Universidade de São Paulo
Escola de Engenharia de Lorena
Departamento de Biotecnologia

Curso Engenharia Química

Disciplina Bioquímica

Metabolismo de Glicídeos – Primeira parte

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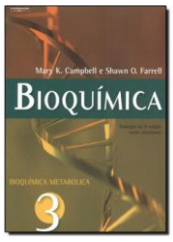
LOT2004 – Bioquímica

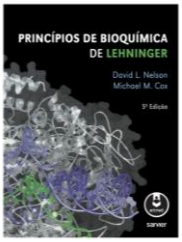
2° parte – Metabolismo e Vias da Informação

Cronograma

Data	Atividades
12 de Maio	Profa. Tatiane (Glicólise e Fermentação)
19 de Maio	Profa. Tatiane (Ciclo do Ácido Cítrico e Fosforilação Oxidativa)
26 de Maio	Profa. Tatiane (Fotossíntese)
02 de Junho	Profa. Tatiane (Metabolismo de Lipídeos)
09 de Junho	Vista da P1
16 de Junho	Não haverá aula (Ponte – Feriado de Corpus Christi)
23 de Junho	Profa. Tatiane (Vias de Informação)
30 de Junho	**P2**
07 de Julho	Vista da P2
14 de Julho	Recuperação

Bibliografia recomendada

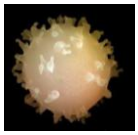




Queijos, Pães, Vinhos, Iogurtes

Refrigerante

Antibióticos



Metabolismo Celular

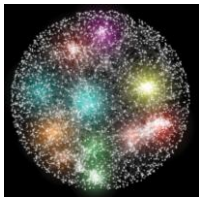
Etanol

Adstringentes, Fixador de cabelo

❖ Rotas Metabólicas

kegg pathway

❖ Interação entre proteínas



Costanzo, Baryshnikova, et al., Science, 2010

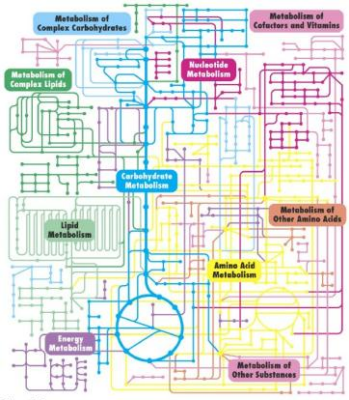


Figure 15-2
Biochemistry, Sixth Edition
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Metabolismo

❖ Soma de todas as reações químicas na célula:

❑ Obter energia

❑ Converter moléculas

❑ Polimerização de macromoléculas

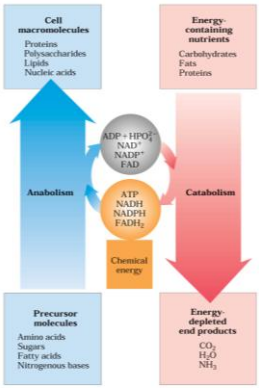


FIGURE 3 Energy relationships between catabolic and anabolic pathways. Catabolic pathways deliver chemical energy in the form of ATP, NADH, NADPH, and $FADH_2$. These energy carriers are used in anabolic pathways to convert small precursor molecules into cell

Fatos da Vida

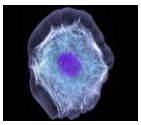
A célula:

❖ Sistema isotérmico

❖Trocam matéria e energia com o ambiente

❖ Moléculas mais organizadas

❖ Necessitam de fonte de energia livre



Termodinâmica

Equação de Gibbs

$$\Delta G = \Delta H - T\Delta S$$

ΔG: Variação da Energia de Gibbs; ΔH: Variação da Entalpia; TΔS: Variação da Entropia associada com a temperatura

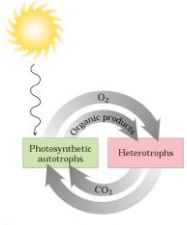


FIGURE 1 Cycling of carbon dioxide and oxygen between the autotrophic (photosynthetic) and heterotrophic domains in the biosphere.

Estado Padrão:

Todos os reagentes e produtos a 1M!

ΔG < 0 **Exergônica**

ΔG = 0 **Equillíbrio**

ΔG > 0 **Endergônica**

Reações Acopladas

A ⇌ B + C $\Delta G^{\circ\prime} = +5$ kcal/mol

B ⇌ D $\Delta G^{\circ\prime} = -8$ kcal/mol

A ⇌ C + D $\Delta G^{\circ\prime} = -3$ kcal/mol

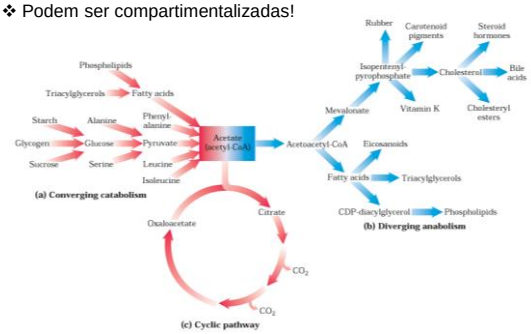
TABLE 13-4 Standard Free-Energy Changes of Some Chemical Reactions at pH 7.0 and 25 °C (298 K)

Reaction type	$\Delta G^{\circ\prime}$ (kJ/mol)	$\Delta G^{\circ\prime}$ (kcal/mol)
Hydrolysis reactions		
Acid anhydrides		
Acetic anhydride + H_2O ⟶ 2 acetate	−91.1	−21.8
ATP + H_2O ⟶ ADP + P_i	−30.5	−7.3
ATP + H_2O ⟶ AMP + PP_i	−45.6	−10.9
PP_i + H_2O ⟶ $2P_i$	−19.2	−4.6
UDP-glucose + H_2O ⟶ UMP + glucose 1-phosphate	−43.0	−10.3
Esters		
Ethyl acetate + H_2O ⟶ ethanol + acetate	−19.6	−4.7
Glucose 6-phosphate + H_2O ⟶ glucose + P_i	−13.8	−3.3
Amides and peptides		
Glutamine + H_2O ⟶ glutamate + NH_4^+	−14.2	−3.4
Glycylglycine + H_2O ⟶ 2 glycine	−9.2	−2.2
Glycosides		
Maltose + H_2O ⟶ 2 glucose	−15.5	−3.7
Lactose + H_2O ⟶ glucose + galactose	−15.9	−3.8
Rearrangements		
Glucose 1-phosphate ⟶ glucose 6-phosphate	−7.3	−1.7
Fructose 6-phosphate ⟶ glucose 6-phosphate	−1.7	−0.4
Elimination of water		
Malate ⟶ fumarate + H_2O	3.1	0.8
Oxidations with molecular oxygen		
Glucose + $6O_2$ ⟶ $6CO_2$ + $6H_2O$	−2,840	−686
Palmitate + $23O_2$ ⟶ $16CO_2$ + $16H_2O$	−9,770	−2,338

Vias metabólicas

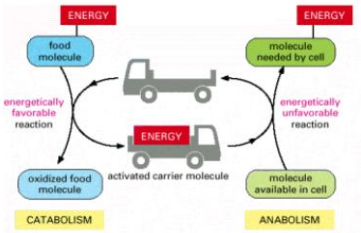
❖Biossíntese e degradação **quase sempre** em vias distintas!

❖ Podem ser compartimentalizadas!



Moléculas carreadoras ativadas

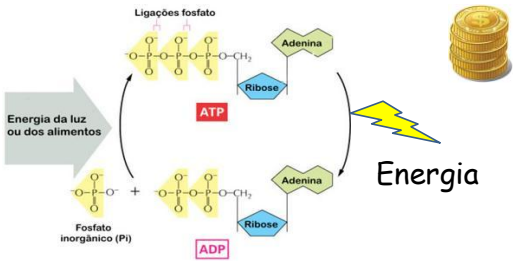
❖ Carregam energia Química na Célula



Moléculas Carreadoras Ativadas

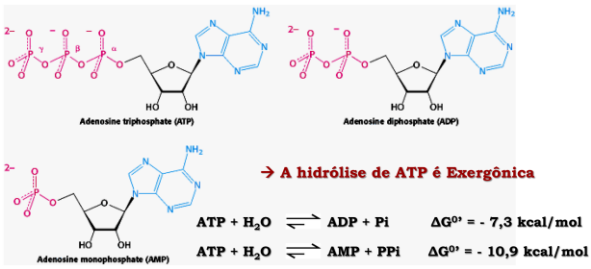
❖ **Adenosina trifosfato (ATP)**: Principal moeda energética das células

❖ **ATP -> ADP + Pi**



Hidrólise de ATP

✓ Três posições de possível hidrólise do ATP

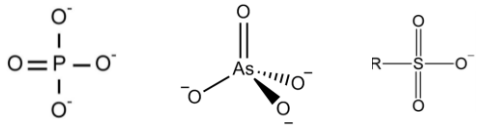


Porque o Fosfato e não os outros?

✓ Estabilidade: Velocidade de reação lenta

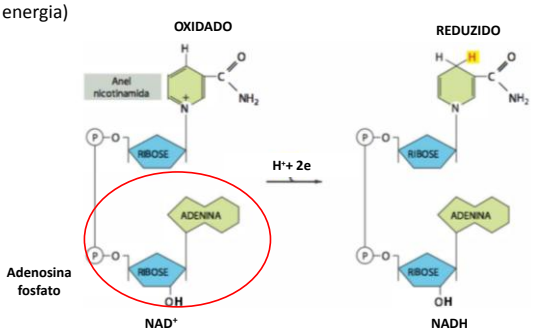
✓ Maior reserva de energia: Energia nas ligações

Candidatos	k de hidrólise (do íon)
Fosfato	0,000000004 (1/s)
Arsenato	0,0004 (1/s)
Sulfonato	0,00025 (1/s)



NAD+/NADH - Nicotinamida adenina

❖ NAD+/ NADH (Carrega de **um próton** e dois **elétrons ricos** em energia)



Principais Reações do Metabolismo

Saccharomyces cerevisae

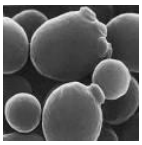
❖ Cerca de 500 reações

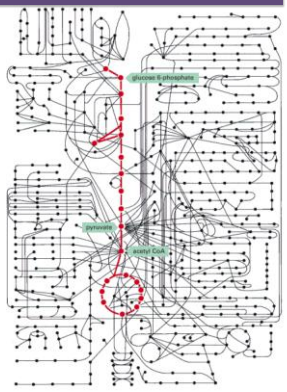
Metabolismo de Glicídios

❖ Glicólise

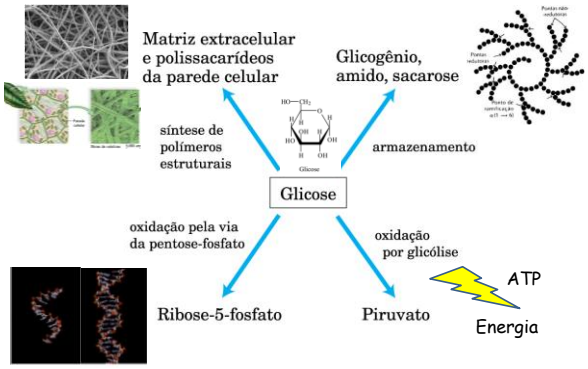
❖ Ciclo do Ácido Cítrico

❖ Fermentação



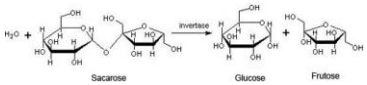


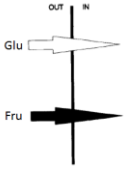
Principais vias de Utilização da Glicose



Glicose na Célula

- *S. cerevisae*
- Anaeróbio facultativo



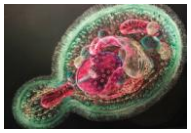


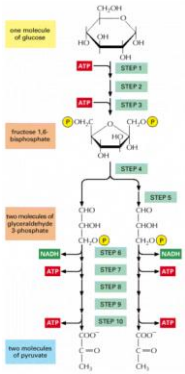
Reação da Glicólise

- Hidrólise do Açúcar
- Para algumas células, única fonte de energia!
- Total de 10 reações

No citoplasma

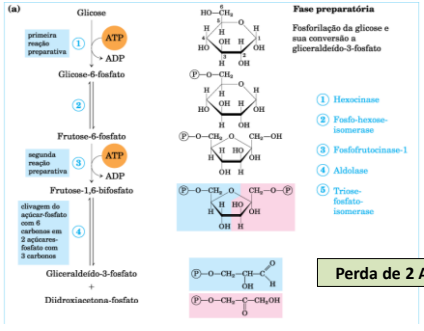
1 Glicose => 2 Piruvato





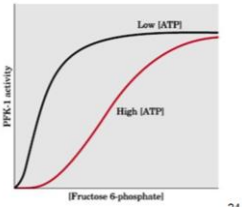
Glicólise – Fase preparatória

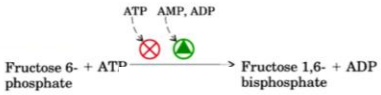
- **Investimento Energético:**
- **Glicose => Gliceraldeído 3 Fosfato e Dihidrocicetona fosfato**



Perda de 2 ATP

Enzima Alostérica Fosfofrutocinase

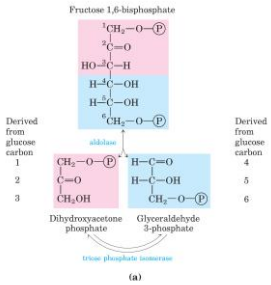




Glicólise – Fase preparatória

❖ **Hidrólise**

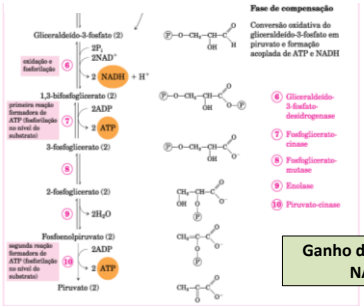
❖ **Frutose 1,6 Bifosfato** => **Gliceraldeído 3 Fosfato e Dihidrocicetona fosfato**



Glicólise – Fase Compensatória

❖ **Geração de energia.**

❖ **Gliceraldeído 3 Fosfato** => 2 **Piruvato**



Ganho de 4 ATP +2 NADH

Glicólise

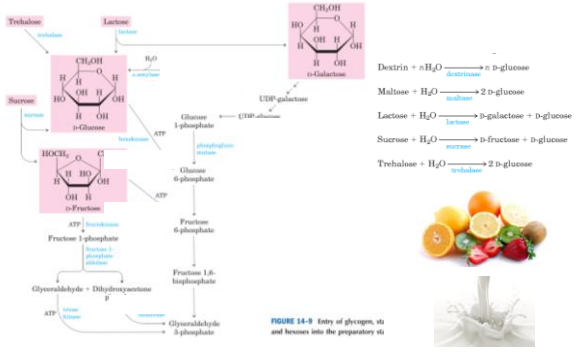
❖ Reação Geral da Glicólise:

Glicose + 2NAD⁺ + 2ADP + 2Pi ⟶ 2 Piruvato + 2NADH + 2H⁺ + 2ATP +2H_2O

Rendimento Líquido: 2 ATP +2 NADH
(-32,1 kcal mol^{-1} de glicose consumida)

Vias Alimentadoras da Glicólise

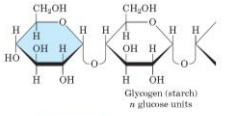
❖ **Polissacarídeos e dissacarídeos:** convertidos em intermediários

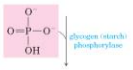


Degradação de Glicogênio

❖Glicogênio fosforilase: Cliva ligações β 1,4

❖ Enzimas de desramificação: Clivam α 1,6





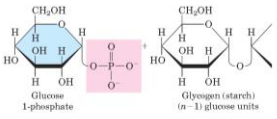
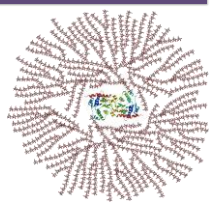
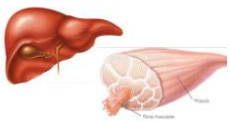


FIGURE 14-10 Glycogen breakdown by glycogen phosphorylase.

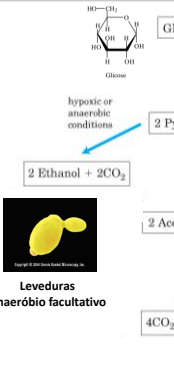


Glicogênio

Fígado e Músculo



Oxidação da Glicose: Vias Principais

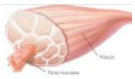


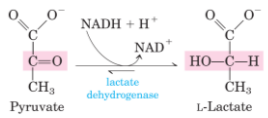
Leveduras
Anaeróbio facultativo

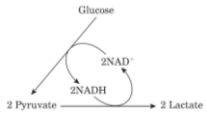
Lactobacilos
Anaeróbio facultativo

Fermentação Lática

Piruvato + NADH + H⁺ ⟶ Lactato + NAD⁺

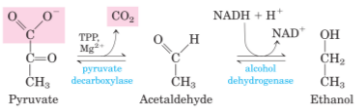


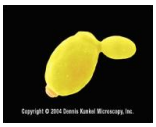




Fermentação Alcólica

Piruvato + NADH + H⁺ ⟶ Etanol + NAD⁺

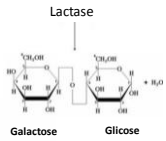




Intolerância a Lactose

❖ Ausência da Lactase Intestinal

❖ Processo fermentativos no intestino



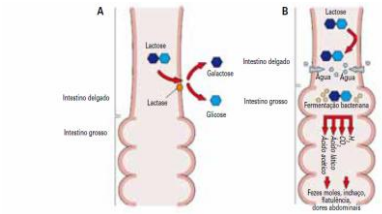


Imagem A
A lactase hidrolisa a lactose. Não há sintomas de intolerância à lactose

Imagem B
A lactose não absorvida no intestino grosso provoca os sintomas de intolerância à lactose.

Fermentação

❖ Reação – Fermentação Lática

Glicose + 2ADP + 2Pi ⟶ 2 Lactato + 2ATP +2H_2O

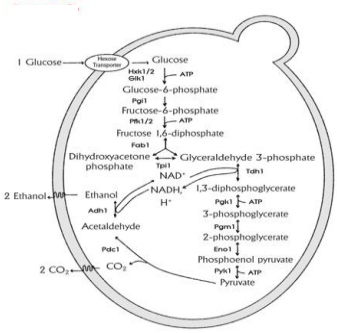
❖ Reação – Fermentação Alcoólica:

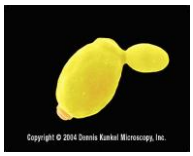
Glicose + 2ADP + 2Pi ⟶ 2 Etanol + 2CO2 + 2ATP +2H_2O

Rendimento Líquido: 2 ATP

Fermentação

❖ Exemplo: Processo completo de Fermentação Alcoólica em levedura





Fábricas Químicas

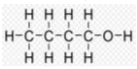
❖ **Fermentação no processo Industrial**

Produtos de Fermentação
Ácido Fórmico
Ácido Acético
Alcoóis Glicerol
Metanol
Isopropanol

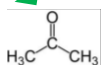
Amido

Fermentação

Clotrisdium acetobutyricum



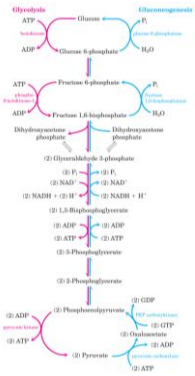
Butanol



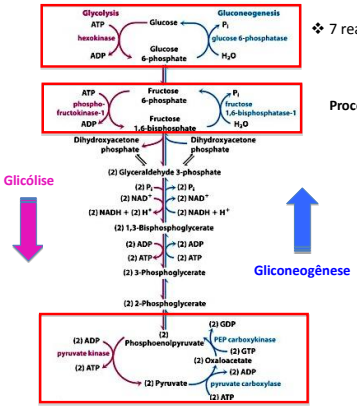
Acetona

Gliconeogênese

- ❖ Nova formação de Açúcar
- ❖ Queda nos níveis de Glicose
- ❖ Queda nos níveis de carboidrato de reserva
- ❖ 2 Piruvato => Glicose



Regulação da Glicólise/Gliconeogênese



- ❖ 7 reações reversíveis com a Glicólise

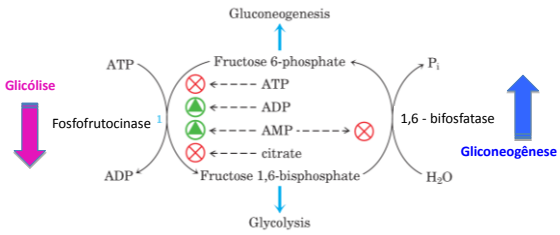
Processos Irreversíveis!

Regulação Glicólise / Gliconeogênese

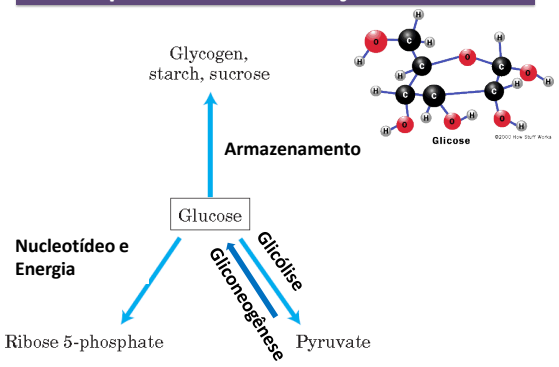
- ❖ Regulação nas reações irreversíveis

Exemplo : Segunda reação da Glicólise

Induz
Reprime



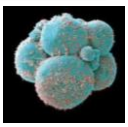
Principais Vias de Utilização da Glicose

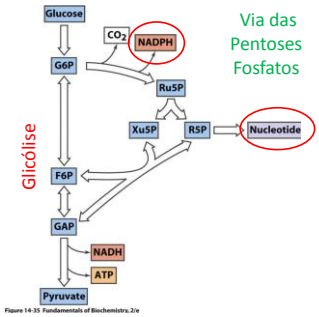


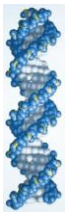
Via das pentoses fosfato

❖ Via atlernativa a Glicólise

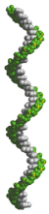
❖ Produto Principal: Açúcares de 5 Carbono e NADPH







DNA

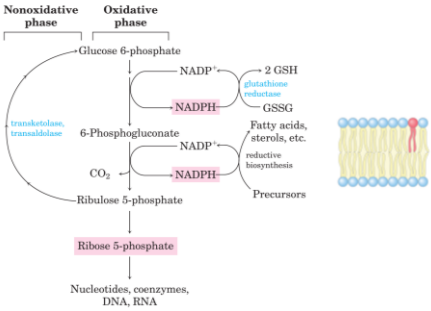


RNA

Via das pentoses fosfato

❖ **Fase Oxidativa**: Glicose 6 fosfato ⟶ Ribose 5 fosfato

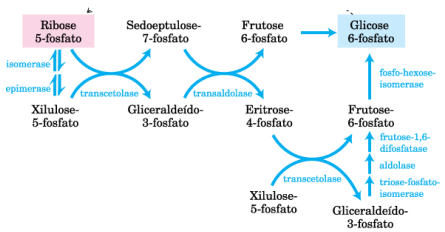
❖ Produto principal: Pentoses fosfato e NADPH



Via das pentoses fosfato

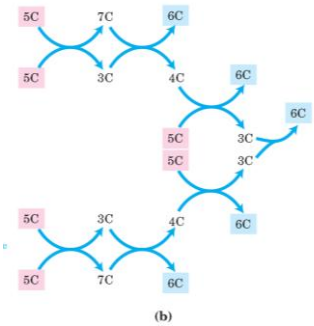
❖ **Fase Não Oxidativa**

❖ Converte Pentose fosfato a Hexose fosfato. Reciclagem da Glicose 6P!

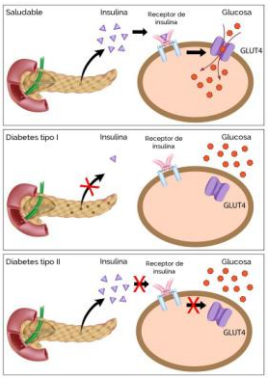
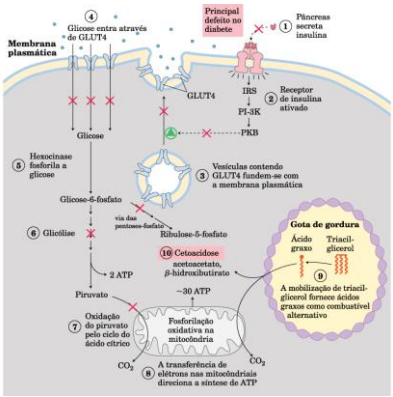


Via das pentoses fosfato

❖ **Fase Não Oxidativa**



Diabetes e o Metabolismo de Carboidratos



❖ **Privação de Glicose dentro da célula**