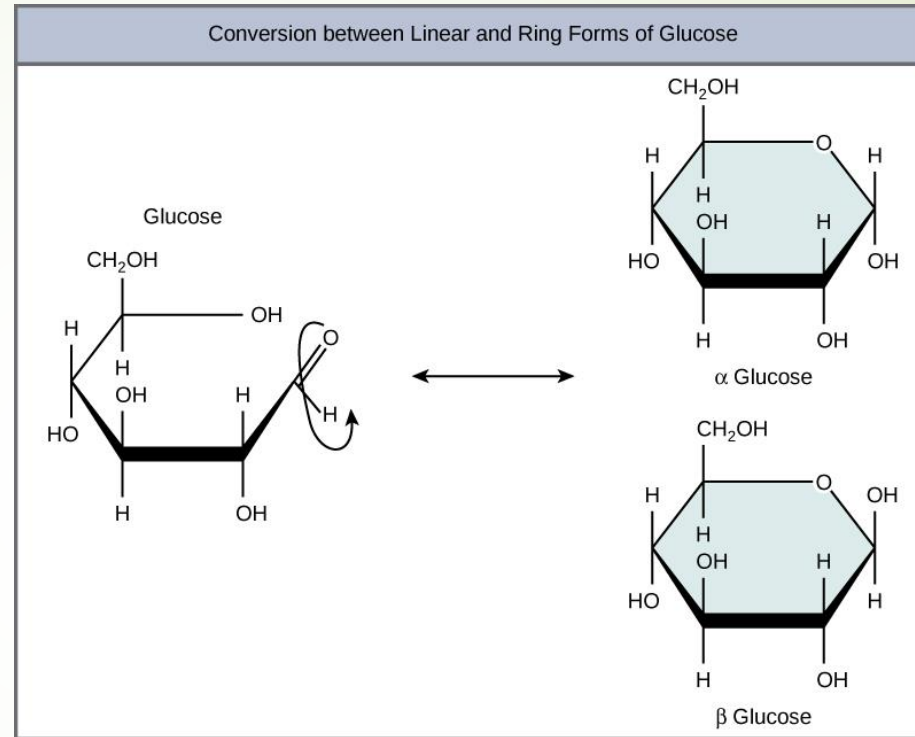


**Fructose**

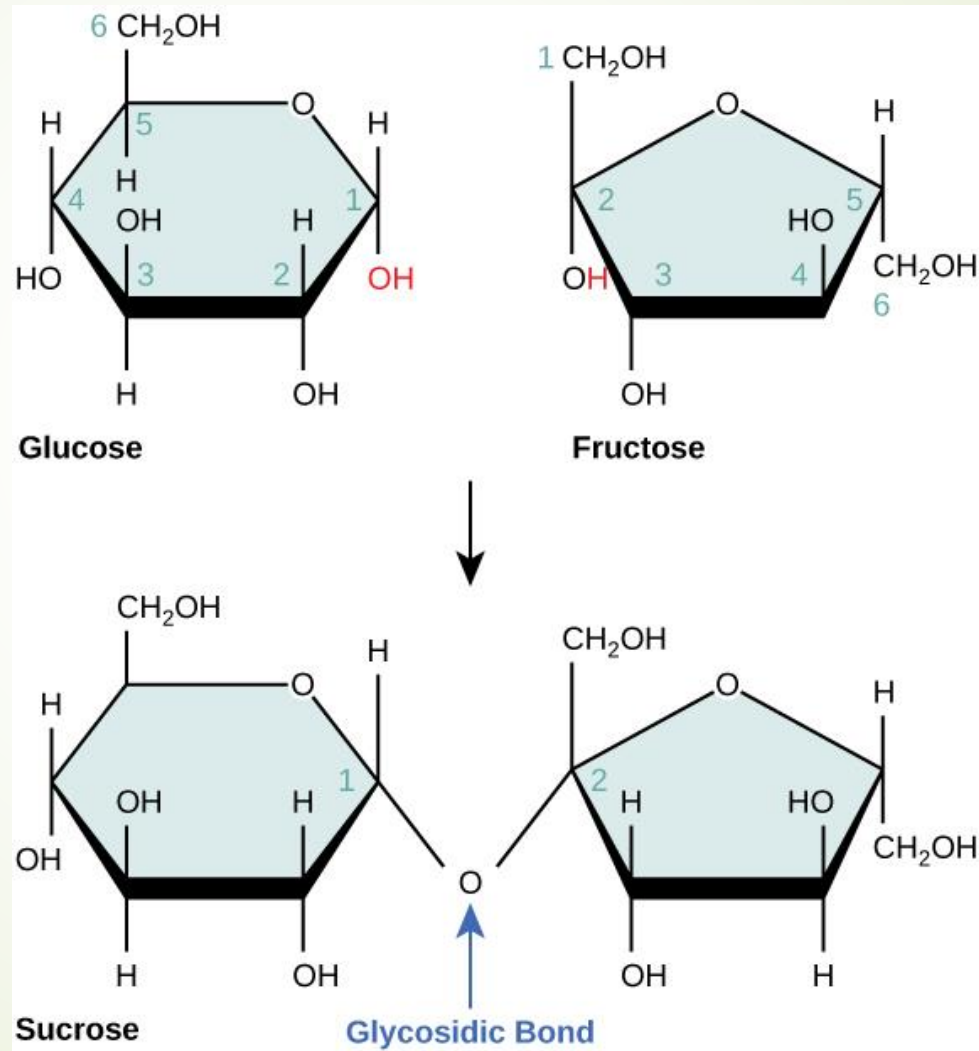




# Conversão entre as formas linear e cíclica da glicose



# Estrutura da Sacarose: glicose + frutose

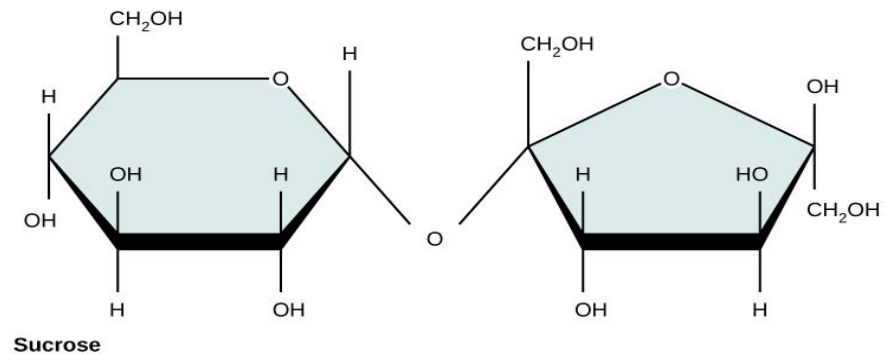
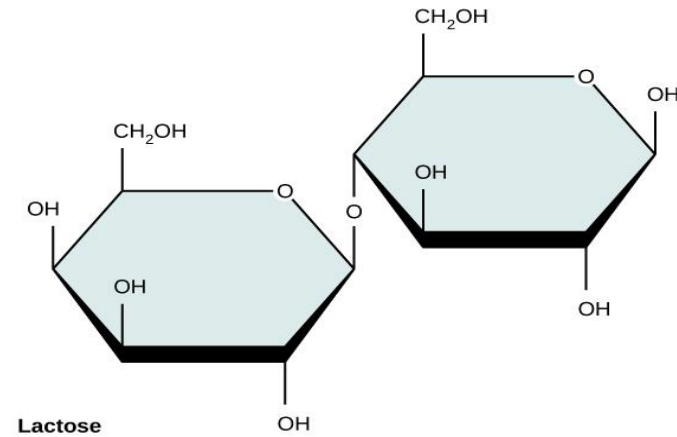
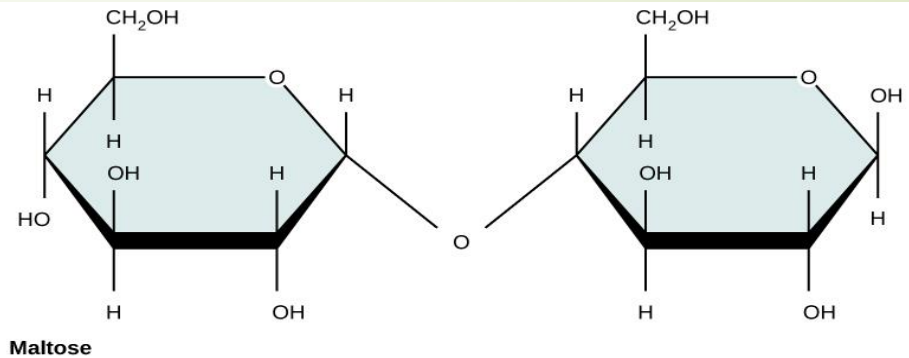


## Estrutura de dissacarídios:

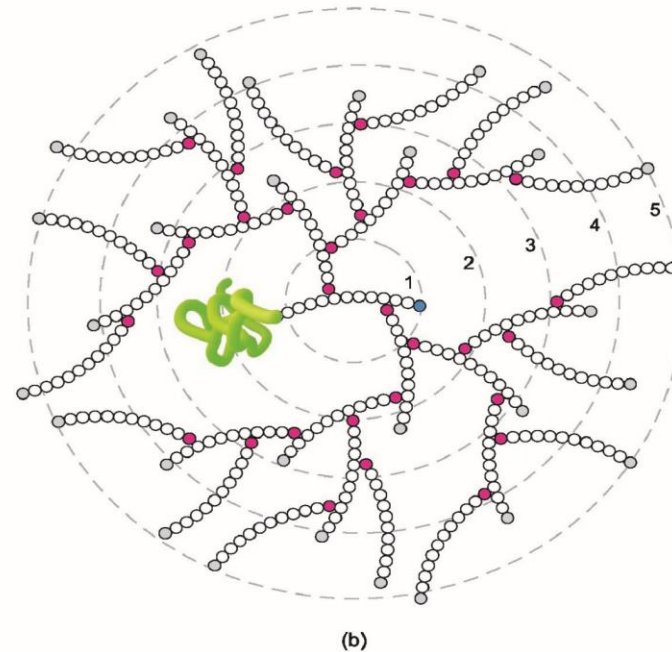
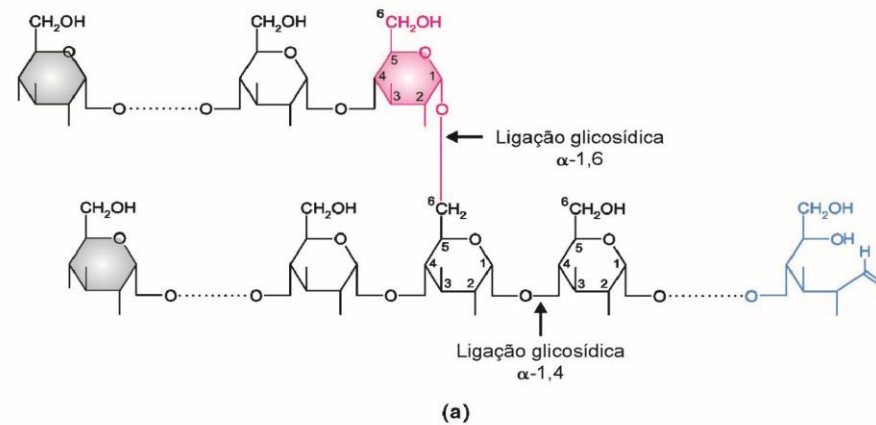
**Maltose: 2 glicoses**

**Lactose: galactose + glicose**

**Sacarose: glicose + frutose**



# Glicogênio



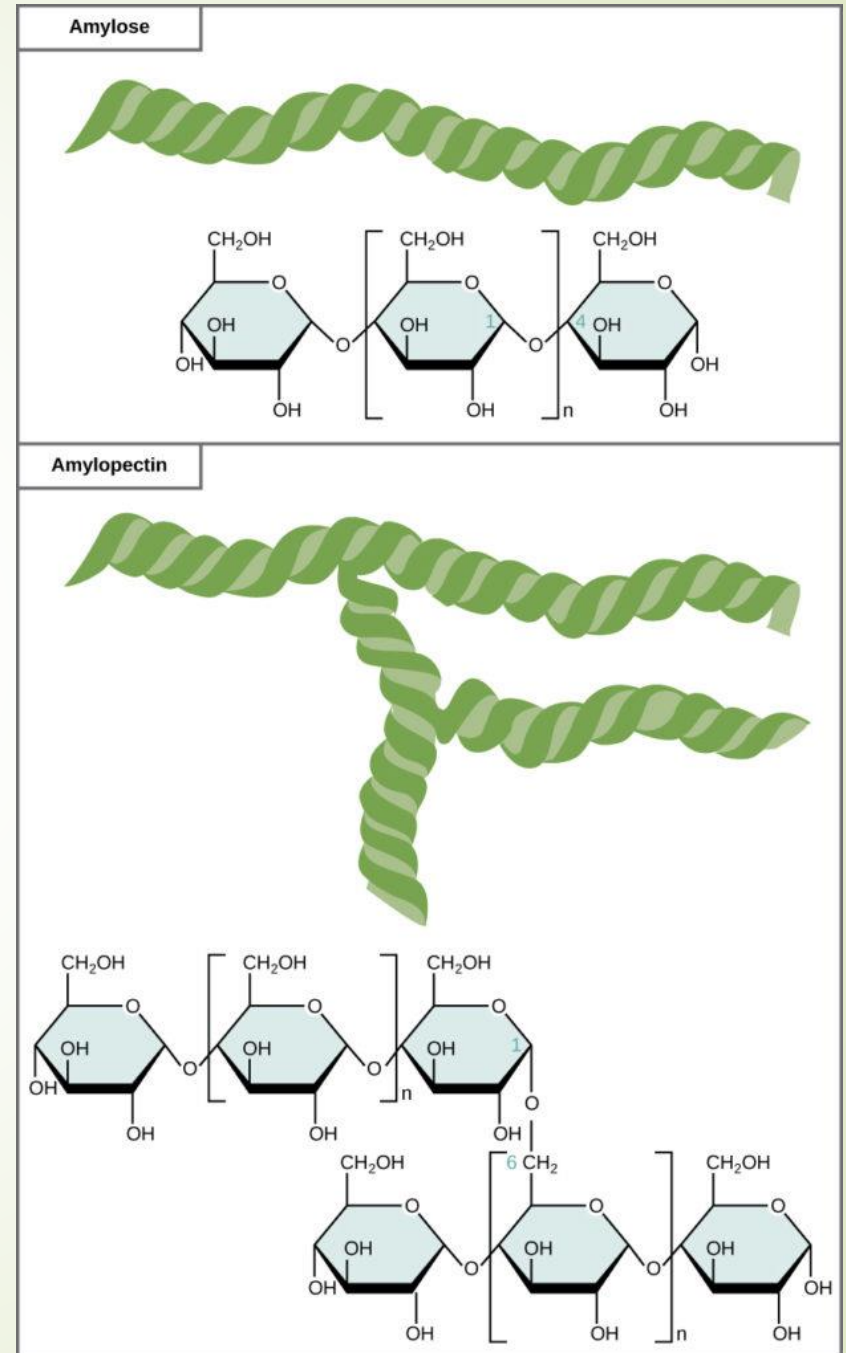
**Fig. 6.4** a) Representação de parte de uma cadeia de amilopectina ou de glicogênio. As unidades de glicose nas porções lineares são conectadas por ligações  $\alpha$ -1,4; a ramificação é resultante de uma ligação  $\alpha$ -1,6. Os resíduos de glicose das extremidades não-redutoras estão assinalados em cinza; aquele que inicia a ramificação, em vermelho, e o resíduo da única extremidade redutora, em azul. Este último resíduo está representado na forma aberta, para destacar o grupo aldeído do carbono 1. b) Modelo bidimensional da estrutura do glicogênio. A molécula é uma esfera, resultante do arranjo de cadeias ramificadas, basicamente, e lineares em 12 camadas concêntricas, das quais apenas 5 são mostradas; notar que somente as cadeias mais externas são lineares. As extremidades são diferenciadas pelas mesmas cores da Fig. 6.4 a. A estrutura de cor verde simboliza a *glicogenina*, a proteína que inicia a síntese do glicogênio (ver Capítulo 13).

**Amido é composto por Amilose e Amilopectina**

**Amilose: polímero de glicose com ligações alfa-1,4**

**e**

**Amilopectina-formada por unidades de glicose unidas em  $\alpha$ -1,4 e  $\alpha$ -1,6, formando uma estrutura ramificada.**

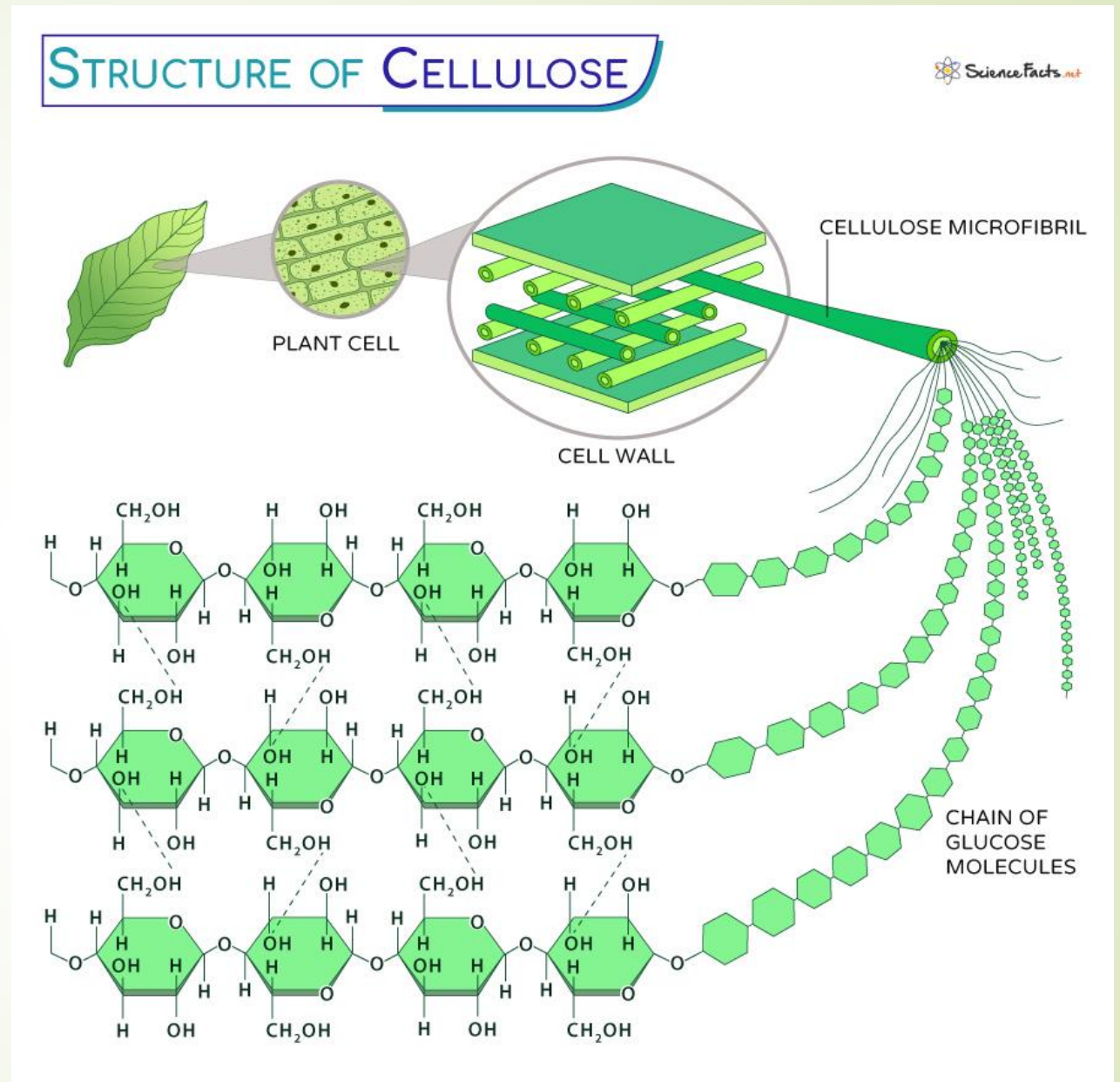


## Estrutura da celulose:

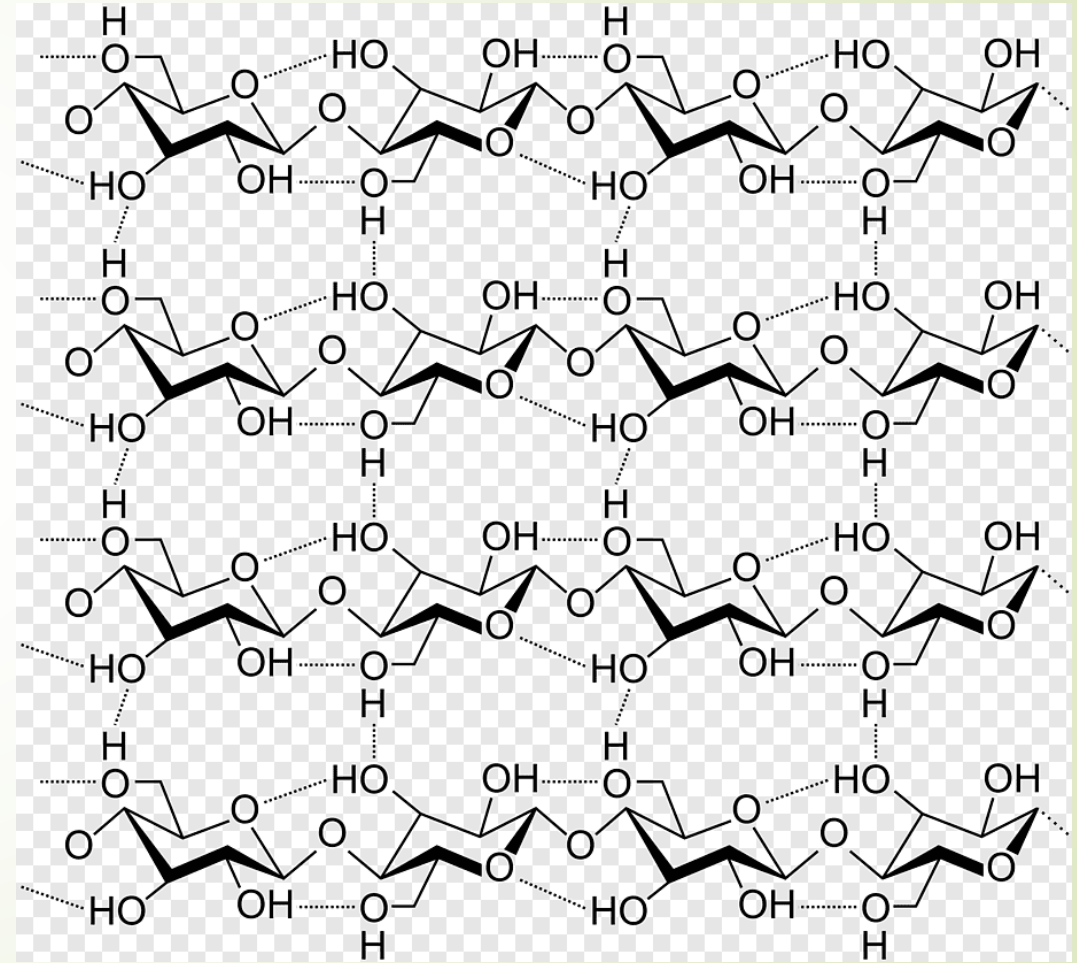
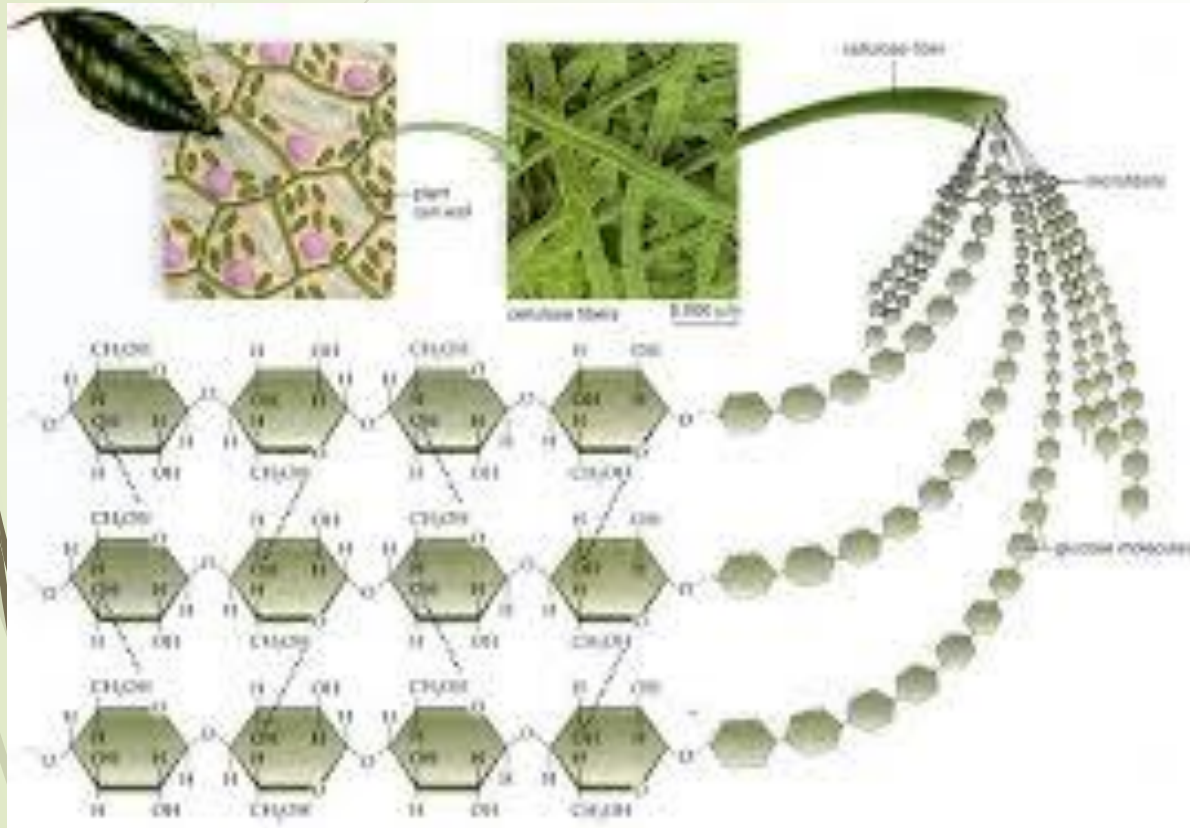
A celulose se forma pela união de moléculas de glicose através de ligações  $\beta$ -1,4-glicosídicas. Sua hidrólise completa produz glicose.

A celulose é um polímero de cadeia longa de peso molecular variável, com fórmula empírica  $(C_6H_{10}O_5)_n$ , com um valor mínimo de  $n=200$  (tipicamente 300 a 700, podendo passar de 7000).

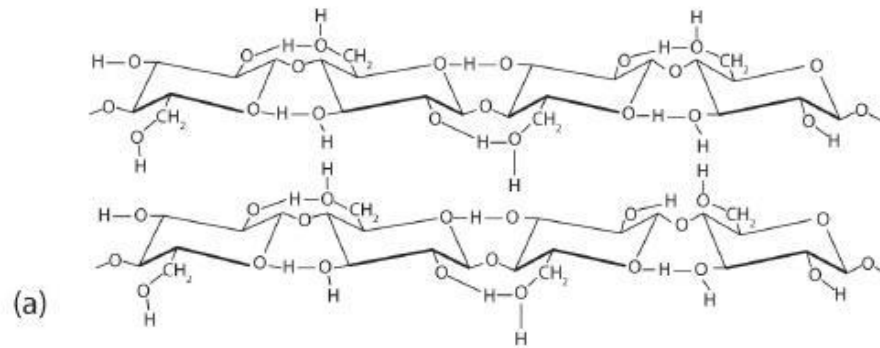
Pontes de Hidrogênio inter-cadeias.



# Celulose



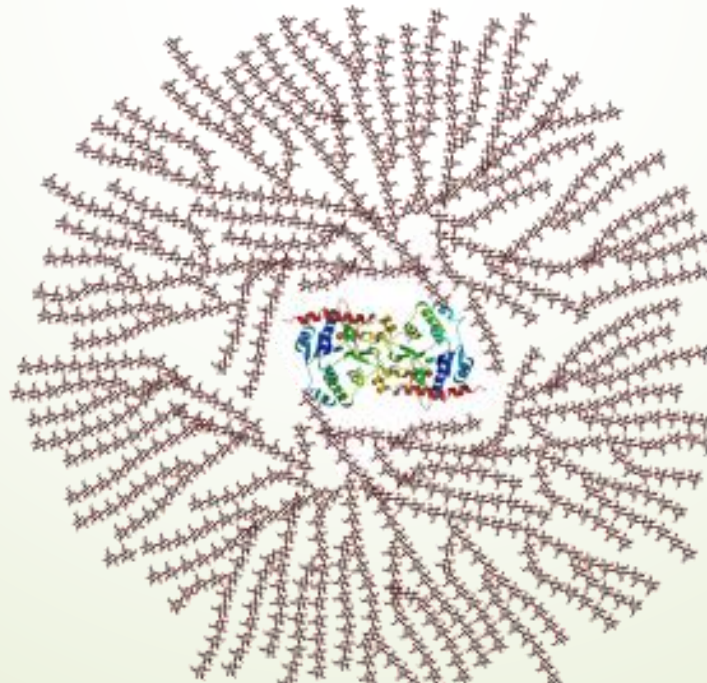
**Figure 5.1.3: Cellulose.** (a) There is extensive hydrogen bonding in the structure of cellulose. (b) In this electron micrograph of the cell wall of an alga, the wall consists of successive layers of cellulose fibers in parallel arrangement.



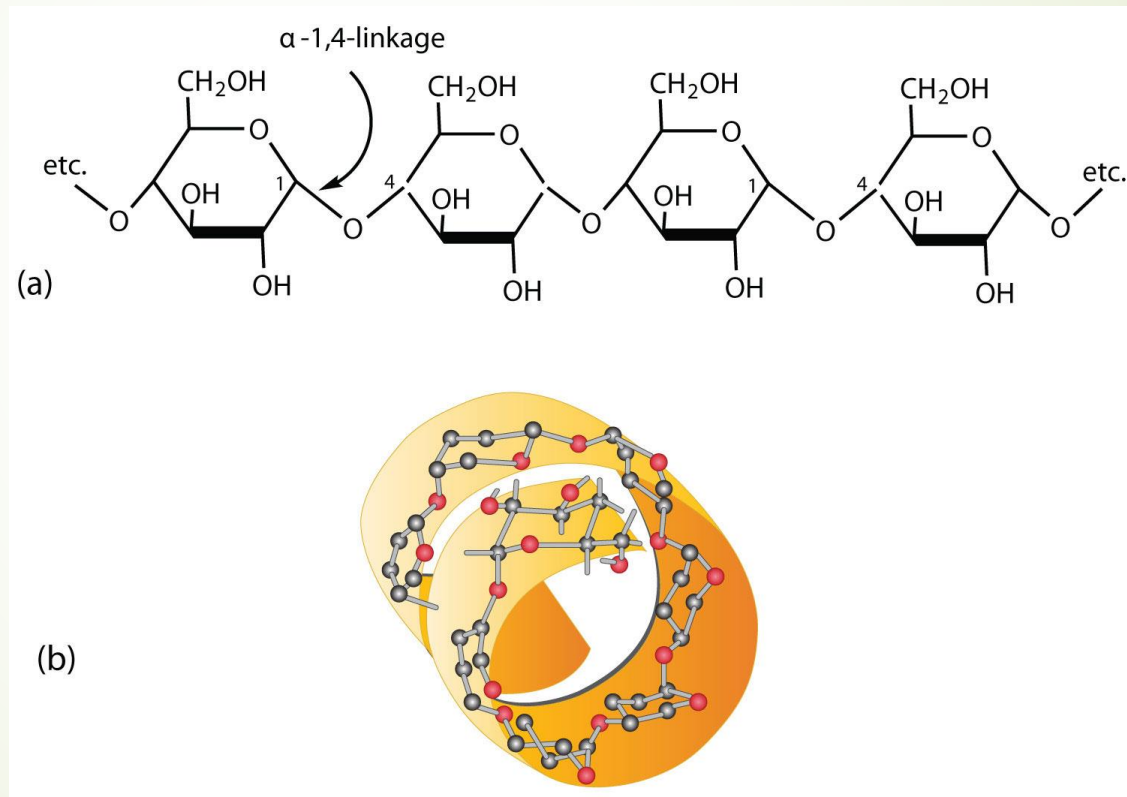


Schematic two-dimensional cross-sectional view of glycogen: A core protein of [glycogenin](#) is surrounded by branches of [glucose](#) units. The entire globular granule may contain around 30,000 glucose units.<sup>[1]</sup>

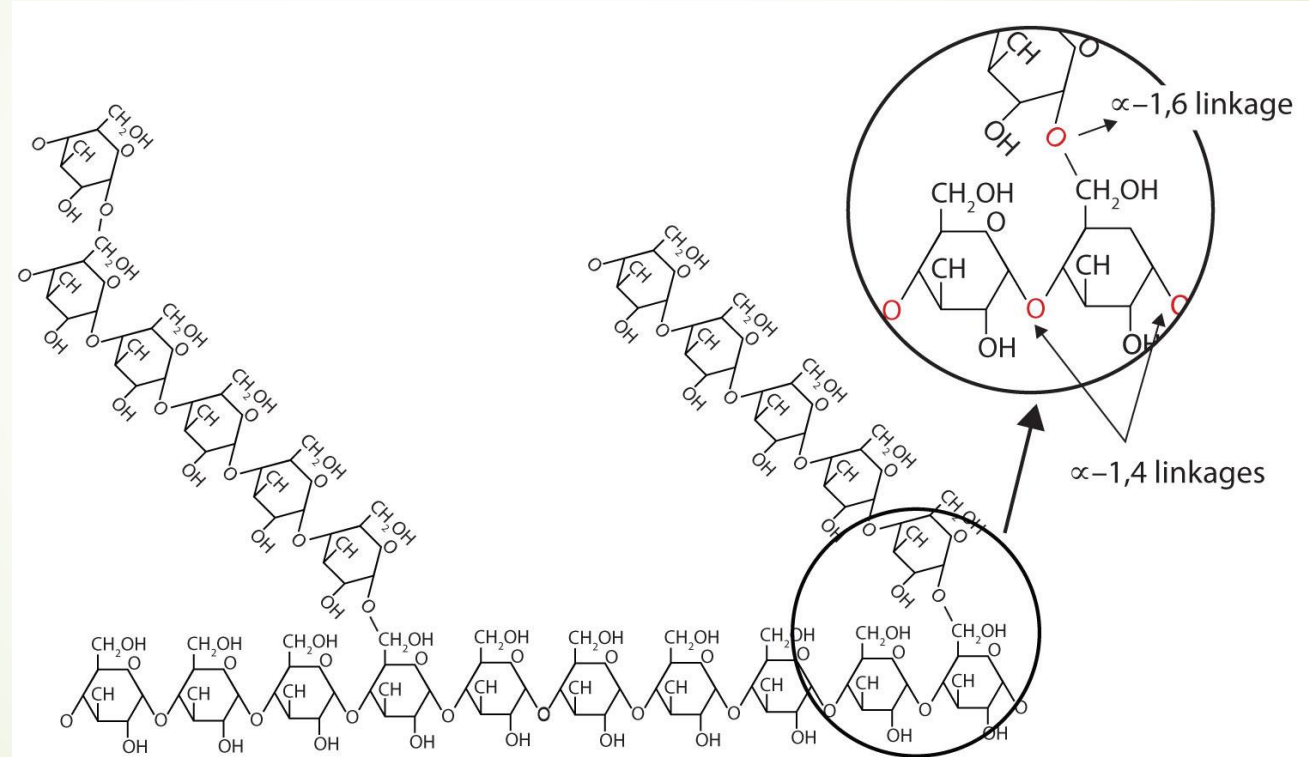
Each glycogen is essentially a ball of glucose trees, with around 12 layers, centered on a [glycogenin](#) protein, with three kinds of glucose chains: A, B, and C. There is only one C-chain, attached to the glycogenin. This C-chain is formed by the self-glucosylation of the glycogenin, forming a short primer chain. From the C-chain grows out B-chains, and from B-chains branch out B- and A-chains. The B-chains have on average 2 branch points, while the A-chains are terminal, thus unbranched. On average, each chain has length 12, tightly constrained to be between 11 and 15. All A-chains reach the spherical surface of the glycogen.<sup>[23][24]</sup>



**Figure 5.1.1: Amylose.** (a) Amylose is a linear chain of  $\alpha$ -D-glucose units joined together by  $\alpha$ -1,4-glycosidic bonds. (b) Because of hydrogen bonding, amylose acquires a spiral structure that contains six glucose units per turn.



Amylopectin is a branched-chain polysaccharide composed of glucose units linked primarily by  $\alpha$ -1,4-glycosidic bonds but with occasional  $\alpha$ -1,6-glycosidic bonds, which are responsible for the branching. A molecule of amylopectin may contain many thousands of glucose units with branch points occurring about every 25–30 units (Figure 5.1.2). The helical structure of amylopectin is disrupted by the branching of the chain, so instead of the deep blue-violet color amylose gives with iodine, amylopectin produces a less intense reddish brown.



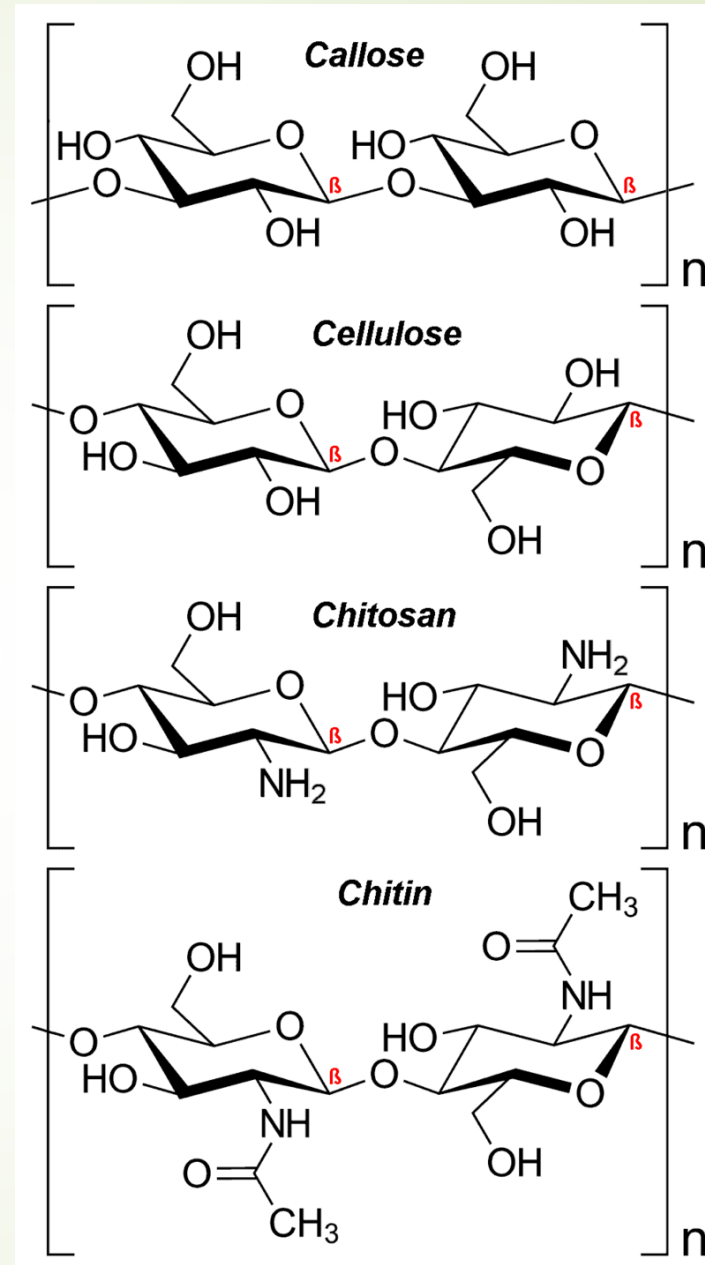
**Figure 5.1.2:** Representation of the Branching in Amylopectin and Glycogen. Both amylopectin and glycogen contain branch points that are linked through  $\alpha$ -1,6-linkages. These branch points occur more often in glycogen.

# Amido, (Starch)

## ➤ Starch

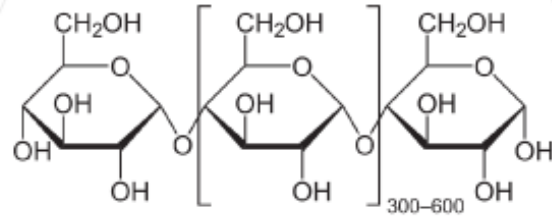
- Starch is the most important source of carbohydrates in the human diet and accounts for more than 50% of our carbohydrate intake. It occurs in plants in the form of granules, and these are particularly abundant in seeds (especially the cereal grains) and tubers, where they serve as a storage form of carbohydrates. The breakdown of starch to glucose nourishes the plant during periods of reduced photosynthetic activity. We often think of potatoes as a “starchy” food, yet other plants contain a much greater percentage of starch (potatoes 15%, wheat 55%, corn 65%, and rice 75%). Commercial starch is a white powder.
- Starch is a mixture of two polymers: amylose and amylopectin. Natural starches consist of about 10%–30% amylose and 70%–90% amylopectin. Amylose is a linear polysaccharide composed entirely of D-glucose units joined by the  $\alpha$ -1,4-glycosidic linkages we saw in maltose (part (a) of Figure 5.1.1). Experimental evidence indicates that amylose is not a straight chain of glucose units but instead is coiled like a spring, with six glucose monomers per turn (part (b) of Figure 5.1.1). When coiled in this fashion, amylose has just enough room in its core to accommodate an iodine molecule. The characteristic blue-violet color that appears when starch is treated with iodine is due to the formation of the amylose-iodine complex. This color test is sensitive enough to detect even minute amounts of starch in solution.

# Polímeros de Glicose



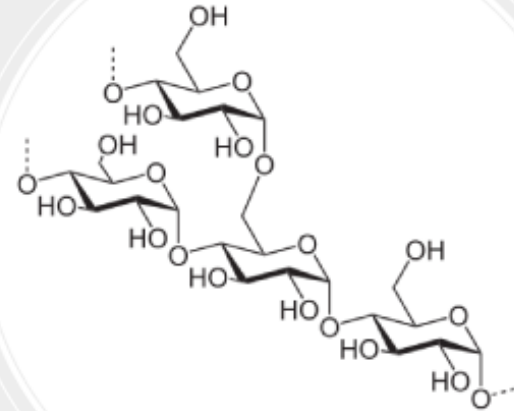
# Amilose e amilopectina

## AMYLOSE VS. AMYLOPECTIN



### AMYLOSE

- Amylose is a straight chain polymer of D-glucose units



### AMYLOPECTIN

- Amylopectin is a branched chain polymer of D-glucose units

## ► Cellulose

# Celulose, Quitina e Pectina

The structural components of plants are formed primarily from cellulose. Wood is largely cellulose and lignin, while paper and cotton are nearly pure cellulose. Cellulose is a polymer made with repeated glucose units bonded together by *beta*-linkages. Humans and many animals lack an enzyme to break the *beta*-linkages, so they do not digest cellulose. Certain animals, such as termites (cupins) can digest cellulose, because bacteria possessing the enzyme are present in their gut. Cellulose is insoluble in water. It does not change color when mixed with iodine. On hydrolysis, it yields glucose. It is the most abundant carbohydrate in nature.


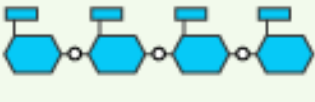
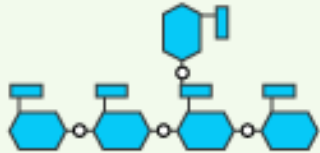
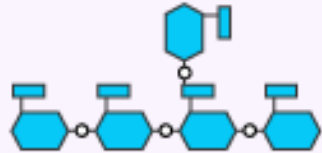
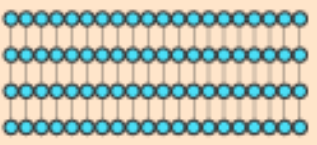

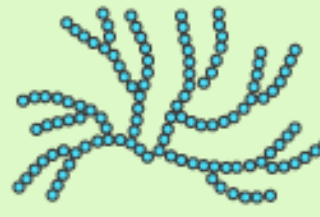
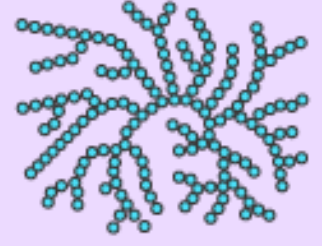
## ► Chitin [exoesqueleto de crustáceos]

► Chitin is one of many naturally occurring polymers. It forms a structural component of many animals, such as exoskeletons. Over time it is bio-degradable in the natural environment. Its breakdown may be catalyzed by enzymes called chitinases, secreted by microorganisms such as bacteria and fungi and produced by some plants. Some of these microorganisms have receptors to simple sugars from the decomposition of chitin. If chitin is detected, they then produce enzymes to digest it by cleaving the glycosidic bonds in order to convert it to simple sugars and ammonia.

► Chemically, chitin is closely related to chitosan (a more water-soluble derivative of chitin). It is also closely related to cellulose in that it is a long unbranched chain of glucose derivatives. Both materials contribute structure and strength, protecting the organism.

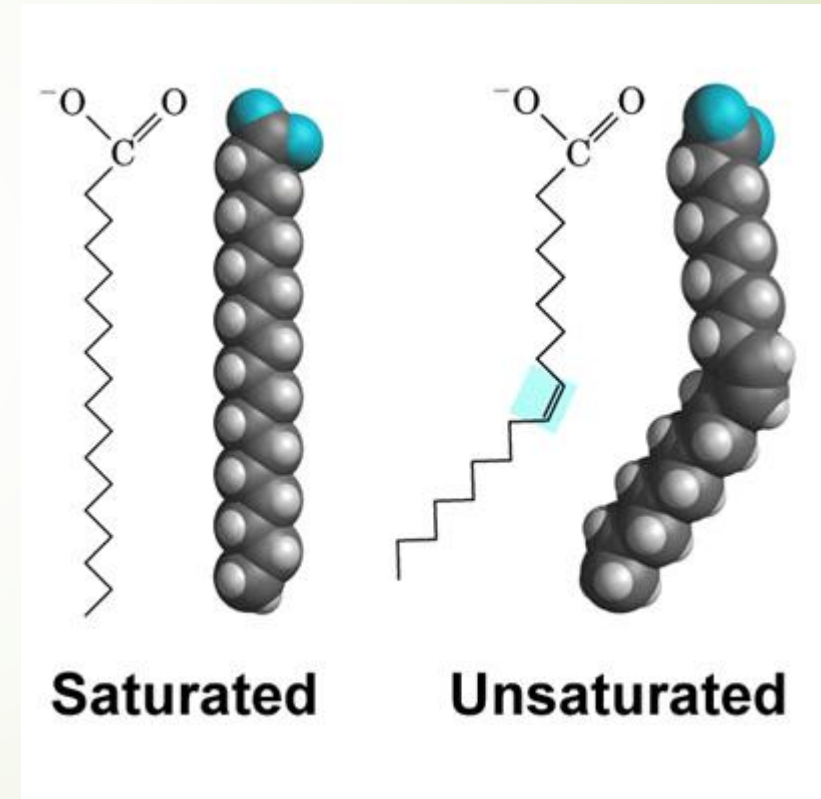
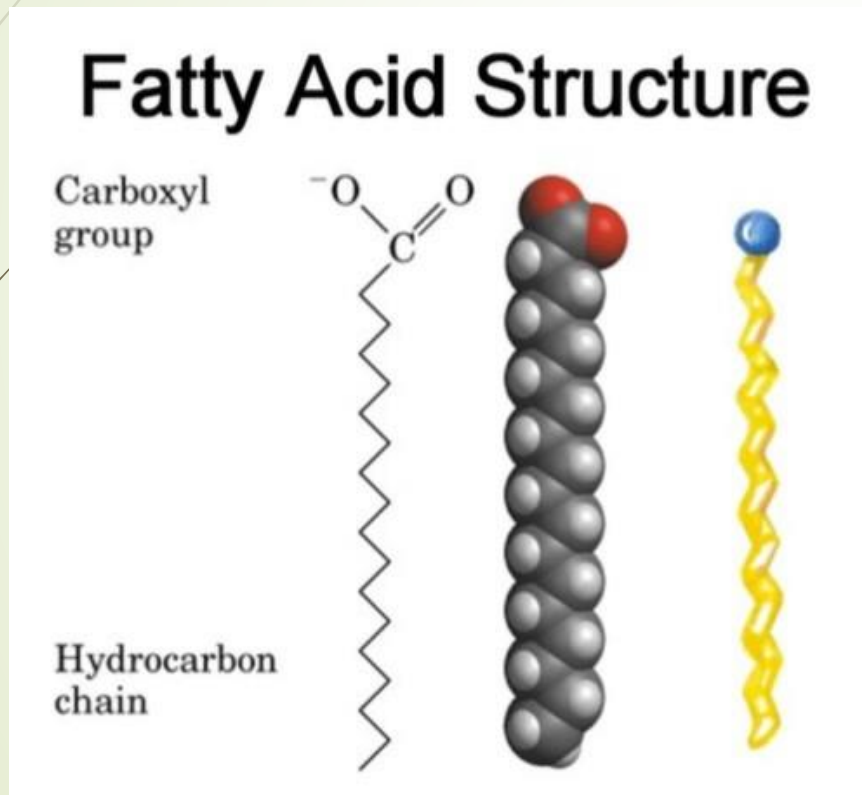
## ► Pectins

► Pectins are a family of complex polysaccharides that contain 1,4-linked  $\alpha$ -D-galactosyl uronic acid residues. They are present in most primary cell walls and in the nonwoody parts of terrestrial plants

	Cellulose	Starch		Glycogen
		Amylose	Amylopectin	
<b>Source</b>	Plant	Plant	Plant	Animal
<b>Subunit</b>	$\beta$ -glucose	$\alpha$ -glucose	$\alpha$ -glucose	$\alpha$ -glucose
<b>Bonds</b>	1-4	1-4	1-4 and 1-6	1-4 and 1-6
<b>Branches</b>	No	No	Yes (~per 20 subunits)	Yes (~per 10 subunits)
<b>Diagram</b>				
<b>Shape</b>				

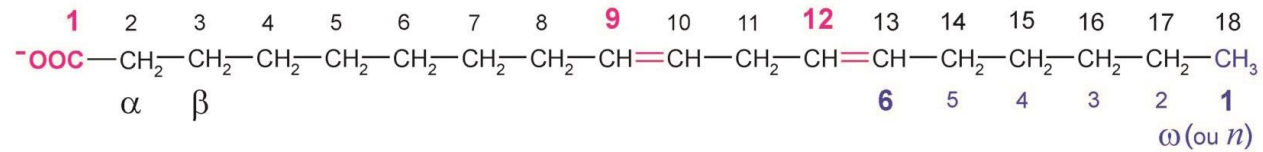


# Estrutura de Ácidos Graxos

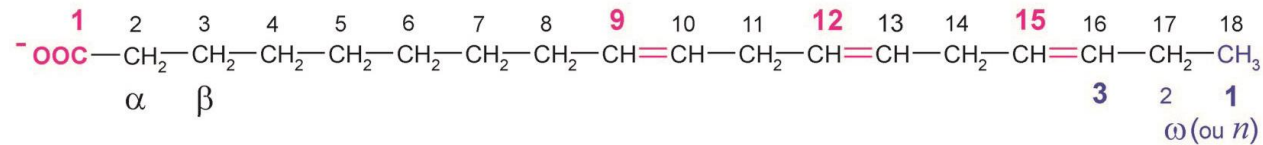


# Estrutura de ácidos graxos insaturados

Ácido linoleico – 18:2  $\Delta^{9,12}$  (ou 18:2  $\Delta^{9,12}$ ) ou 18:2  $\omega$ -6 ou 18:2  $n$ -6



Ácido  $\alpha$ -linolênico – 18:3  $\Delta^{9,12,15}$  (ou 18:3  $\Delta^{9,12,15}$ ) ou 18:3  $\omega$ -3 ou 18:3  $n$ -3

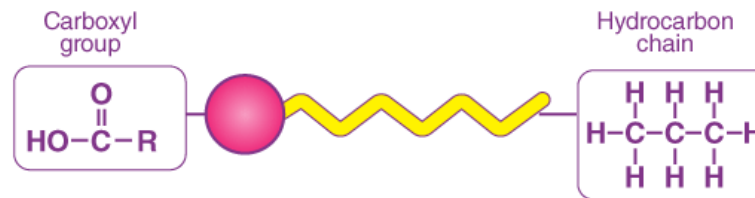


**Fig. 6.7** Sistemas de representação dos ácidos graxos insaturados, ilustrados por esquemas dos ácidos linoleico e  $\alpha$ -linolênico — estão indicados os números e as letras atribuídos aos carbonos, a posição das duplas ligações e as diferentes abreviações dos ácidos graxos, de acordo com os sistemas vigentes.

# Acidos Graxos Saturados e Insaturados

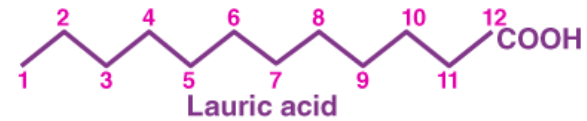
## Fatty Acid

Fatty acid made up from carboxylic group and hydrocarbon chain



### Saturated fatty acid

No double bond in structure

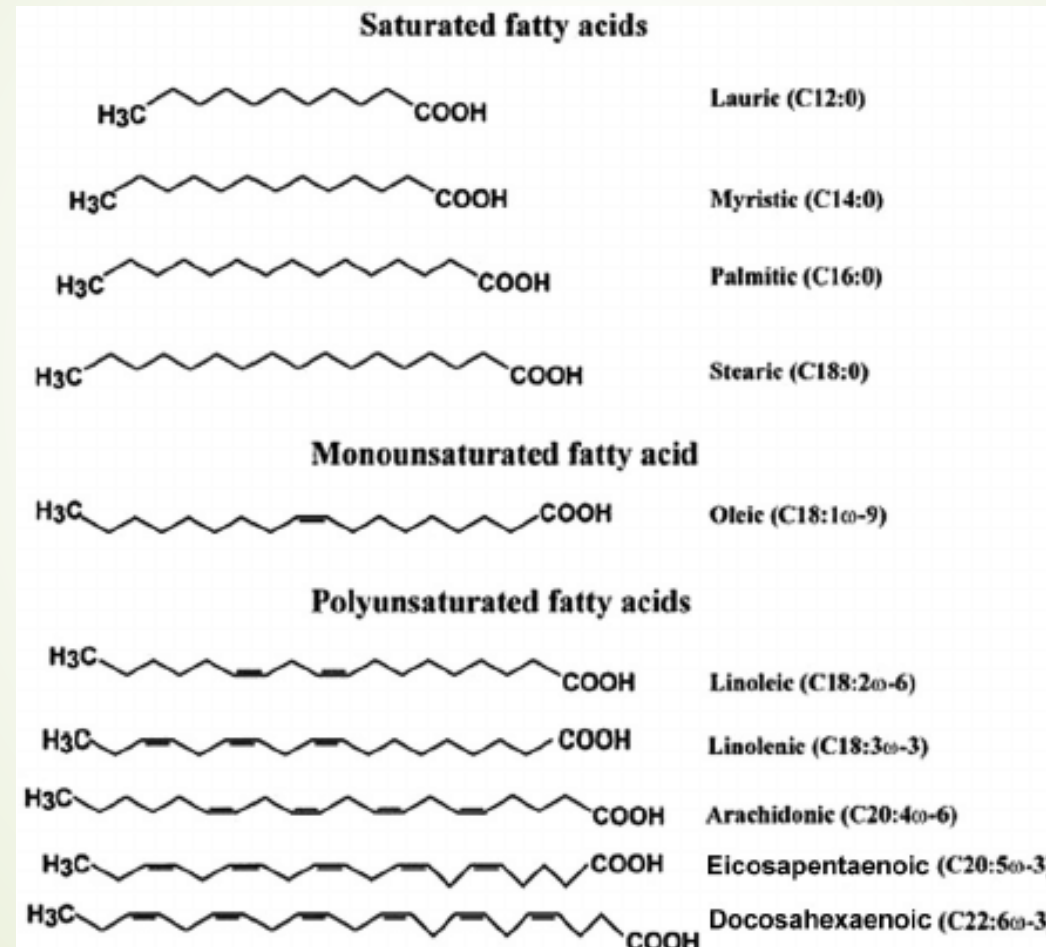


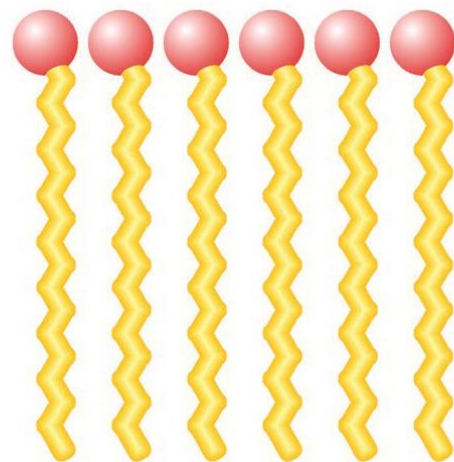
### Unsaturated fatty acid

> 1 of double bond

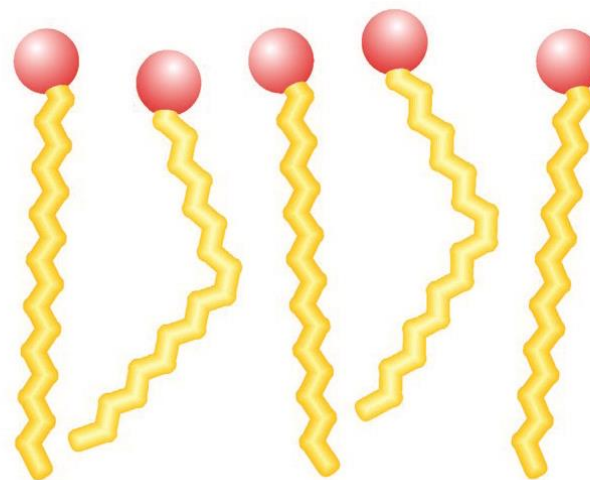


# Estrutura de Ácidos Graxos





(a)



(b)

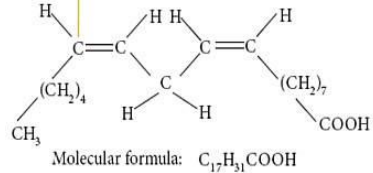
**Fig. 6.8** Interação entre moléculas de ácidos graxos saturados (a) e entre saturados e insaturados (b). A presença de duplas ligações reduz o grau de interação entre moléculas vizinhas.

# Acidos Graxos Essenciais

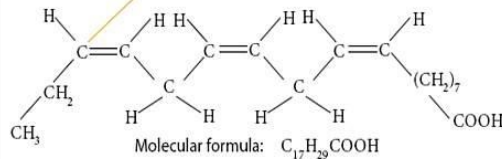
## Essential fatty acids

- Essential fatty acids are not produced in the human body and therefore must be obtained in the diet.

Linoleic acid: C #6 from methyl group, thus omega-6 fatty acid



Linolenic acid: C #3 from methyl group, thus omega-3 fatty acid



Structures of Linoleic and Linolenic acids

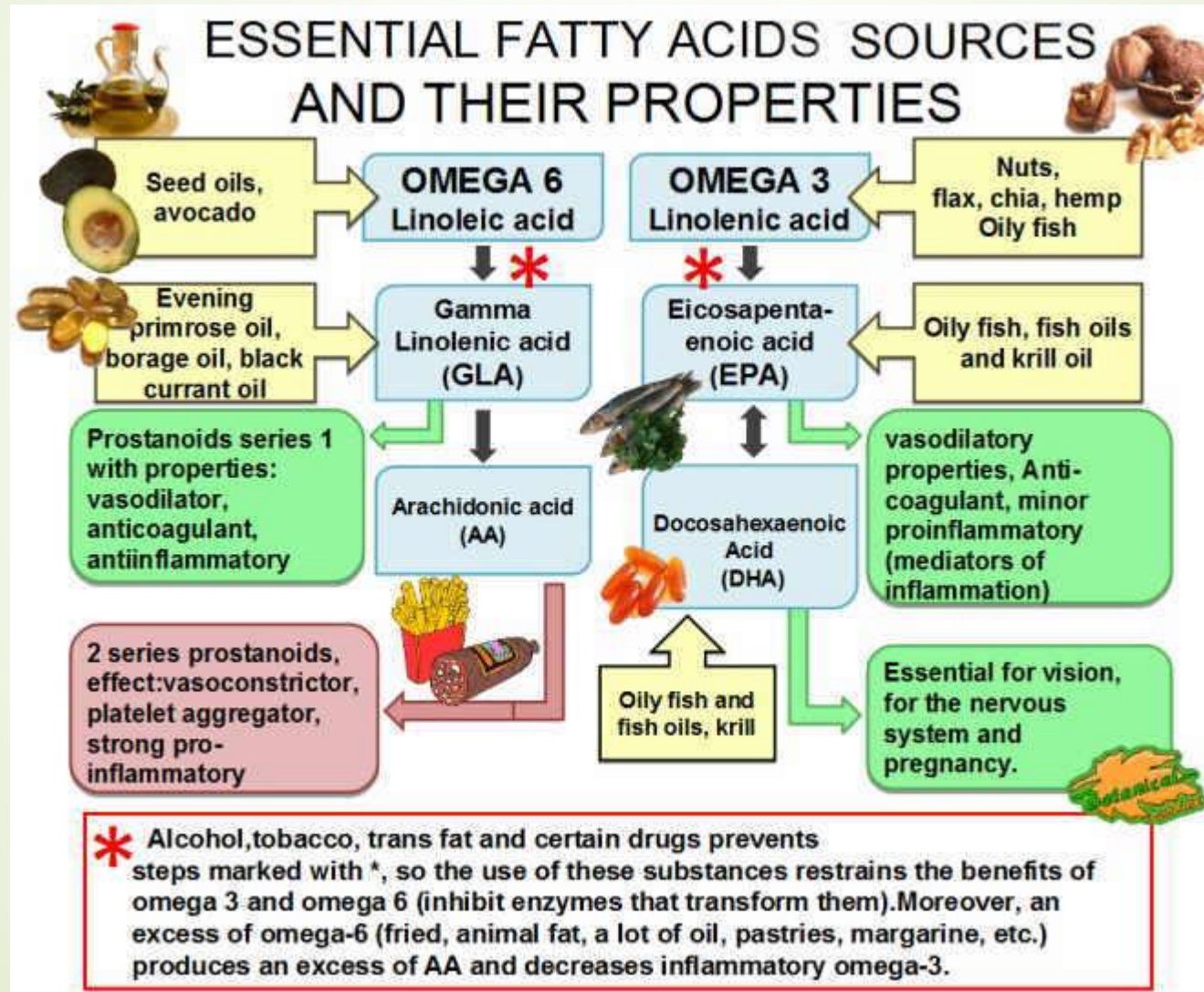
- The two essential fatty acids are linoleic acid and linolenic acid.
- Linoleic is known as omega-6 and linolenic is known as omega-3.
- The numbers refer to the position of the first double bond in the molecule.

TABLE 1.

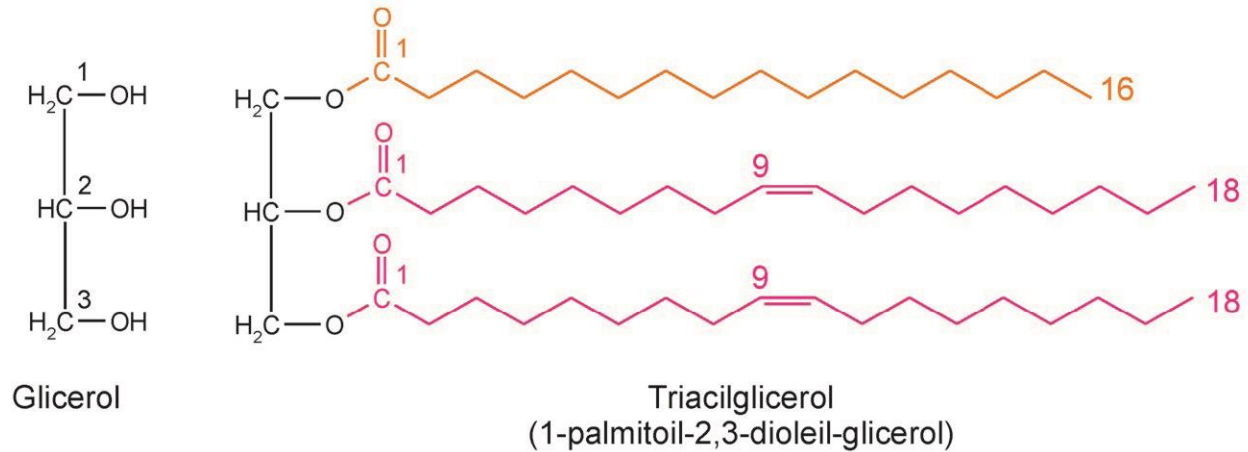
Essential Fatty Acids with Numeric Formula

COMMON NAME (Abbreviation)	NUMERIC FORMULA (chain length:double bonds)	LOCATION OF FIRST DOUBLE BOND (relative to omega end of chain)
Linoleic acid (LA)	18:2	Omega-6
Alpha-linolenic acid (ALA)	18:3	Omega-3
Arachidonic acid (AA)	20:4	Omega-6
Eicosapentaenoic acid (EPA)	20:5	Omega-3
Docosahexaenoic acid (DHA)	22:6	Omega-3

# Ácidos graxos essenciais- Funções



# Triacilglicerol



**Fig. 6.9** Triacilgliceróis são moléculas essencialmente apolares, formadas pela esterificação de três ácidos graxos ao glicerol. Para maior clareza, foi omitida a forma angular das cadeias insaturadas.



# Lipídios que contêm ácidos graxos

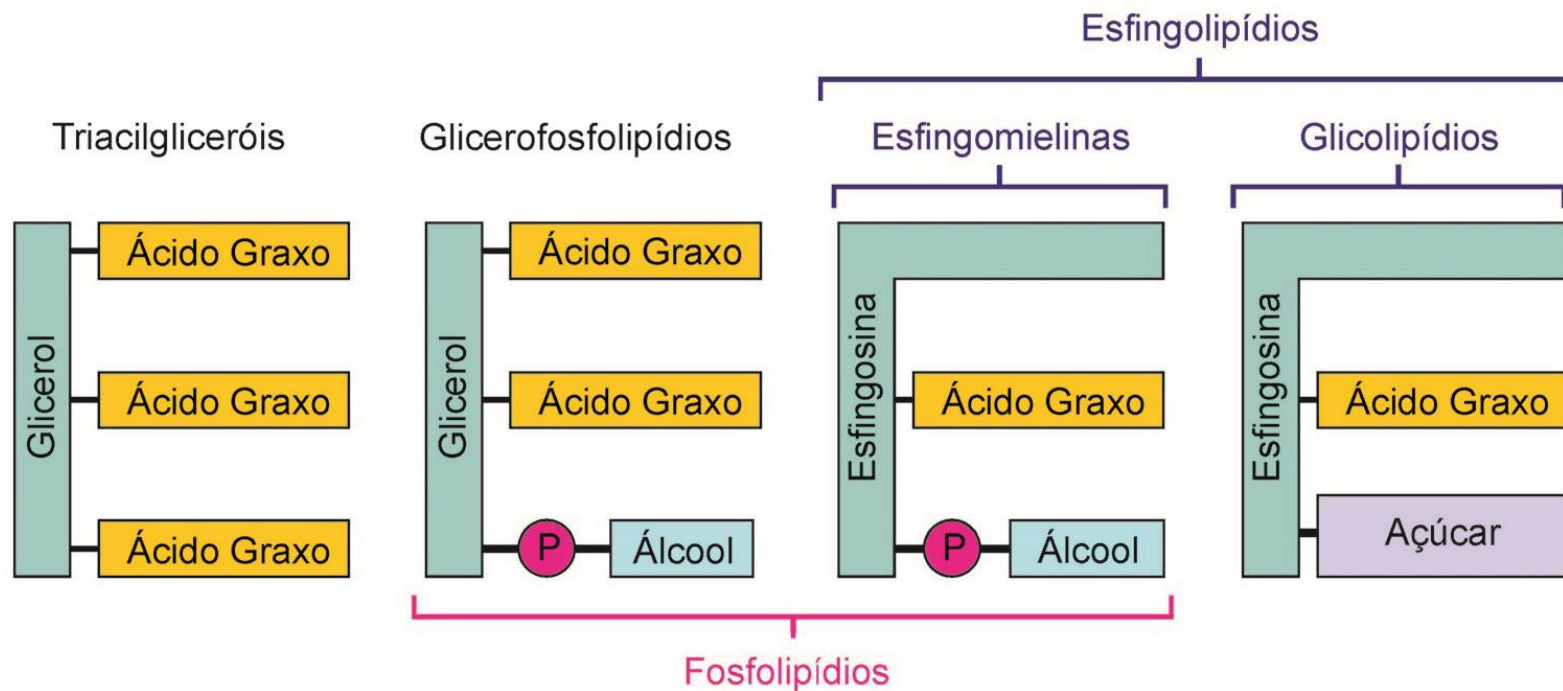
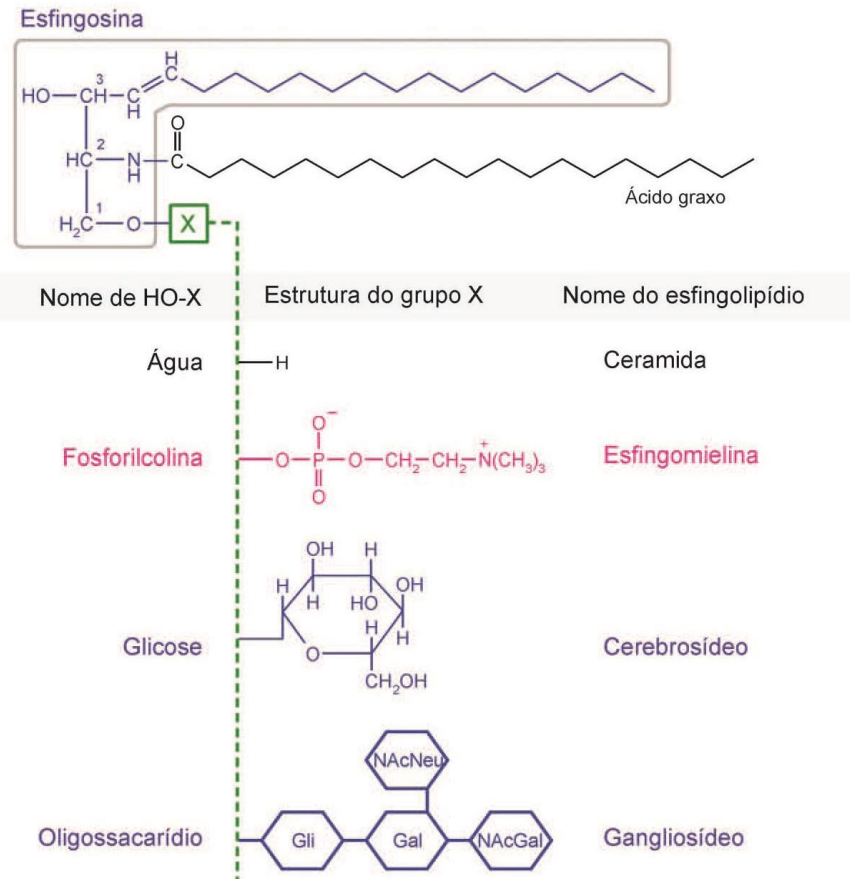


Fig. 6.6 Esquema geral dos principais lipídios que contêm ácidos graxos. P = grupo fosfato.

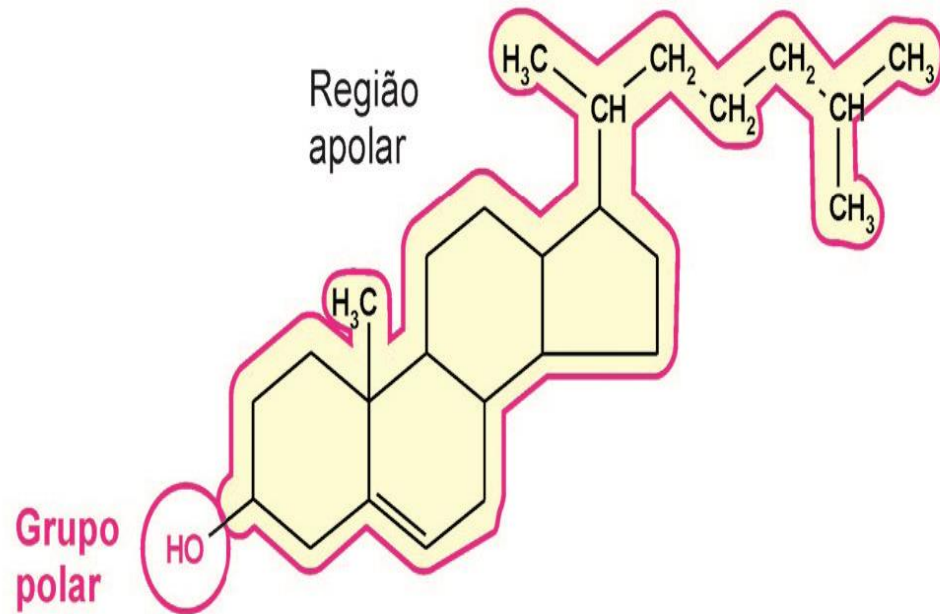


# Esfingolipídios



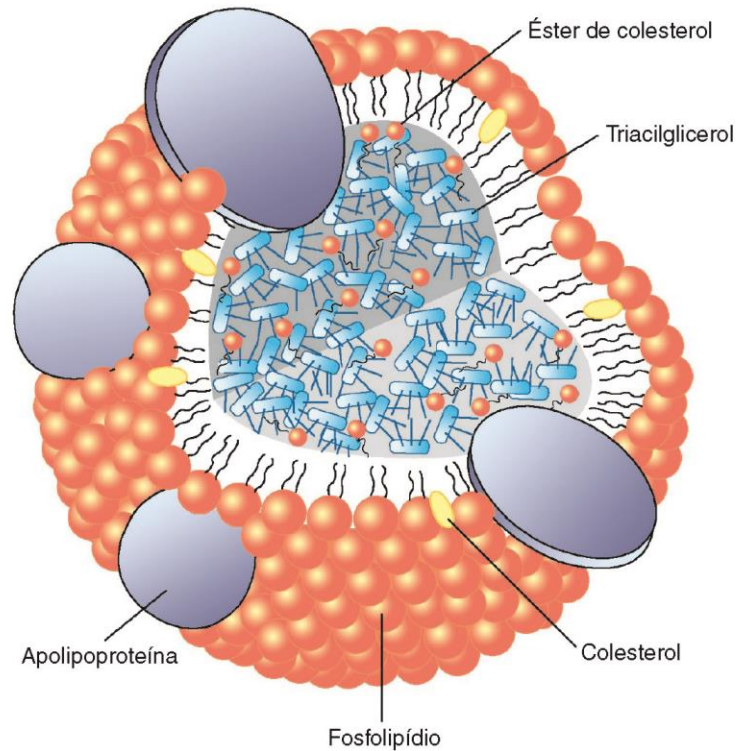
**Fig. 6.11** Esfingolipídios. Os membros desta classe de lipídios diferem quanto ao grupo polar (simbolizado por X) ligado à ceramida; a porção apolar da molécula dos esfingolipídios é formada pelas cadeias carbônicas da esfingosina e do ácido graxo, os componentes da ceramida. Os monossacarídeos componentes da cadeia de oligossacarídios dos gangliosídios são: glicose (Gli), galactose (Gal), N-acetil-galactosamina (NAcGal) e ácido N-acetilneuramínico ou ácido siálico (NAcNeu).

# Colesterol



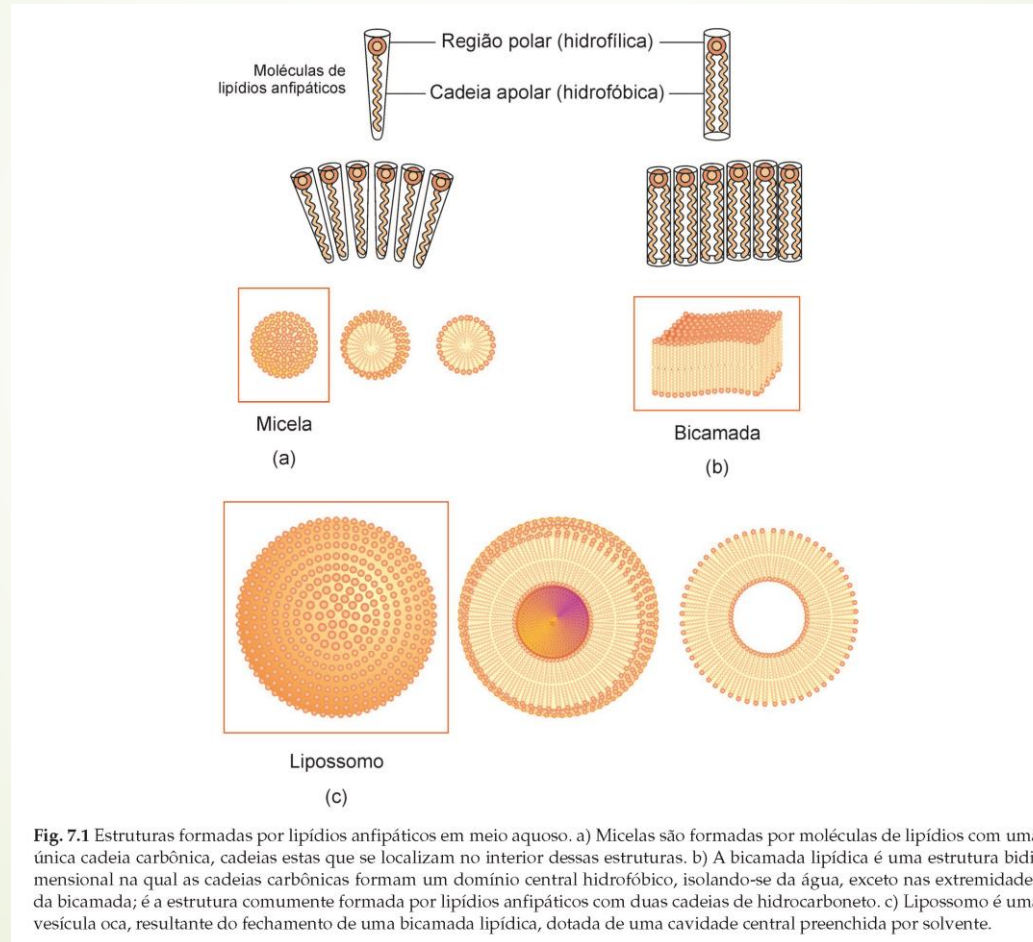
**Fig. 6.12** Estrutura do colesterol. O grupo hidroxila — parte polar da molécula — pode ligar-se a um ácido graxo, formando um éster de colesterol, uma molécula mais apolar que o colesterol.

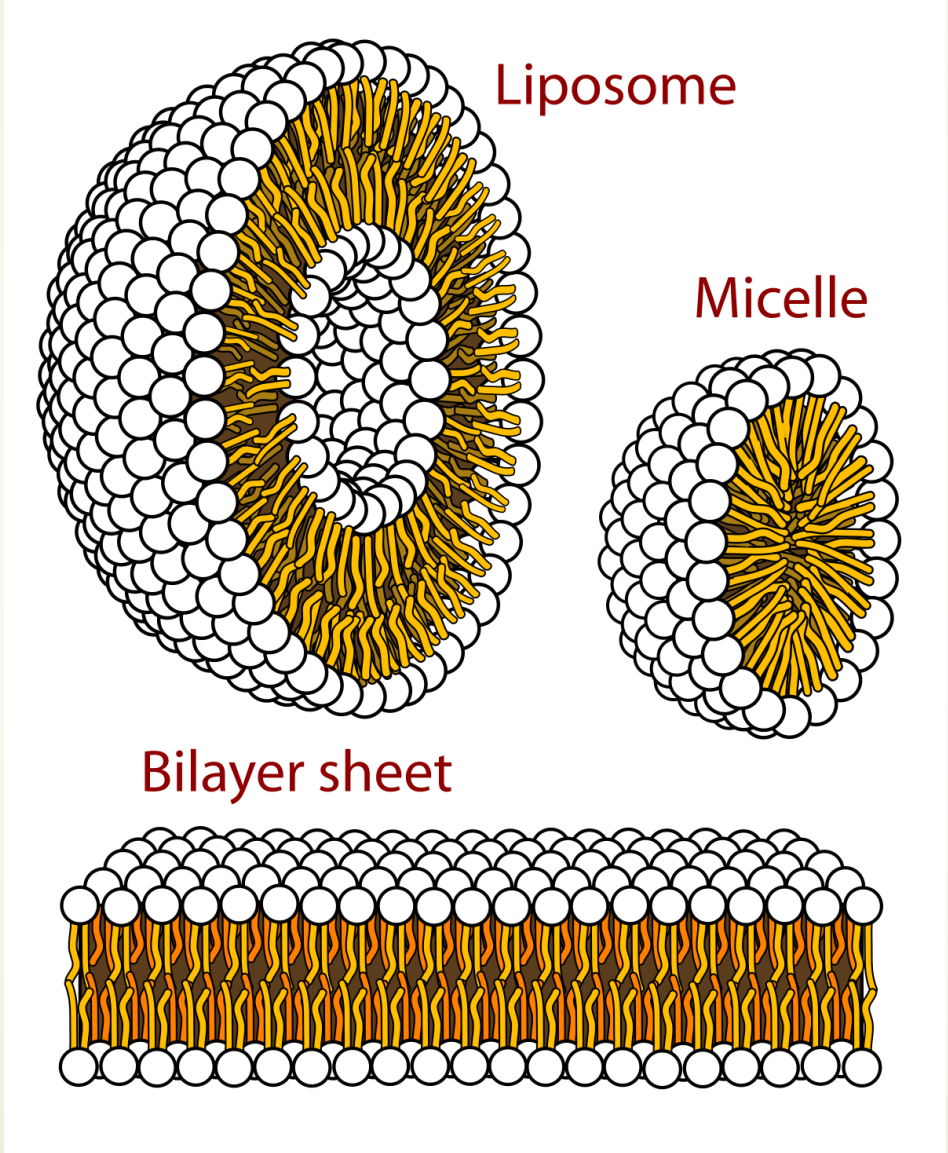
# Lipoproteínas Plasmáticas



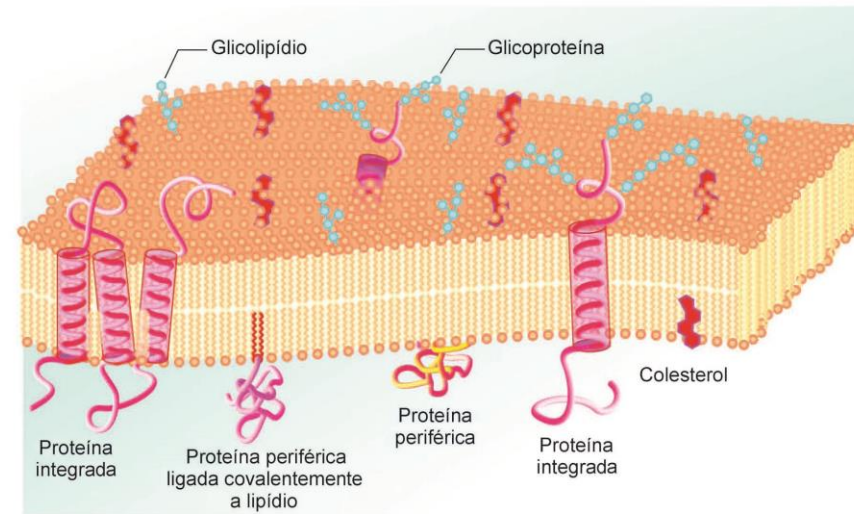
**Fig. 6.13** Esquema geral das lipoproteínas plasmáticas. O modelo aplica-se a todas as classes de lipoproteínas, lembrando que elas diferem quanto à proporção entre os lipídios transportados (Tabela 6.2) e quanto ao tipo de apolipoproteína associada à monocamada periférica. Reproduzida de Ritter, P: Biochemistry – A Foundation, 1<sup>st</sup> edition. Brooks/Cole, 1996.

# Estruturas formadas por Lipídios

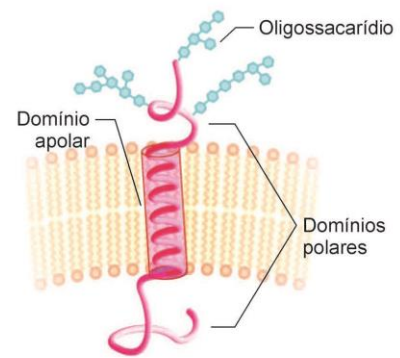




# Membranas Plasmáticas



(a)

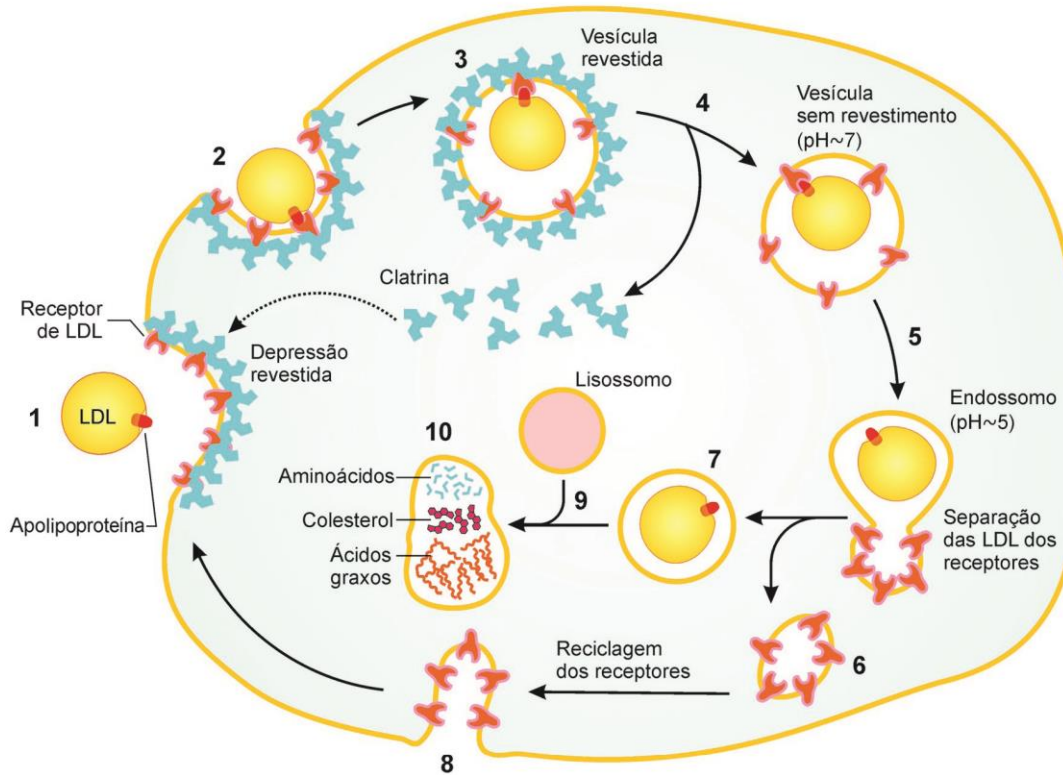


(b)

**Fig. 7.2** (a) Esquema de um fragmento de uma membrana plasmática hipotética em um determinado instante. Os oligossacarídeos de glicoproteínas e glicolípidios projetam-se para o exterior da célula. A proporção entre o tamanho das moléculas não é a verdadeira. Para simplificar o esquema, todas as cadeias carbônicas dos fosfolípidios foram representadas como saturadas. (b) Detalhamento de uma glicoproteína integral.



# LDL



**Fig. 7.3** Transporte de colesterol das LDL plasmáticas para dentro da célula por endocitose adsortiva. As LDL ligam-se, por suas apolipoproteínas, a receptores da membrana plasmática, em depressões revestidas (1). Por invaginação (2), a depressão forma uma vesícula revestida (3) que, em seguida, perde o invólucro de clatrina (4). A vesícula resultante funde-se com um endossomo (5), cujo pH ácido determina a dissociação entre as LDL e os seus receptores. Estes e as LDL concentram-se em regiões distintas do endossomo, que se divide em duas partes: uma estrutura alongada contendo os receptores (6) e uma vesícula contendo as LDL (7). A estrutura com os receptores vazios funde-se com a membrana plasmática, reciclando os receptores para novos ciclos de endocitose (8). A vesícula contendo as LDL funde-se com um lisossomo (9) cujas hidrolases liberam aminoácidos, a partir das apolipoproteínas, e ácidos graxos e colesterol, a partir dos ésteres de colesterol (10).