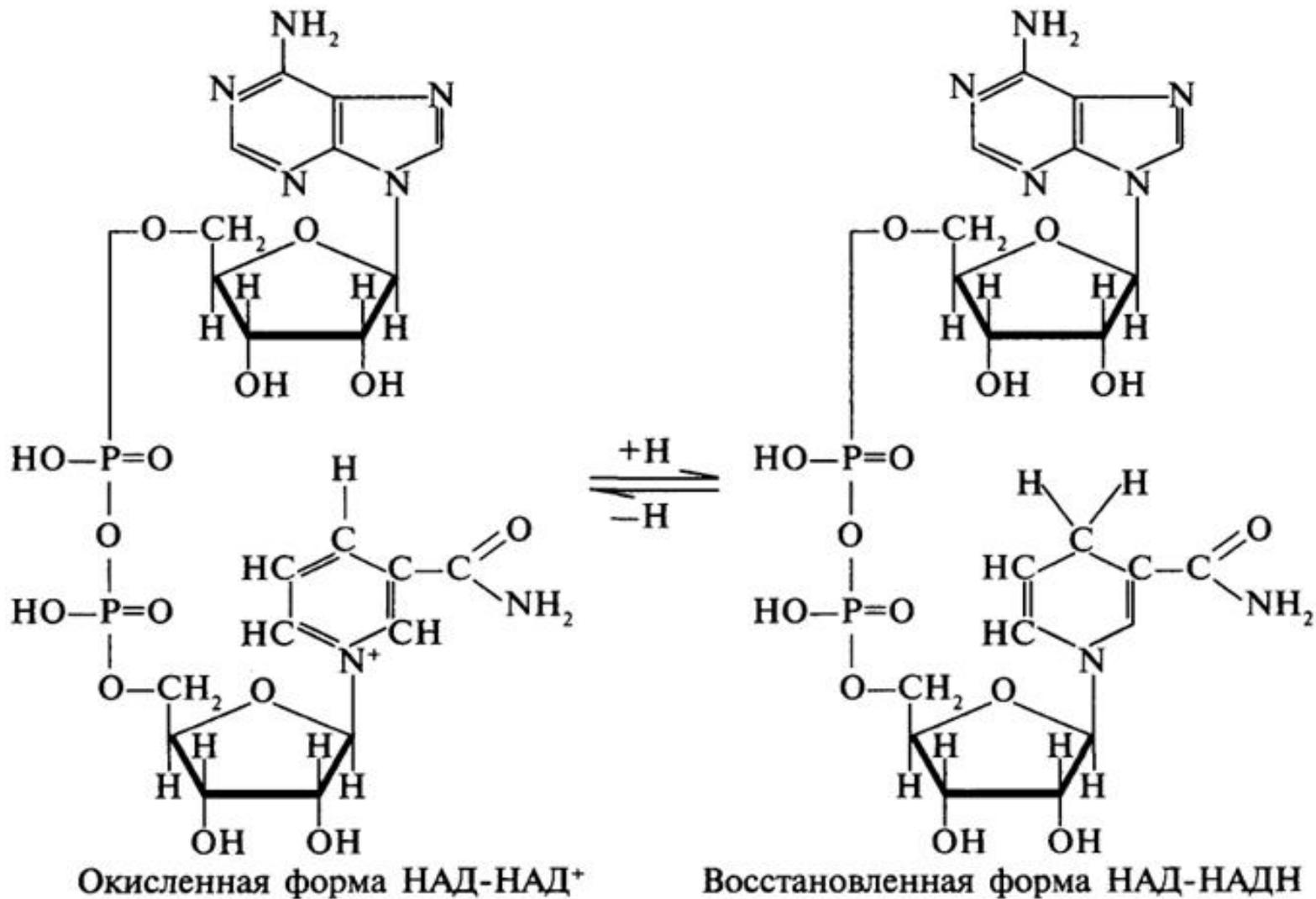
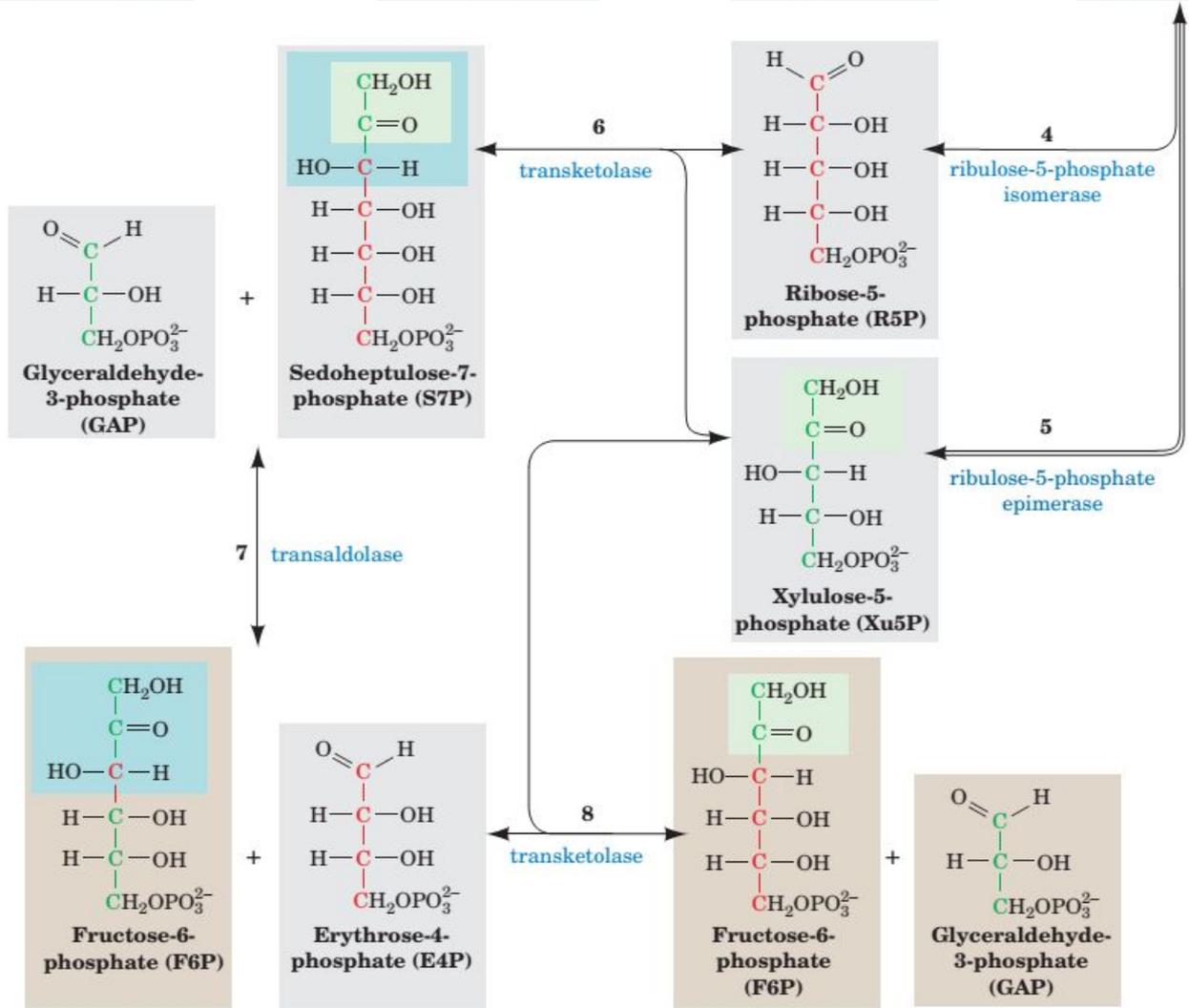
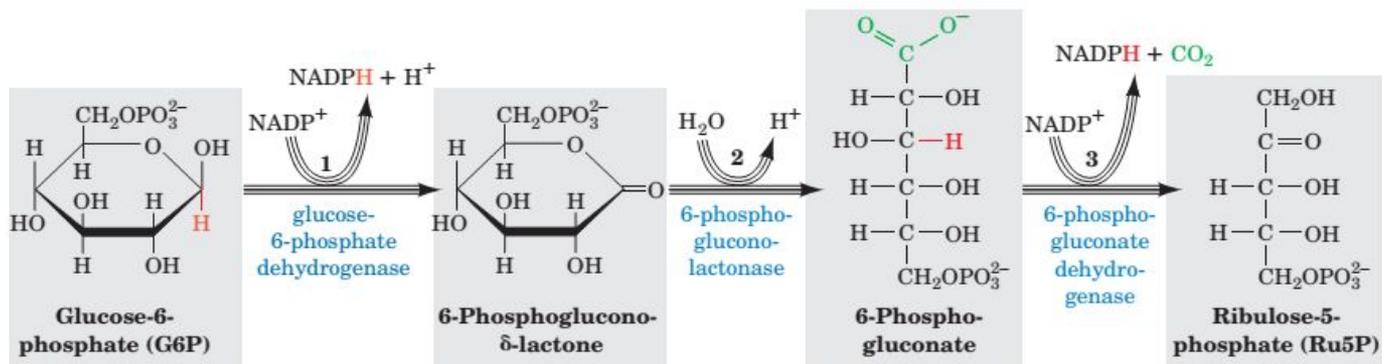


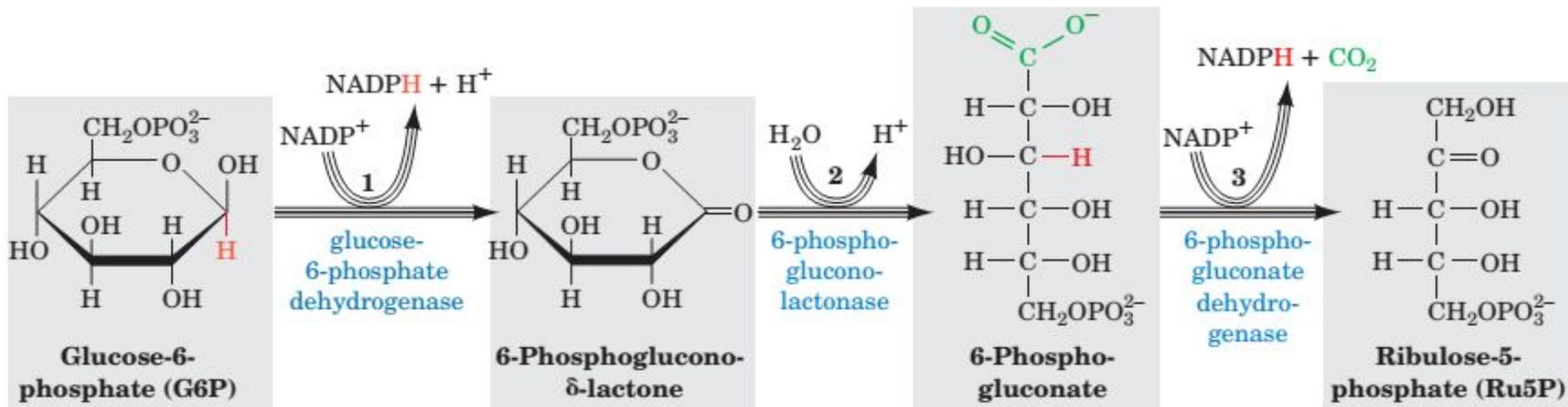
Пентозофосфатный путь (ПФП)  
окисления глюкозы. Обмен  
других моносахаридов.  
Регуляция и патология  
углеводного обмена

# ПЕНТОЗОФОСФАТНЫЙ ПУТЬ ПРЕВРАЩЕНИЯ ГЛЮКОЗЫ

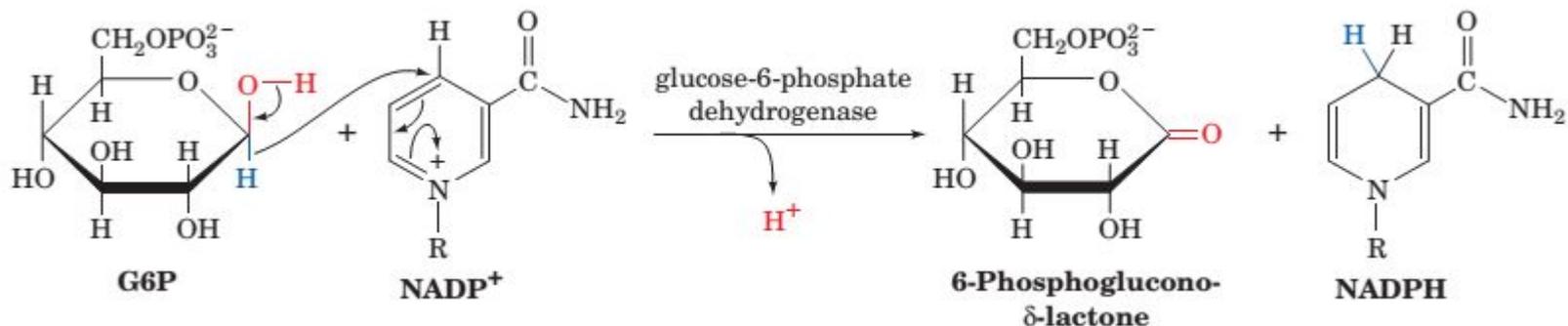




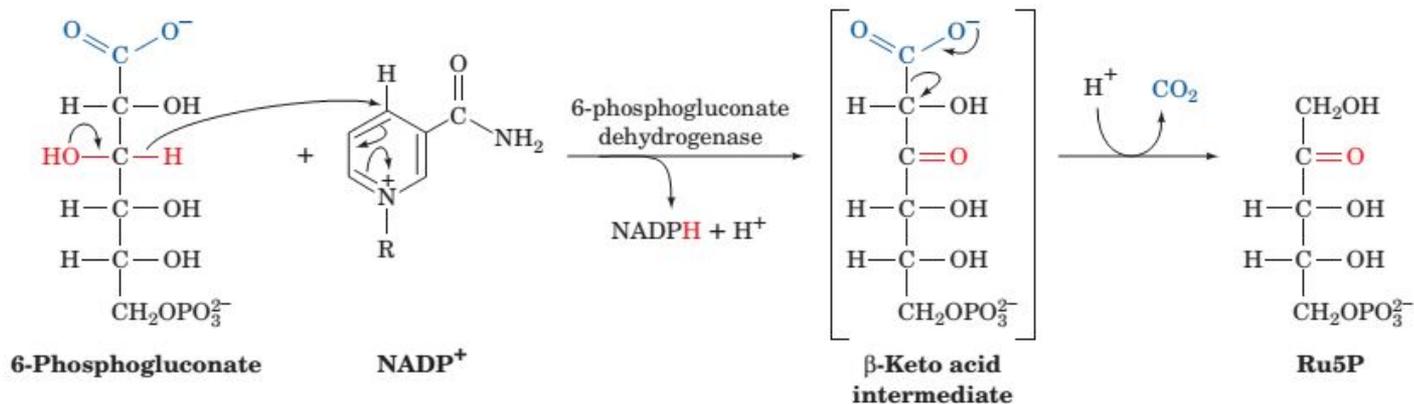
# Окислительный этап

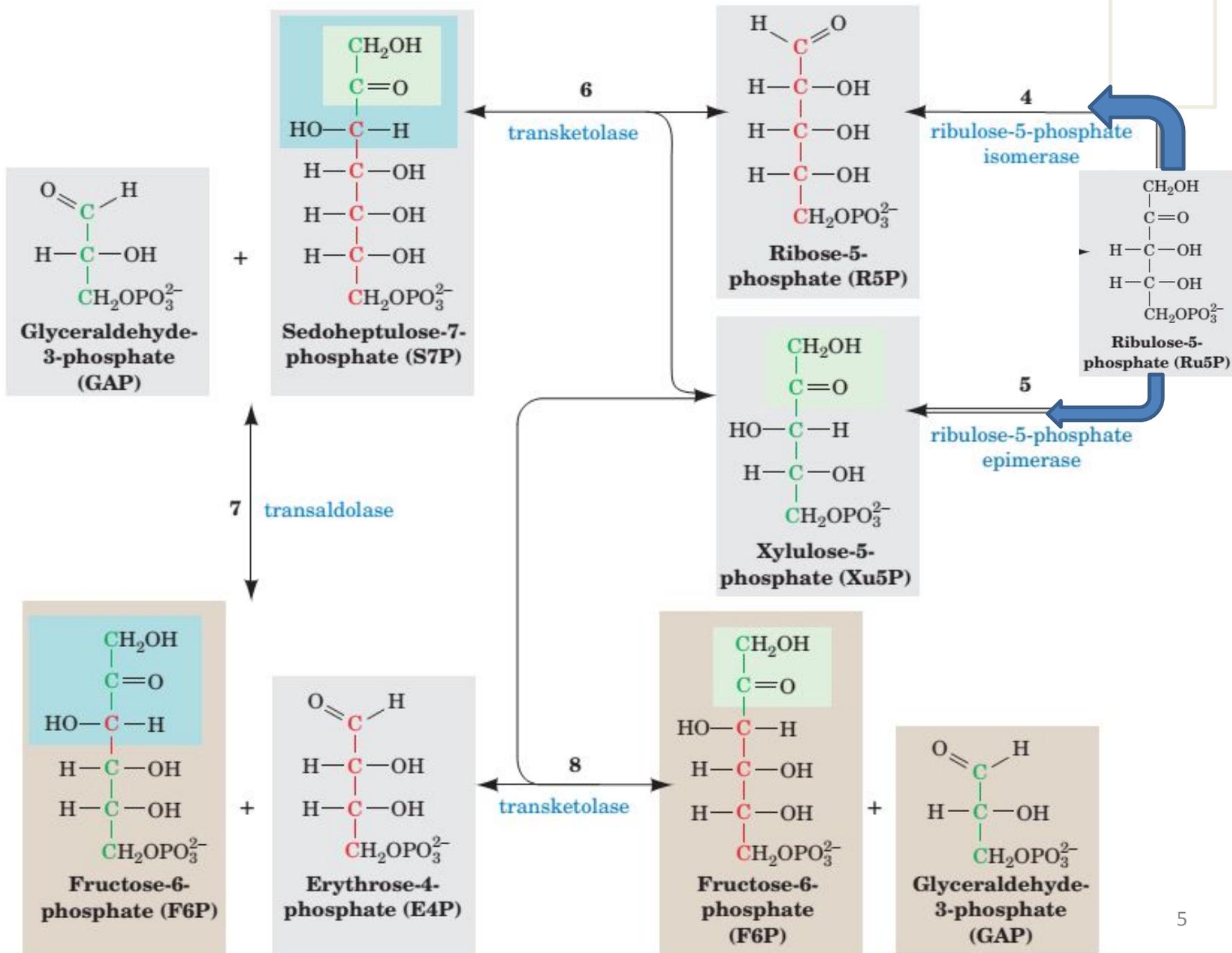


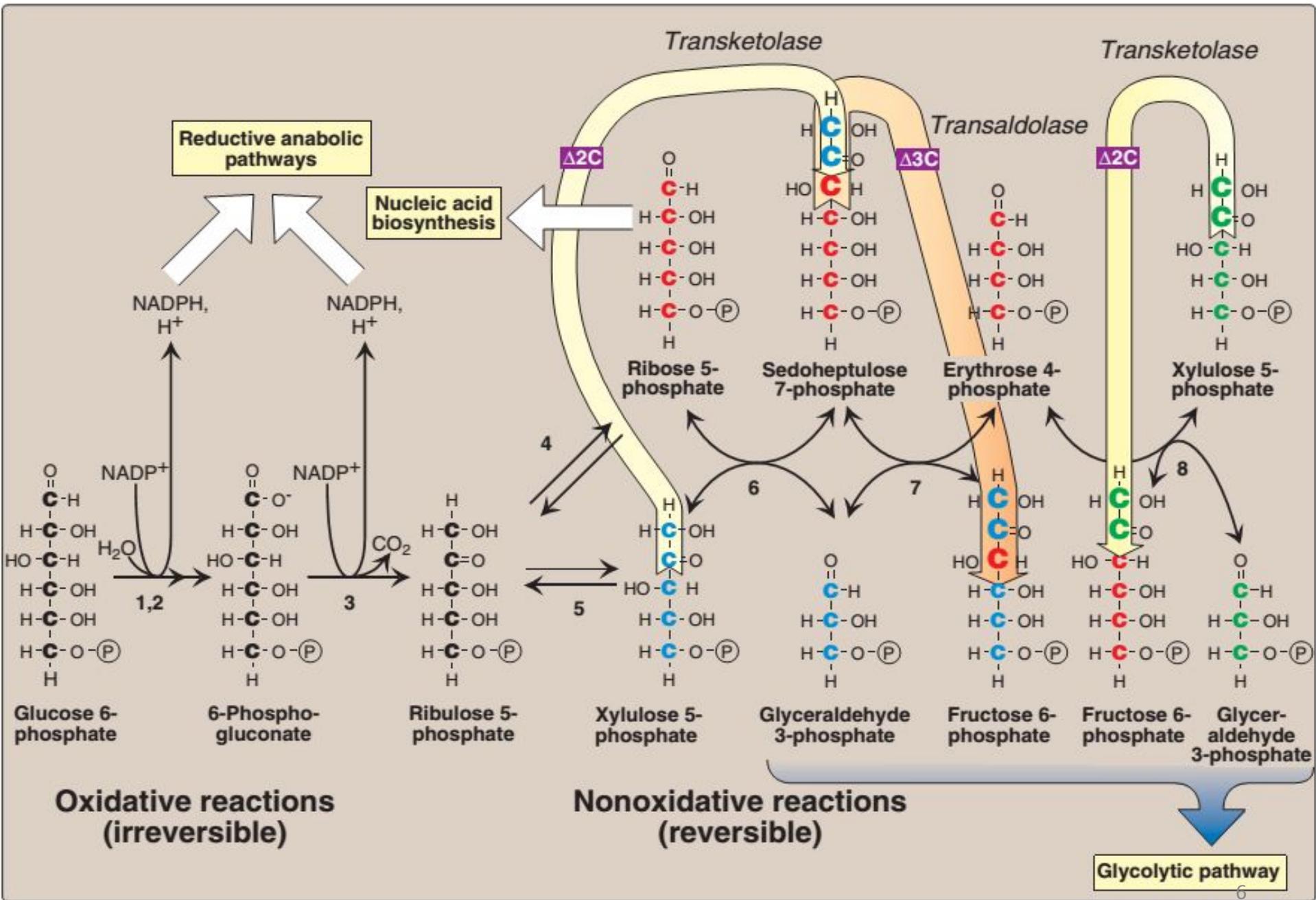
I реакция

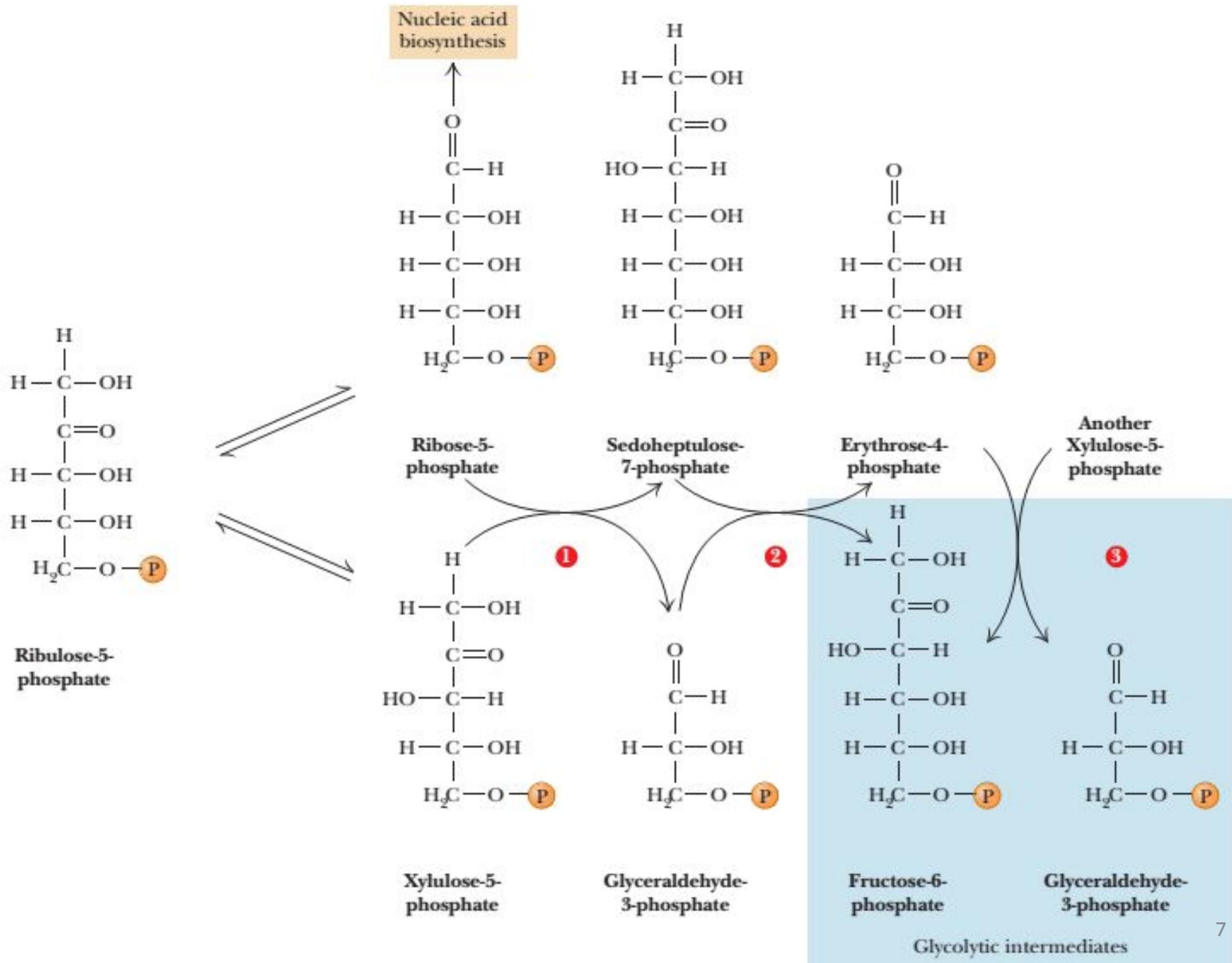


III реакция

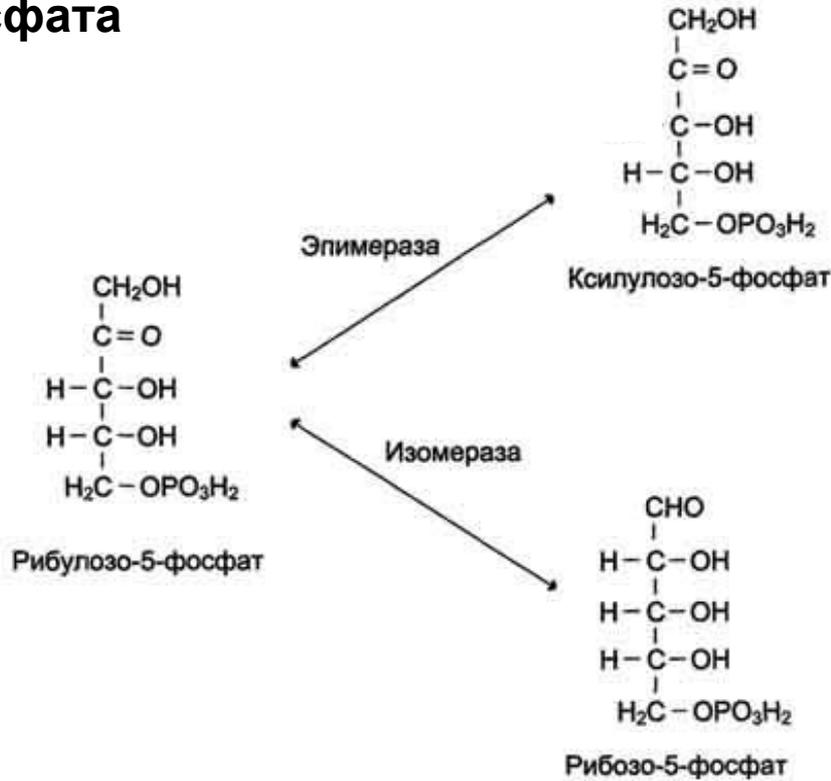




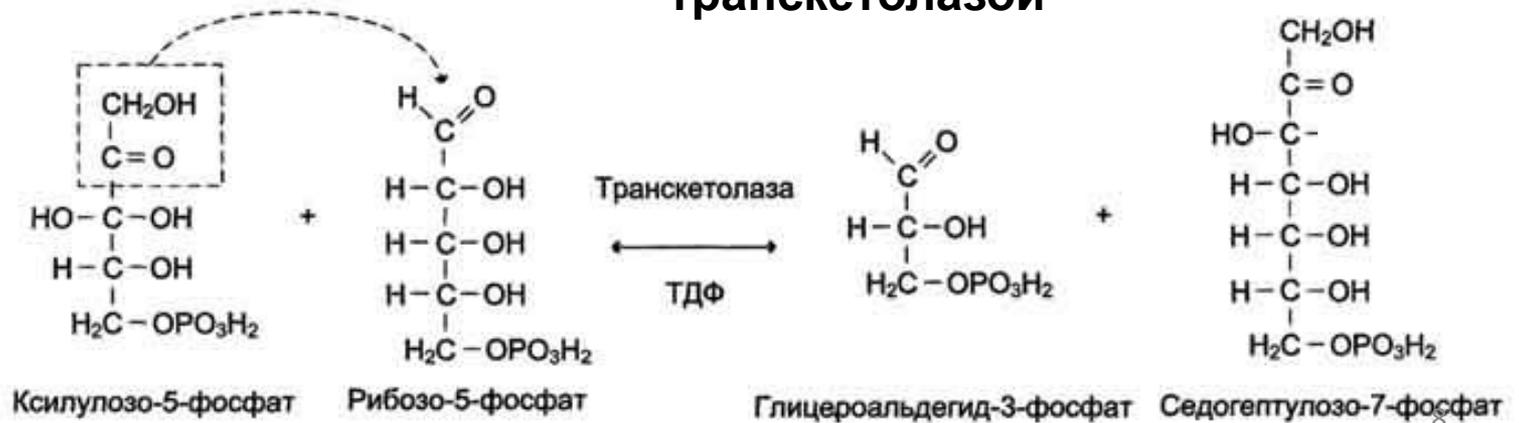




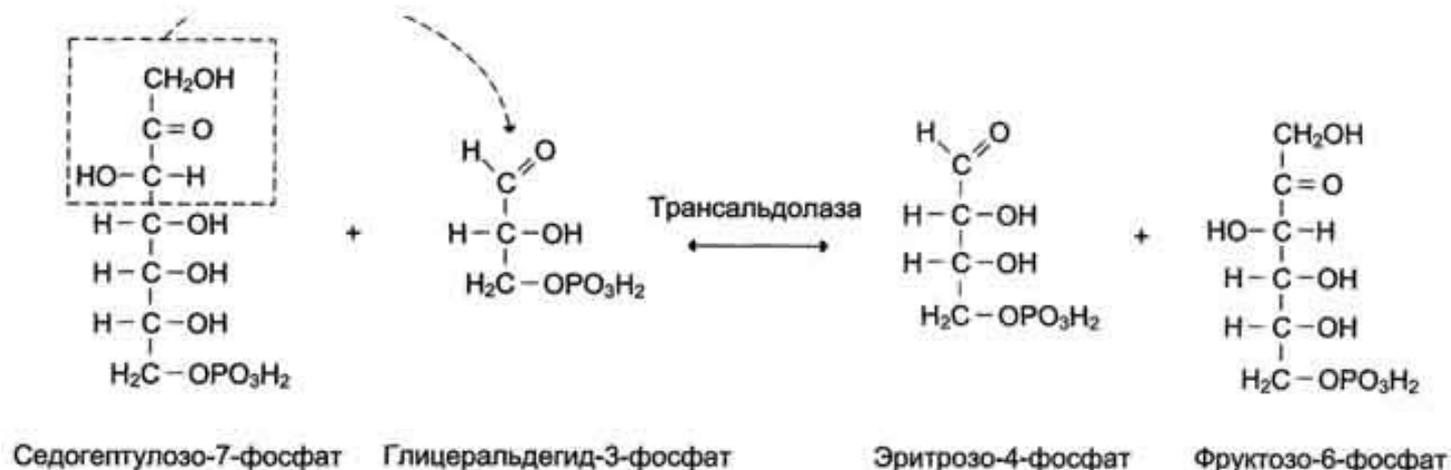
# Превращения рибулозо-5-фосфата



Реакция переноса  
 двухуглеродного  
 фрагмента,  
 катализируемая  
 транскетолазой

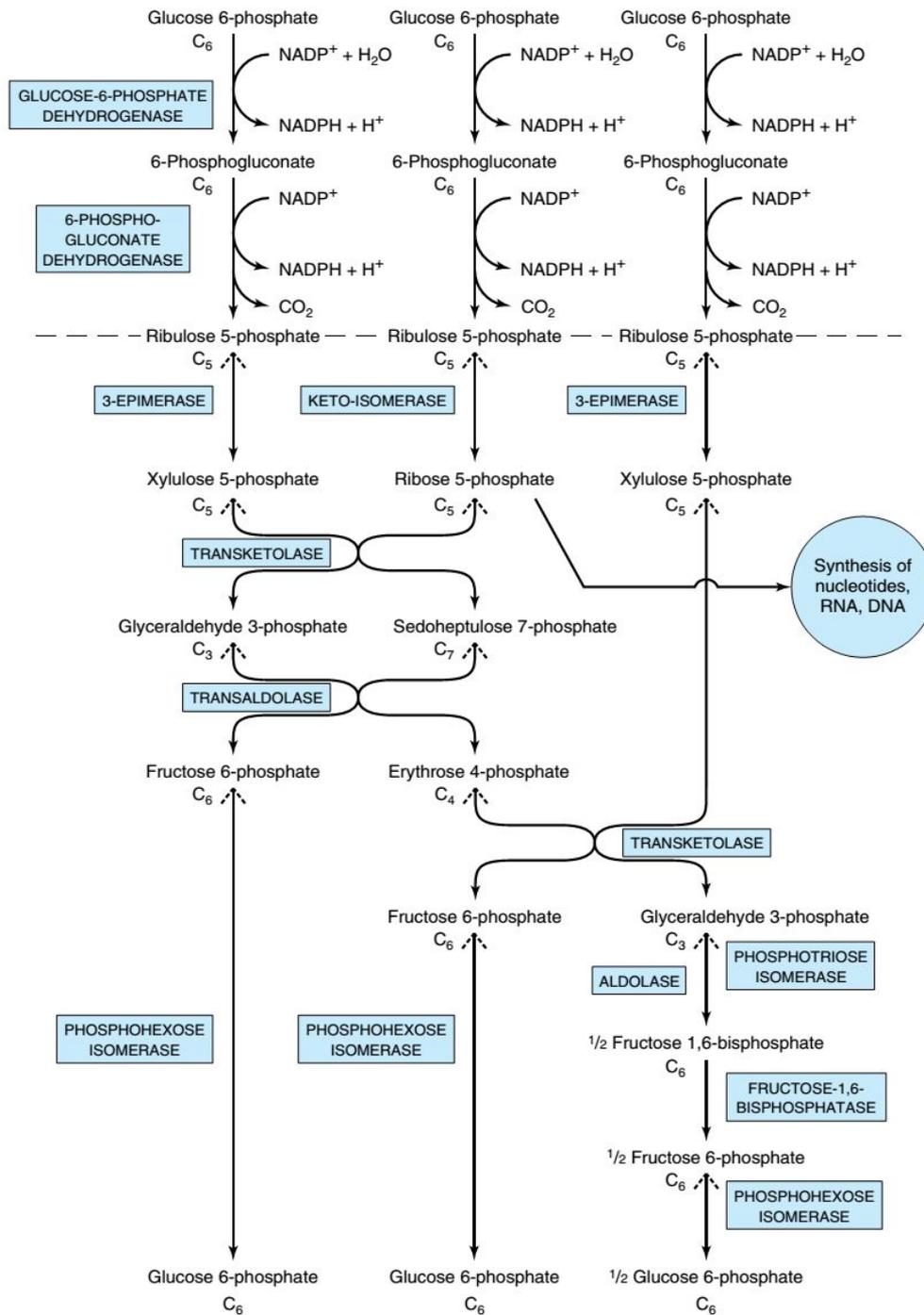


## Реакция, катализируемая трансальдозазой

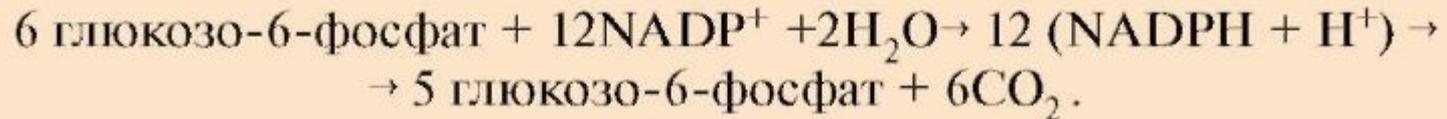


## Реакция, катализируемая транскетолазой





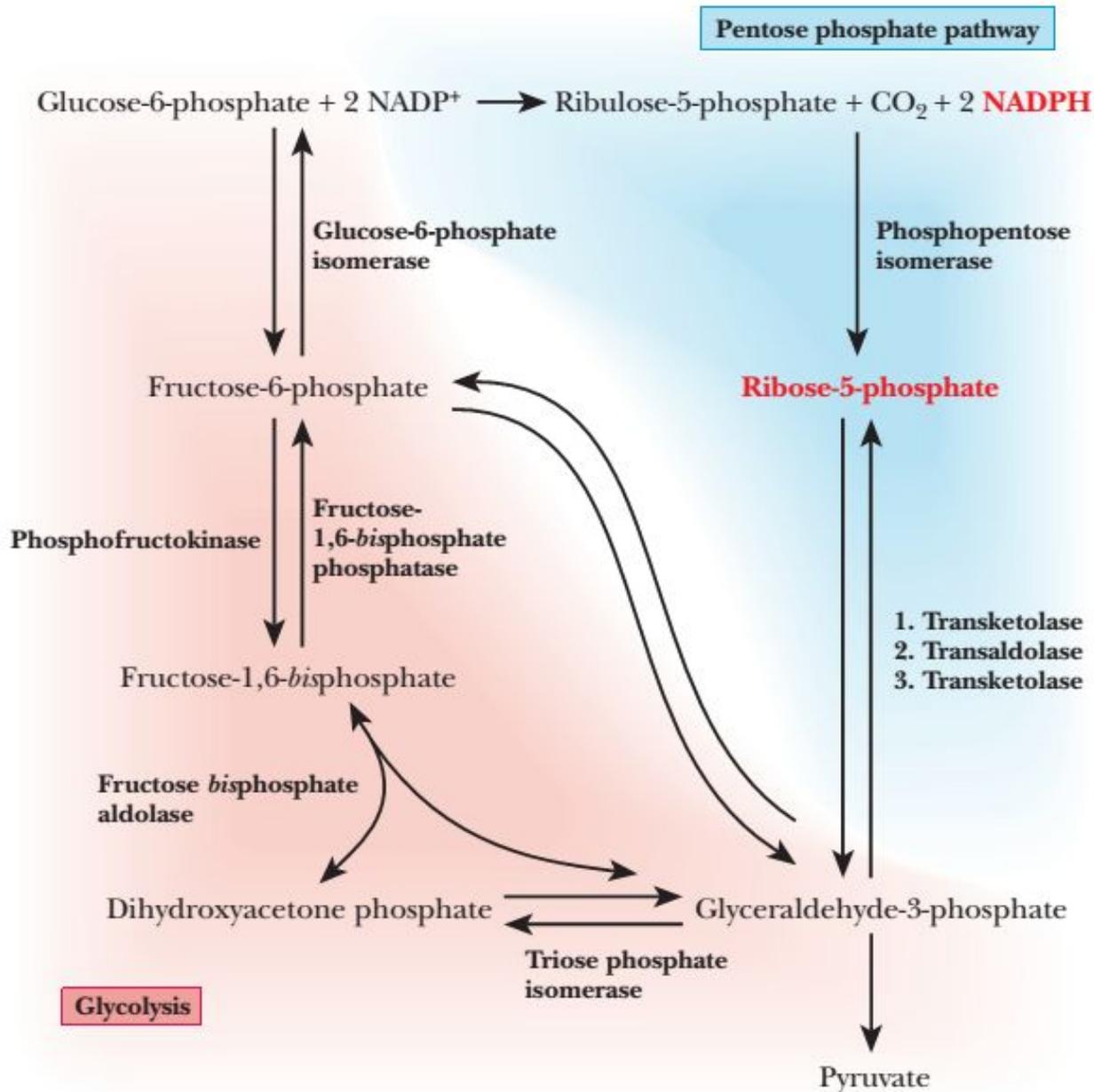
Пентозофосфатный цикл. Окислительный этап синтеза пентоз и этап возвращения пентоз в гексозы (неокислительный этап в обратном направлении) вместе составляют циклический процесс (пентозофосфатный цикл) - за один оборот цикла полностью распадается одна молекула глюкозы. Пентозофосфатный цикл функционирует в основном только в жировой ткани и печени. Суммарное уравнение пентозофосфатного цикла



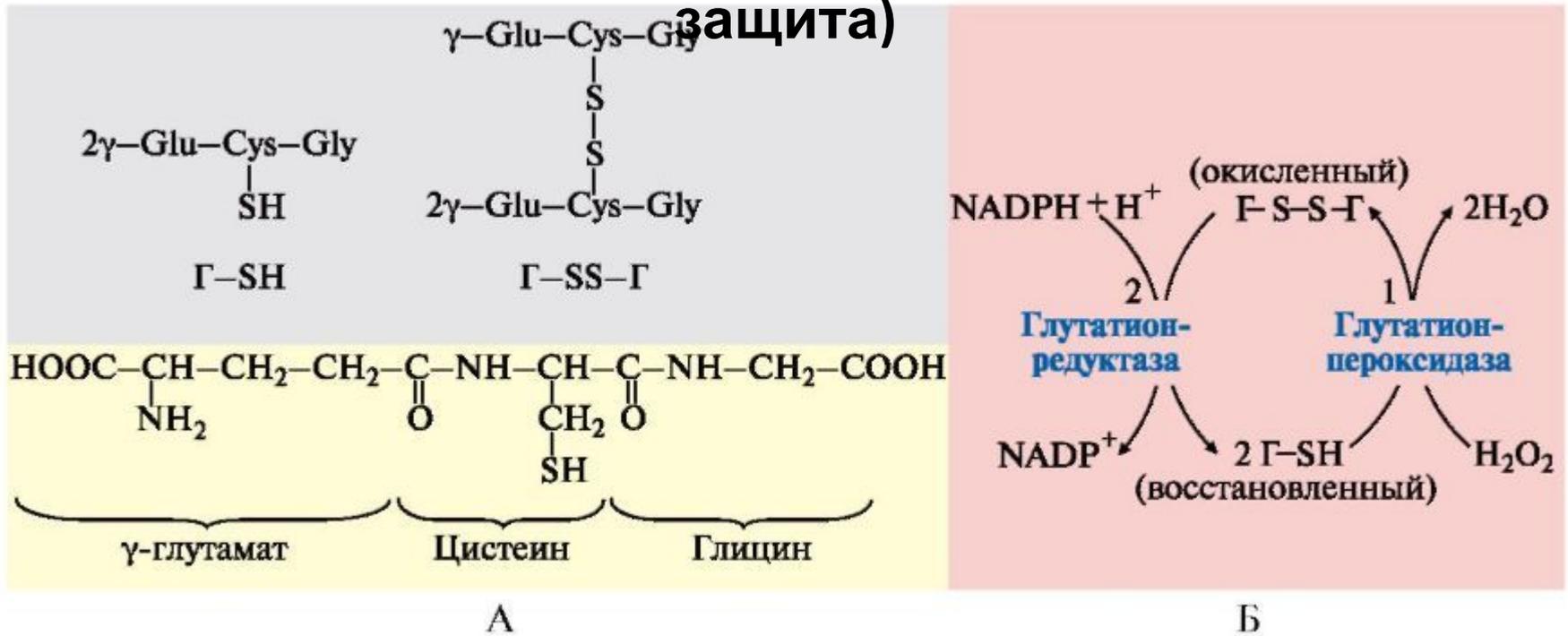
Промежуточные продукты пентозофосфатного пути превращения глюкозы (фруктозо-6-фосфат, глицеральдегид-3-фосфат) могут включаться в пути аэробного и анаэробного окисления и служить источником энергии для синтеза АТФ.

У растений реакции пентозофосфатного пути составляют часть процесса образования гексоз из  $\text{CO}_2$  при фотосинтезе.

# Взаимосвязь ПФП и гликолиза



# Механизм действия глутатиона (антирадикальная защита)



**Восстановление глутатиона с участием NADPH+H<sup>+</sup>:**

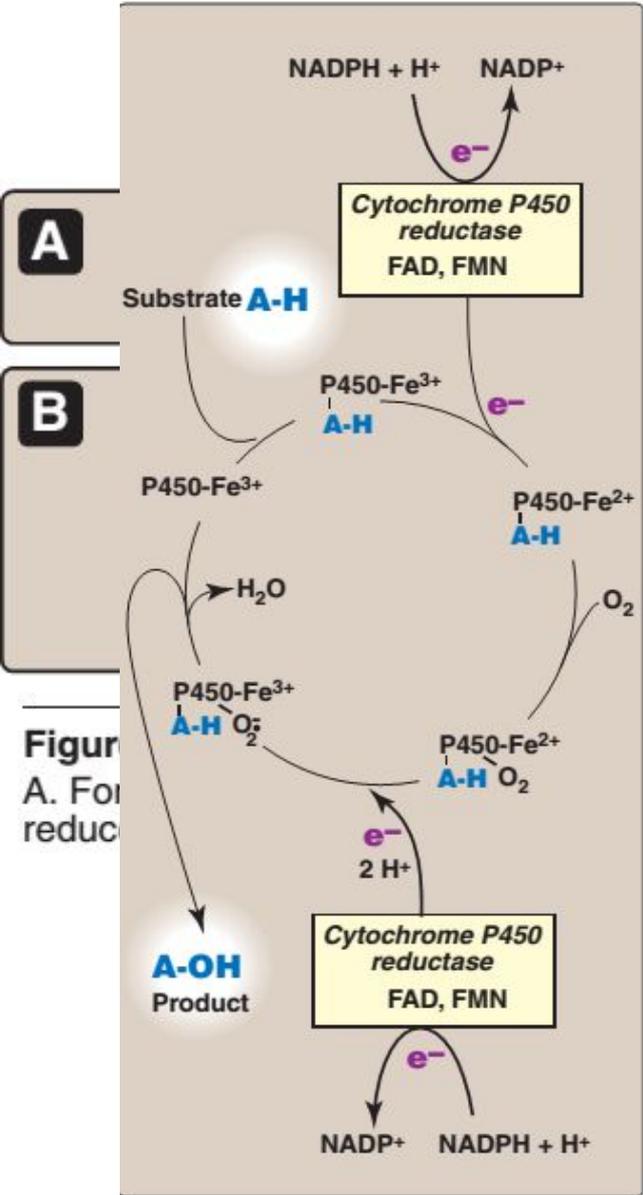
**А - Строение глутатиона:**

Г-SH - восстановленная форма; Г-S-S-Г - окисленная форма;

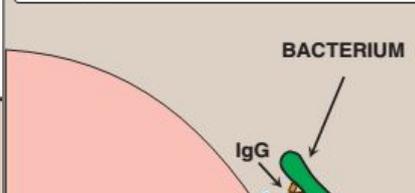
**Б - Участие глутатиона в обезвреживании пероксида водорода и его регенерация:**

1 - взаимодействие глутатиона с H<sub>2</sub>O<sub>2</sub> с образованием воды и окисленной формы глутатиона;

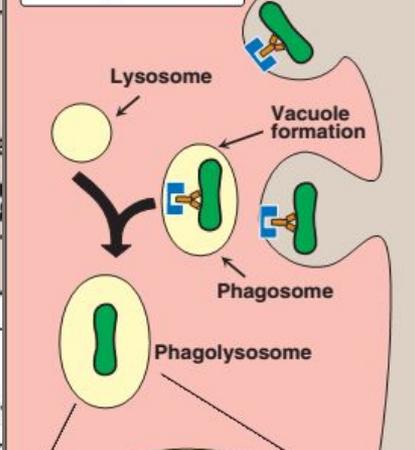
2 - регенерация глутатиона с использованием в качестве донора водорода NADPH+H<sup>+</sup>, образуемой на окислительном этапе пентозофосфатного пути превращения глюкозы



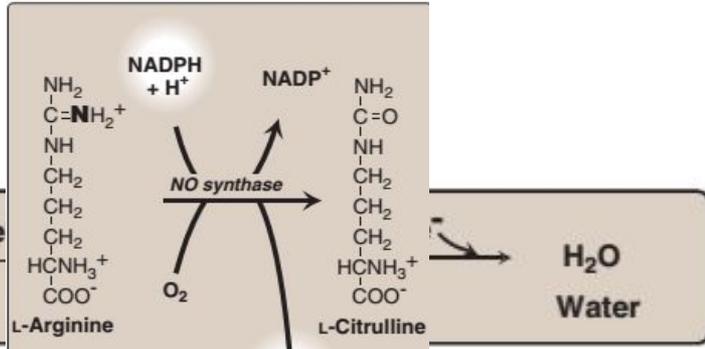
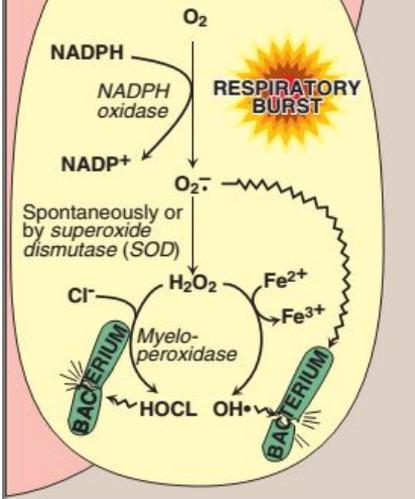
**1** Attachment of the pathogen to a phagocytic cell



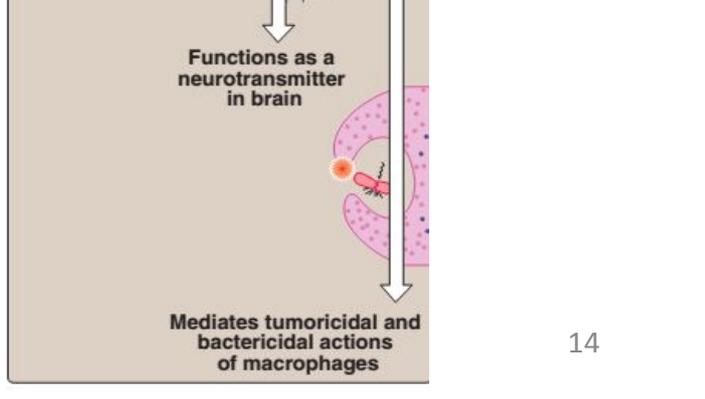
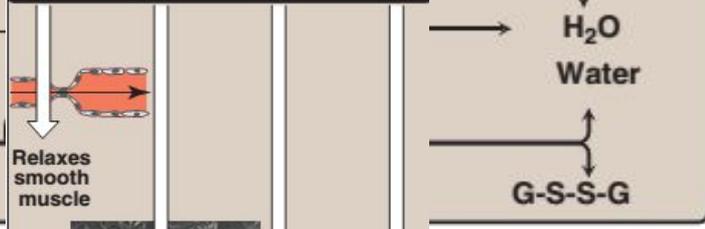
**2** Ingestion of the micro-organism



**3** Destruction of the microorganism

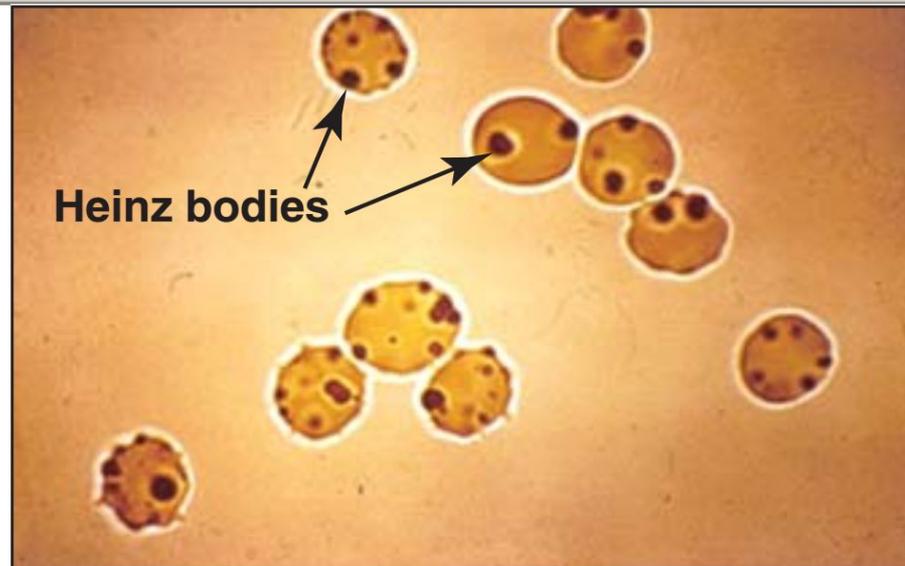
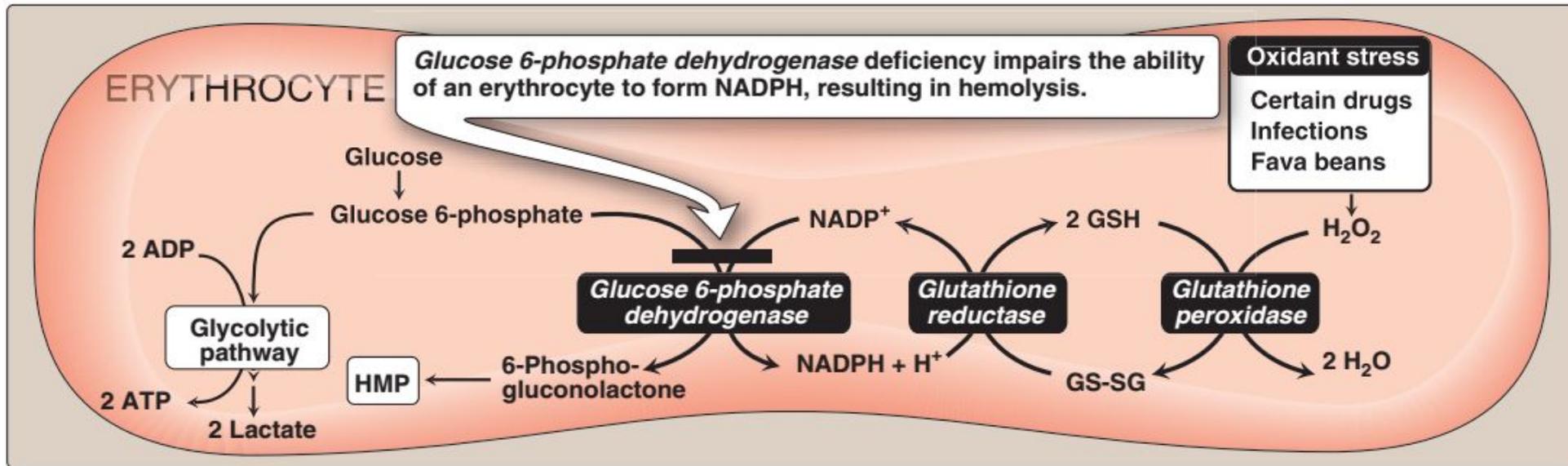


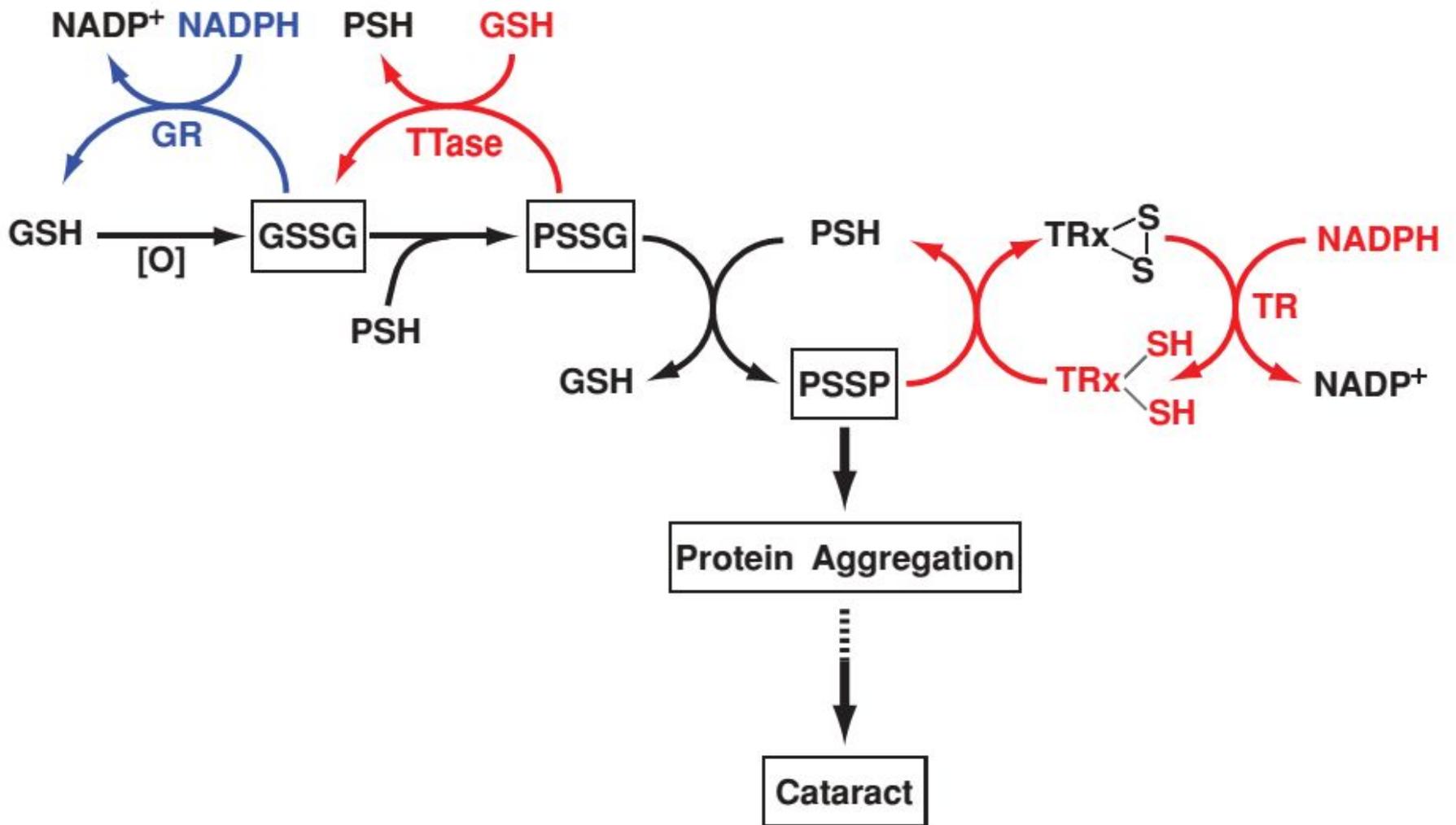
**Nitric oxide**



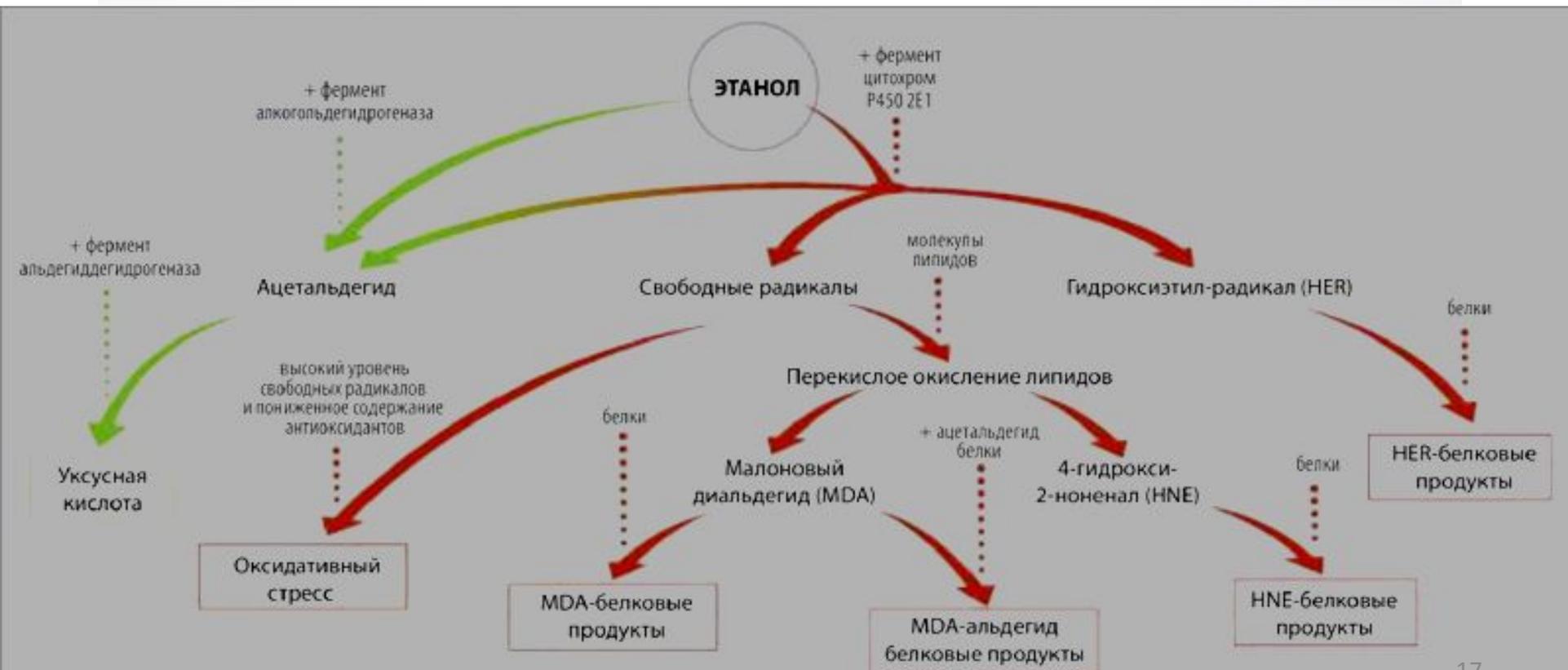
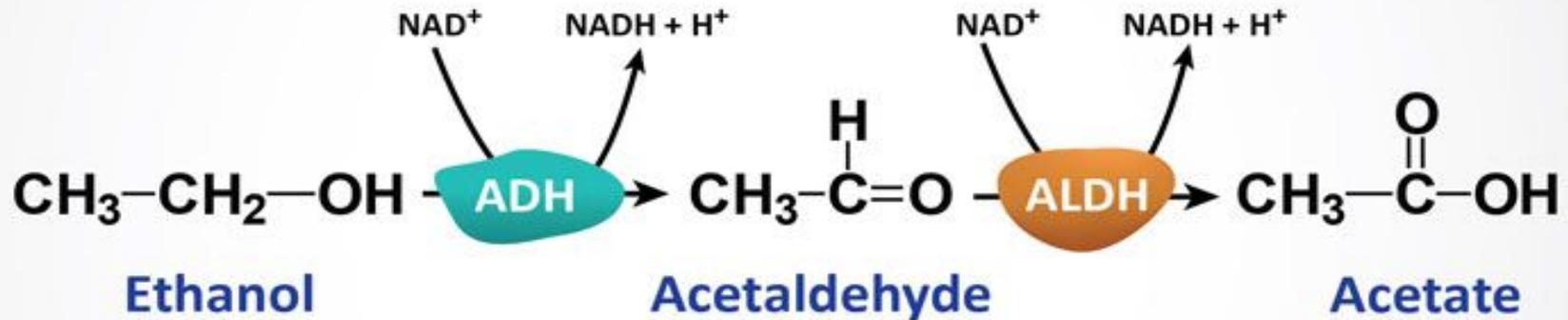
**Figure 13.7**  
*Cytochrome P450 monooxygenase cycle. Electrons move from NADPH to FAD to FMN to the heme iron.*

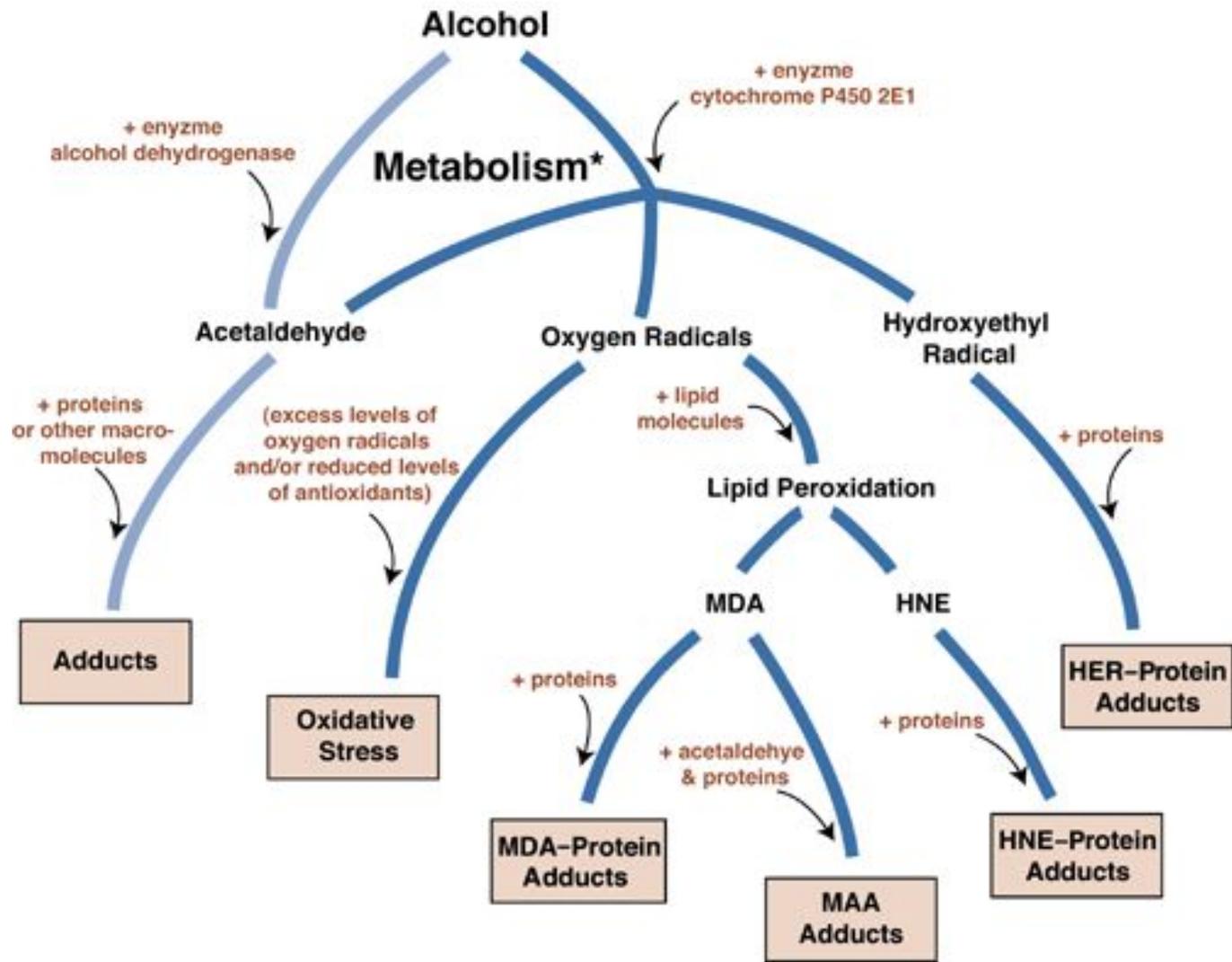
# Метаболизм в эритроците



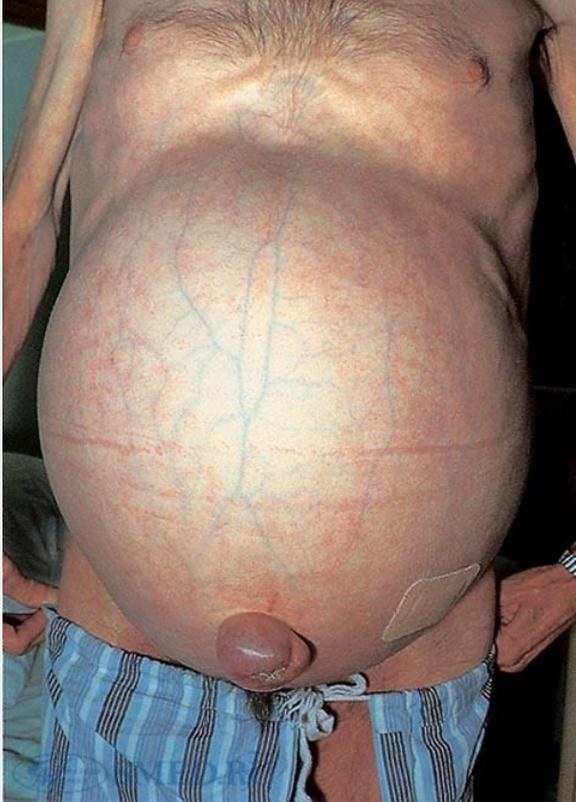
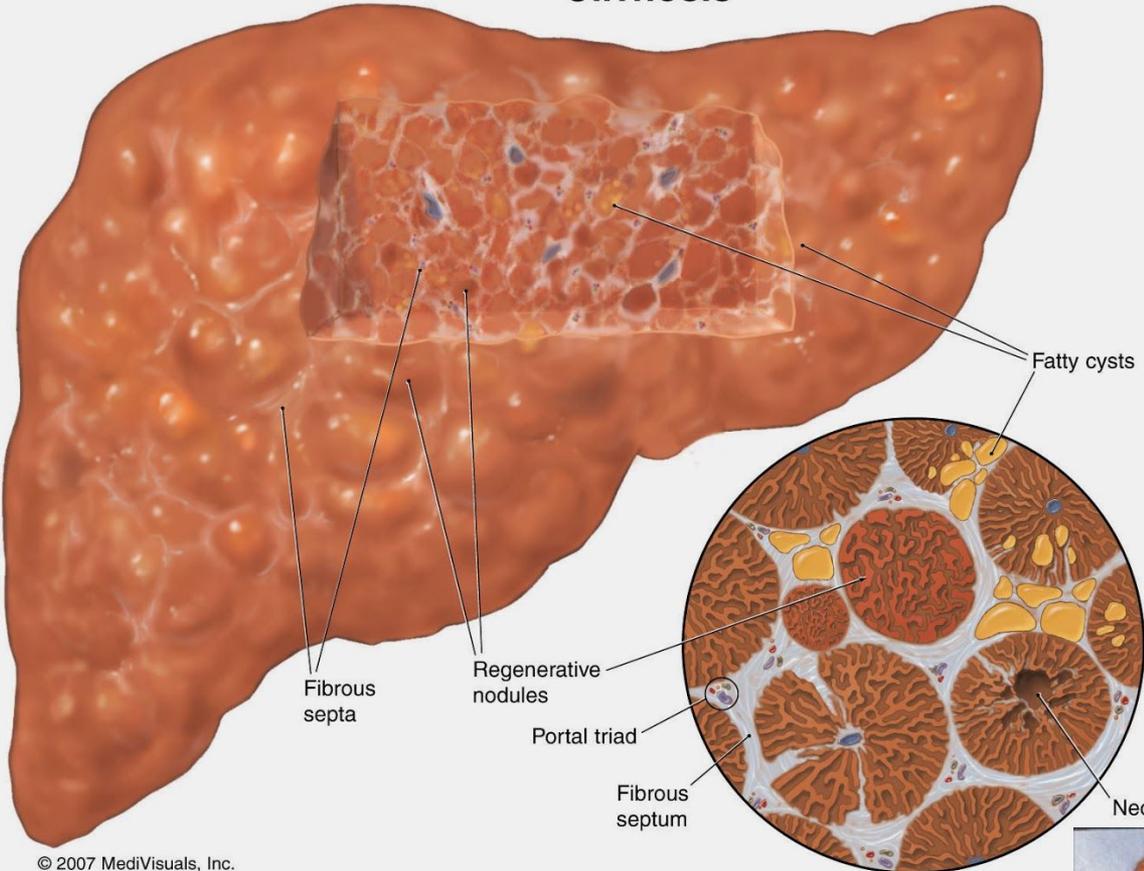


# Метаболизм этанола





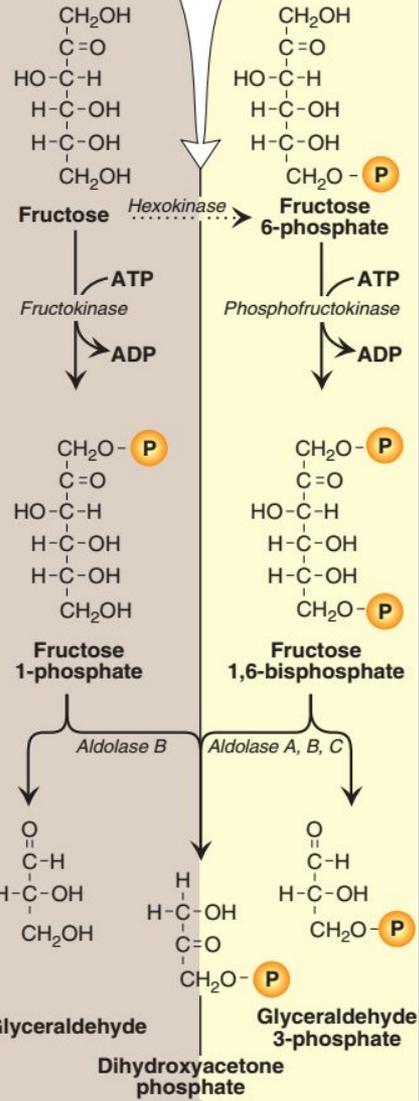
# Cirrhosis



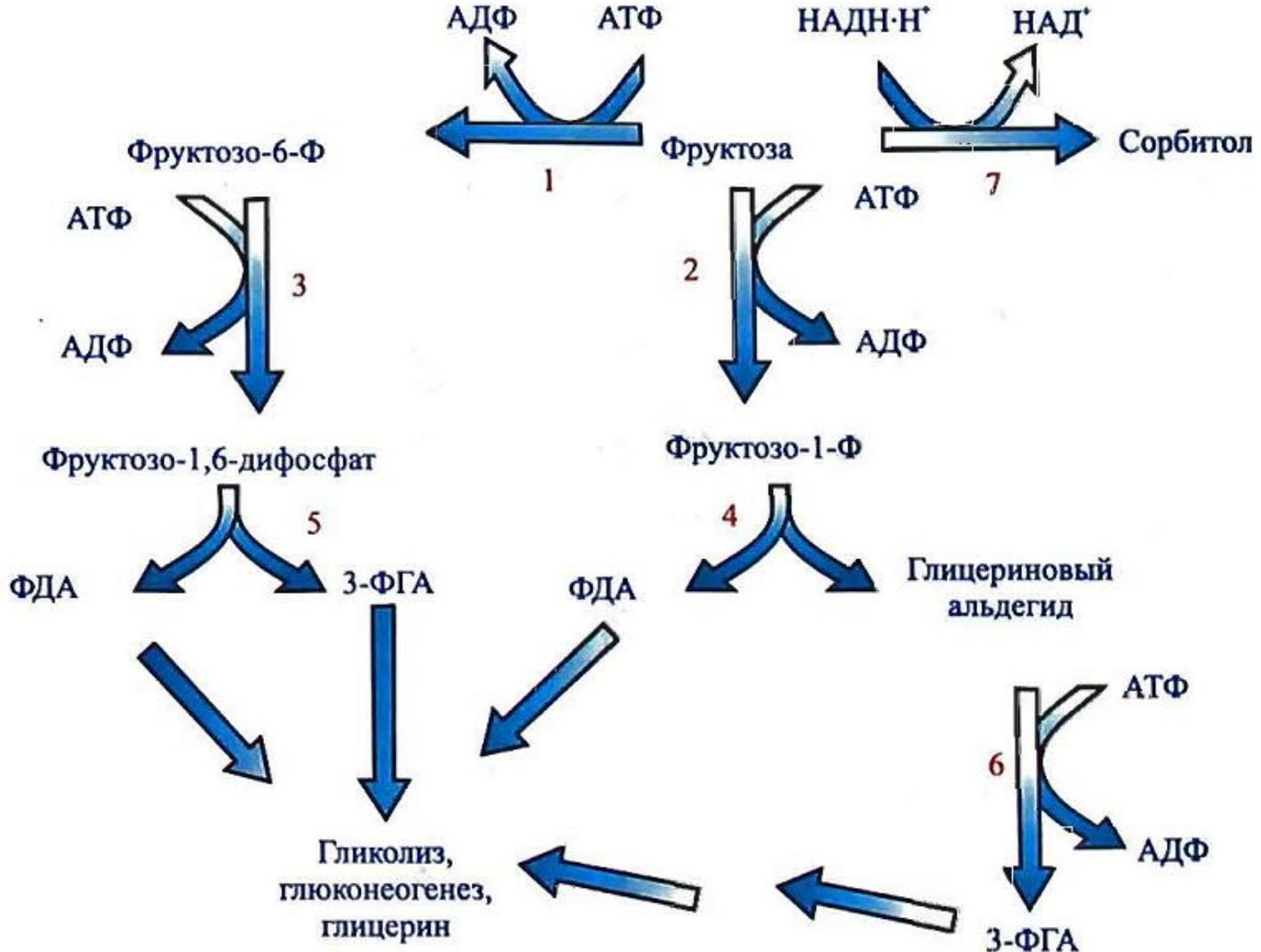
© 2007 MediVisuals, Inc.



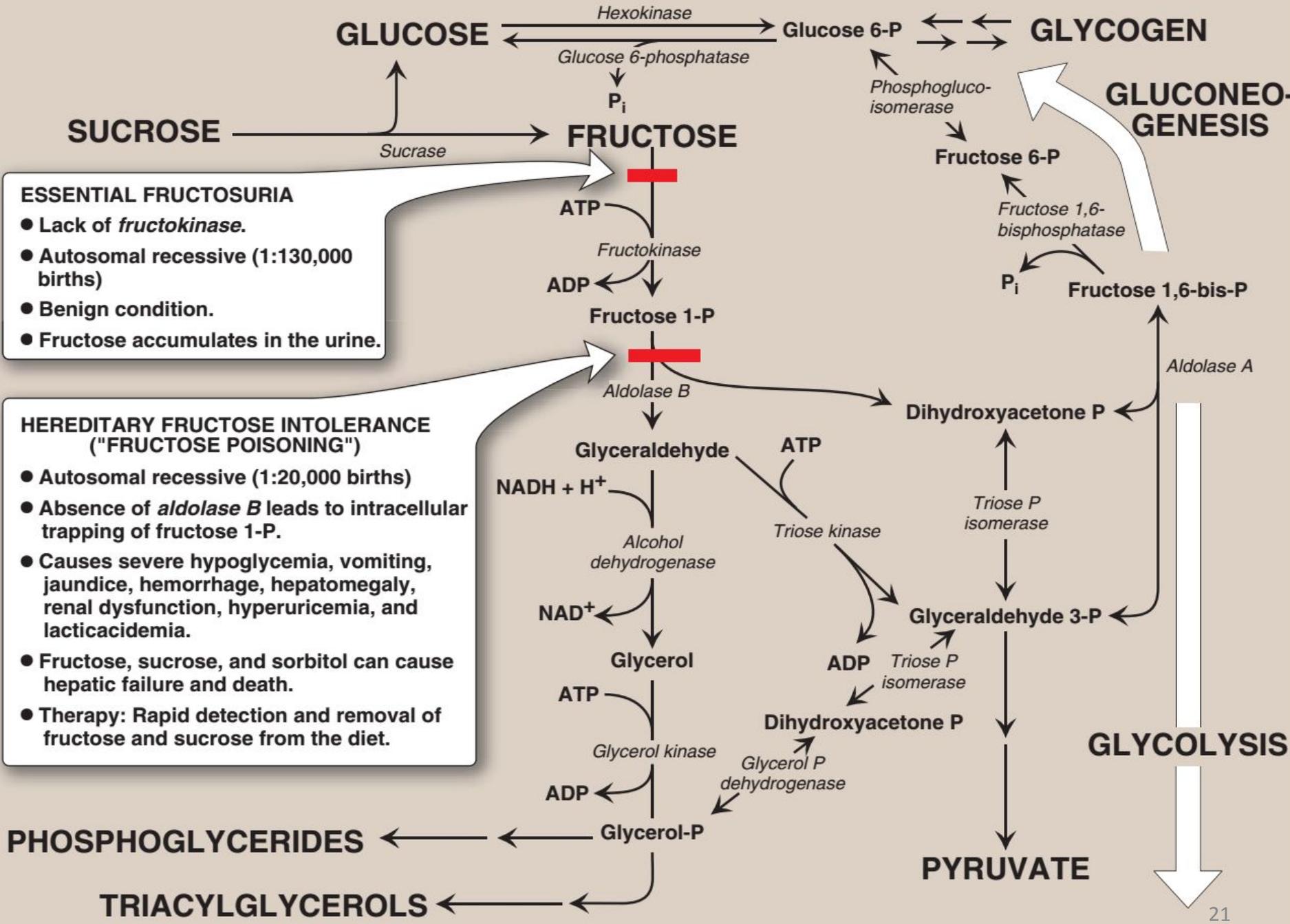
Unless the intracellular concentration of fructose becomes unusually high, *hexokinase* is saturated with and phosphorylates glucose rather than fructose.



# Метаболизм фруктозы



1. Гексокиназа; 2. Фруктокиназа; 3. ФФК; 4. Альдолаза В;
5. Альдолаза А; 6. Триозокиназа; 7. Альдозоредуктаза.



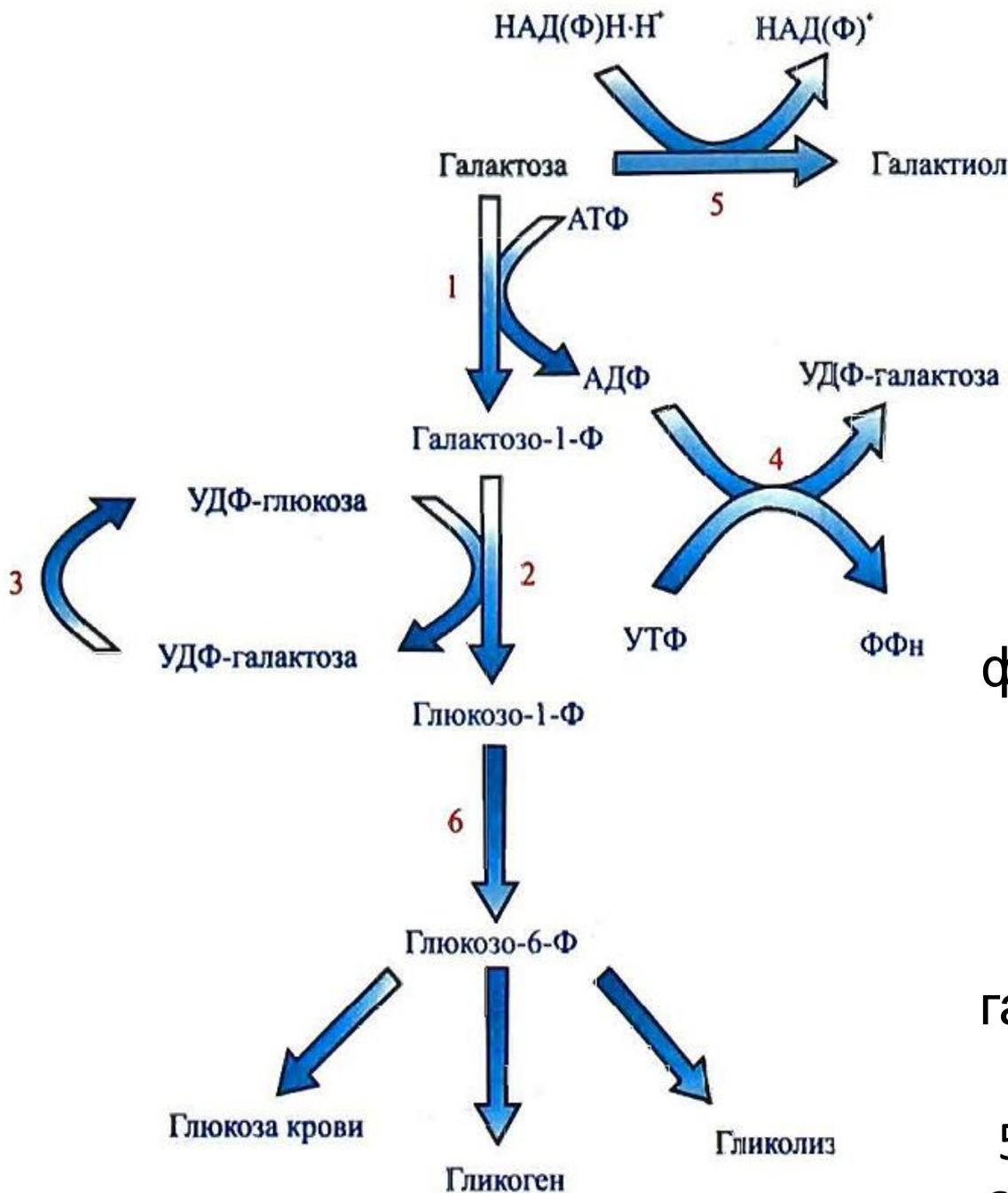
**ESSENTIAL FRUCTOSURIA**

- Lack of *fructokinase*.
- Autosomal recessive (1:130,000 births)
- Benign condition.
- Fructose accumulates in the urine.

**HEREDITARY FRUCTOSE INTOLERANCE ("FRUCTOSE POISONING")**

- Autosomal recessive (1:20,000 births)
- Absence of *aldolase B* leads to intracellular trapping of fructose 1-P.
- Causes severe hypoglycemia, vomiting, jaundice, hemorrhage, hepatomegaly, renal dysfunction, hyperuricemia, and lacticacidemia.
- Fructose, sucrose, and sorbitol can cause hepatic failure and death.
- Therapy: Rapid detection and removal of fructose and sucrose from the diet.

# Обмен галактозы



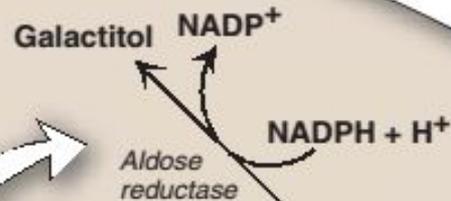
1. Галактокиназа;
2. Галактозо-1-фосфатуридилтрансфераза;
3. УДФ-галактозо-4-эпимераза;
4. УДФ-галактозопирофосфорилаза;
5. Альдозоредуктаза;
6. Фосфоглюкомутаза.

### GALACTOKINASE DEFICIENCY

- Rare autosomal recessive disorder
- Causes elevation of galactose in blood (galactosemia) and urine (galactosuria)
- Causes galactitol accumulation if galactose is present in the diet.
- Elevated galactitol can cause cataracts.
- Treatment is dietary restriction.

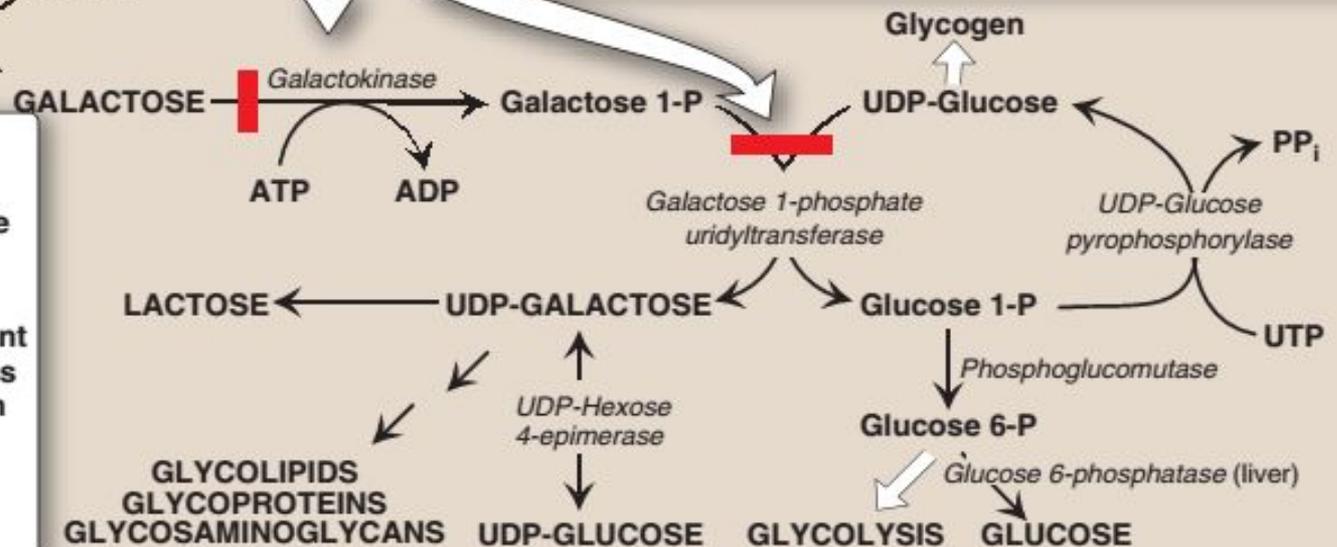
### CLASSIC GALACTOSEMIA

- *Galactose 1-phosphate uridylyltransferase (GALT)* deficiency.
- Autosomal recessive disorder (1:30,000 births).
- Causes galactosemia and galactosuria, vomiting, diarrhea, and jaundice.
- Accumulation of galactose 1-phosphate and galactitol in nerve, lens, liver, and kidney tissue causes liver damage, severe mental retardation, and cataracts.
- Prenatal diagnosis is possible by chorionic villus sampling. Newborn screening is available.
- Therapy: Rapid diagnosis and removal of galactose (and therefore lactose) from the diet.
- Despite adequate treatment, at risk for developmental delays and, in females, premature ovarian failure.

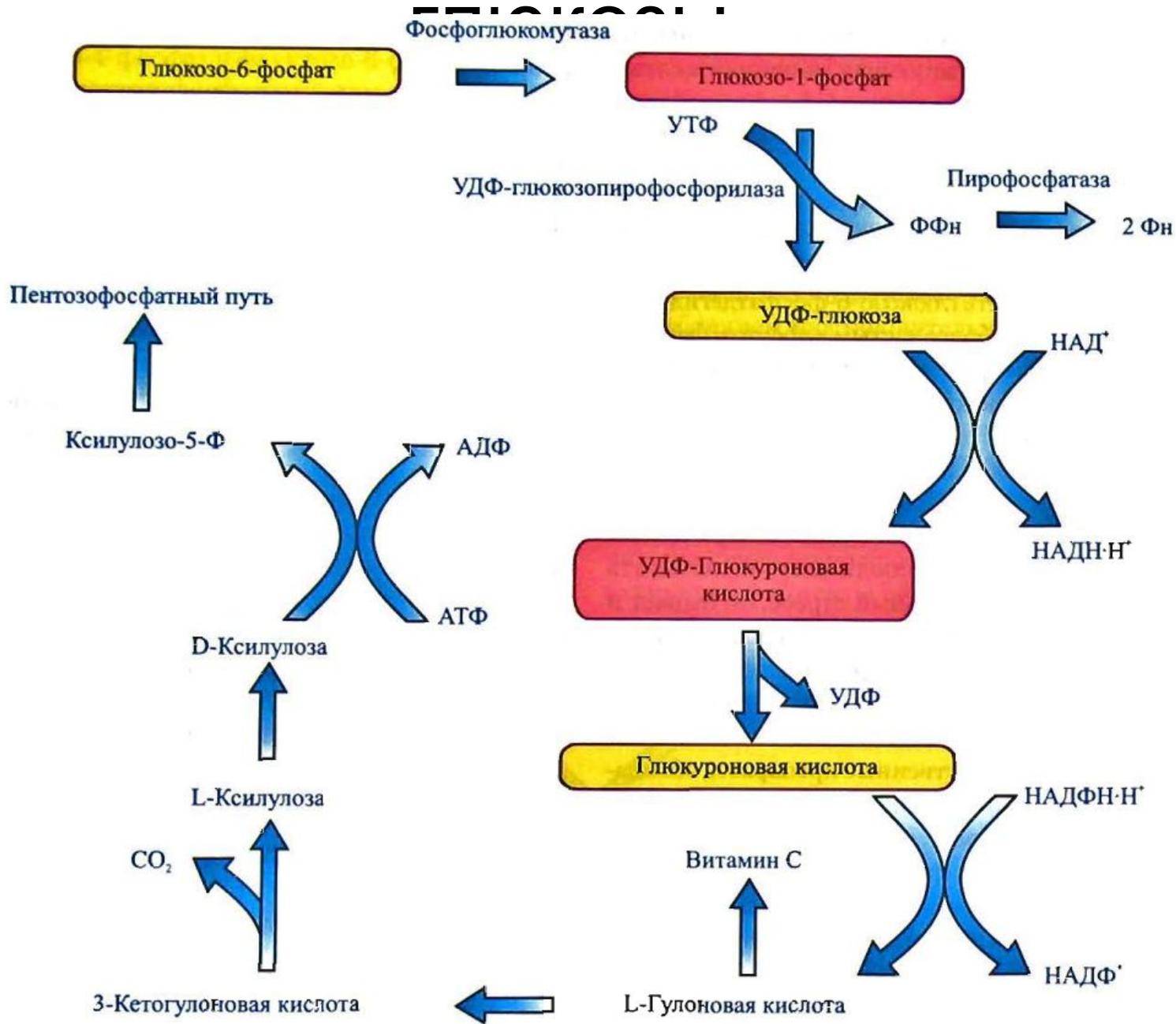


### ALDOSE REDUCTASE

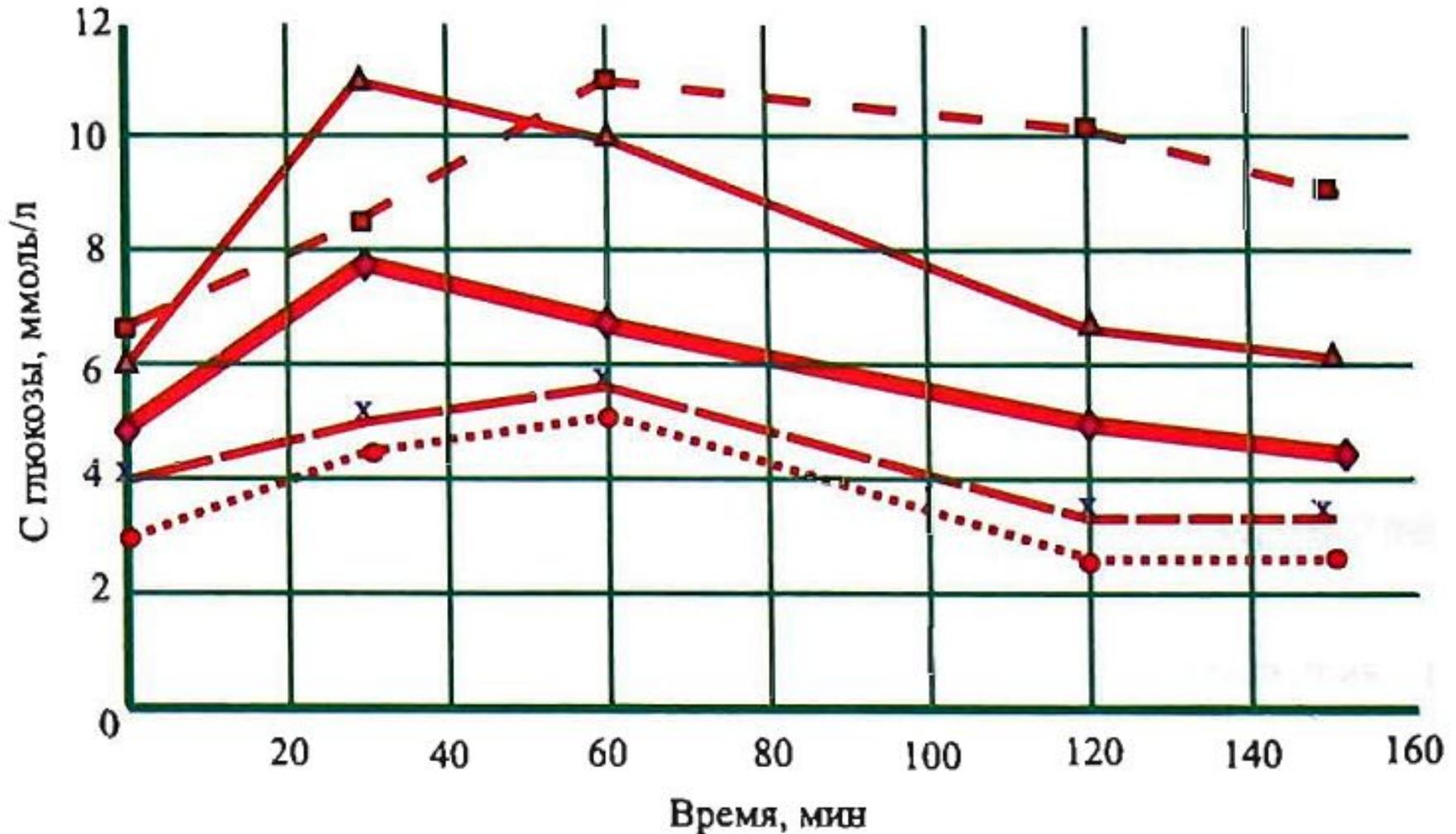
- The enzyme is present in liver, kidney, retina, lens, nerve tissue, seminal vesicles, and ovaries.
- It is physiologically unimportant in galactose metabolism unless galactose levels are high (as in galactosemia).
- Elevated galactitol can cause cataracts.



# I люкуроновый путь обмена



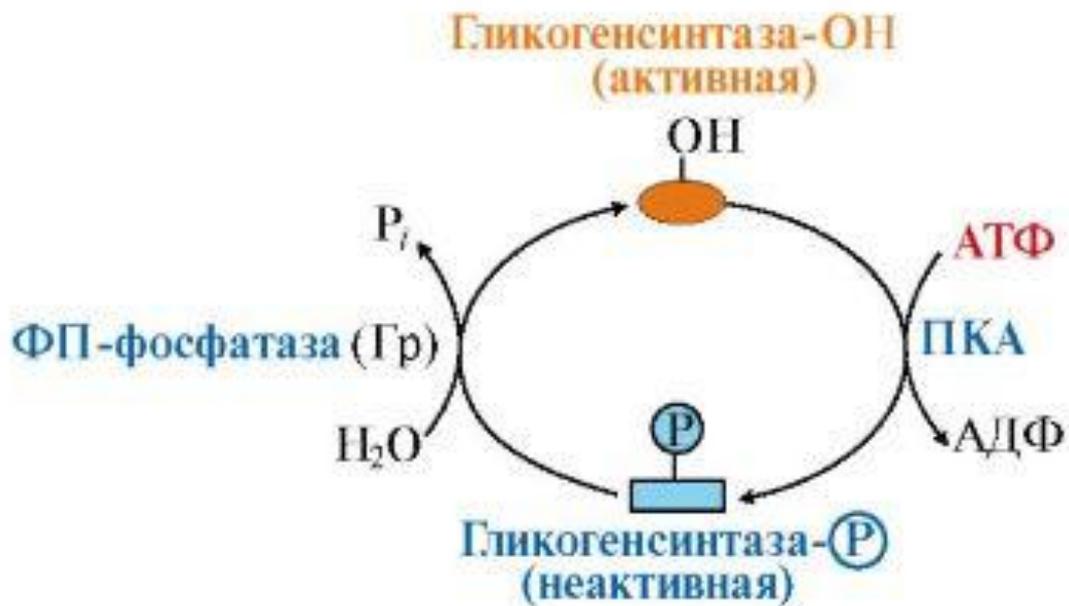
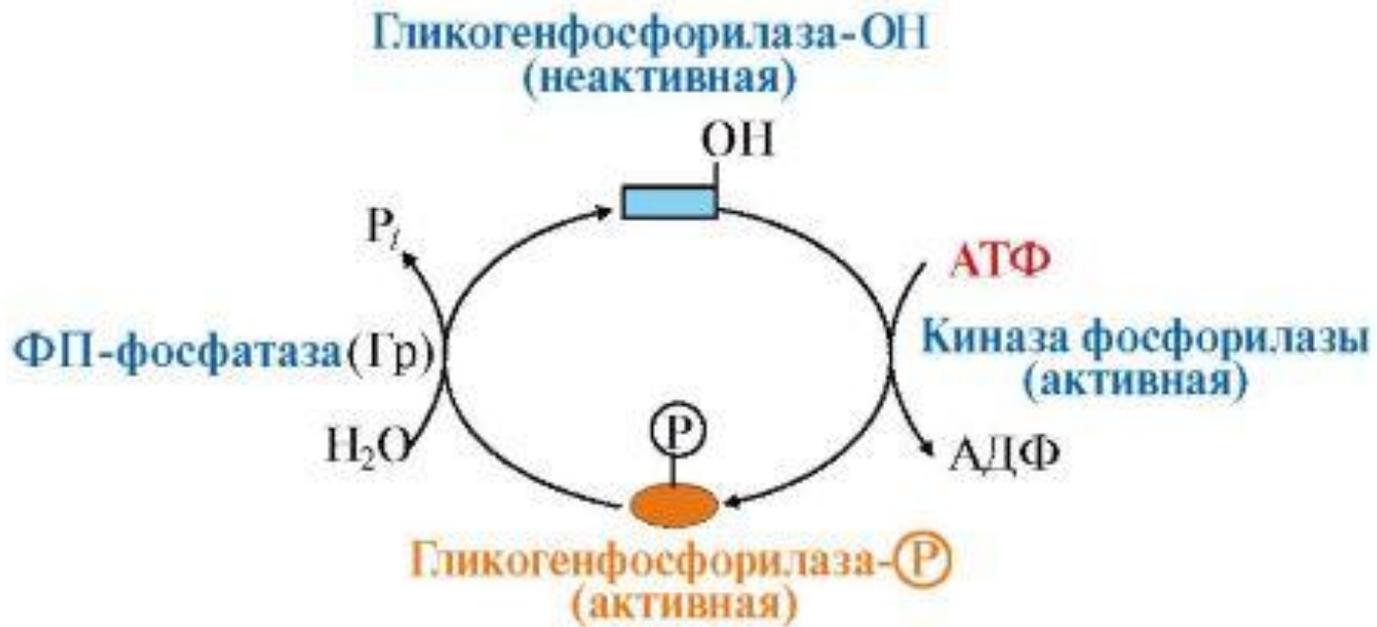
# Изменение концентрации глюкозы в норме и при патологиях



◆ норма    □ диабет    ▲ гипертиреоз    × микседема    ● гиперинсулинизм

# Микседема





# РЕГУЛЯЦИЯ ГЛИКОЛИЗА И ГЛЮКОНЕОГЕНЕЗА В ПЕЧЕНИ

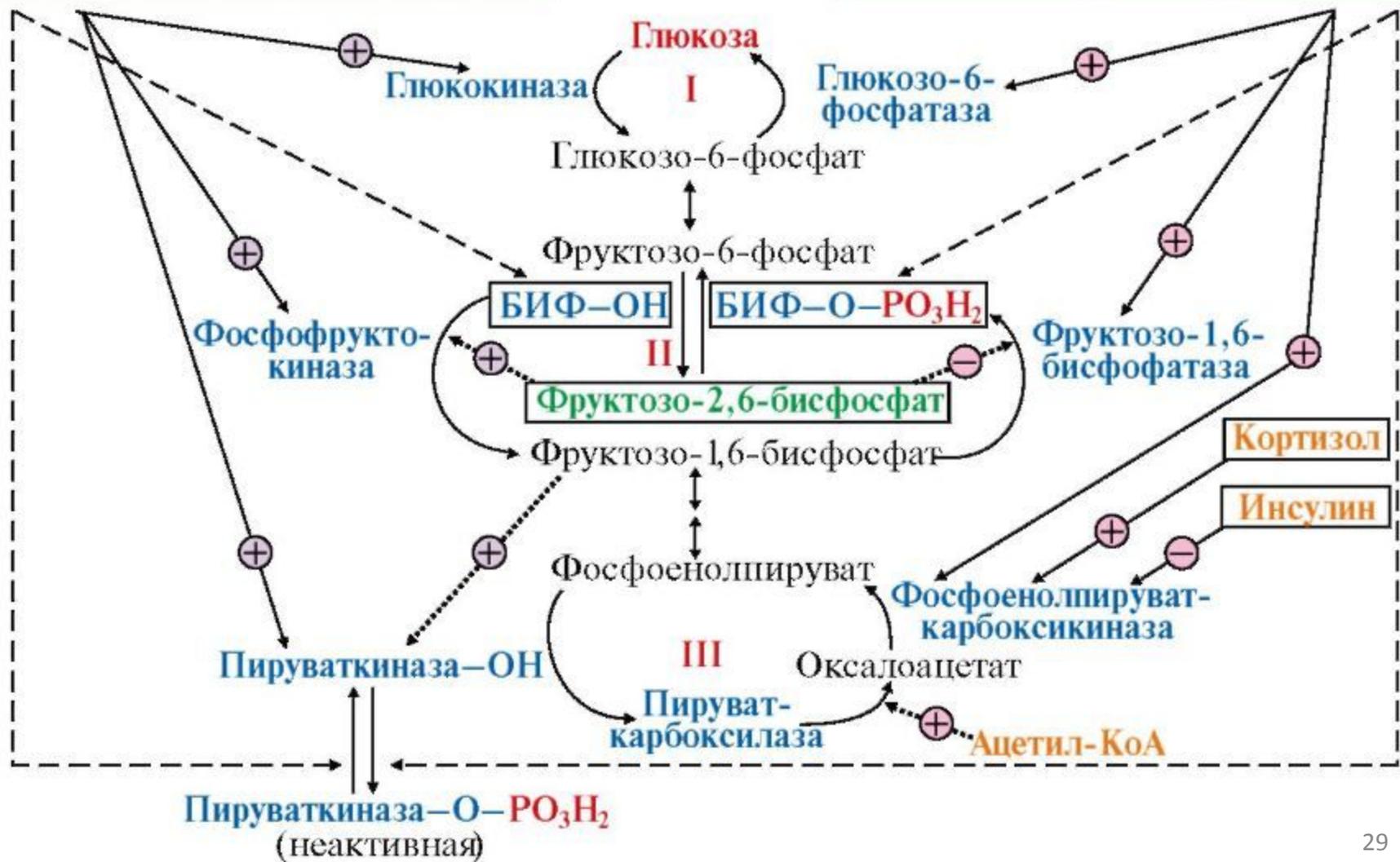
1. Переключение метаболизма печени с гликолиза на глюконеогенез и наоборот происходит при помощи:

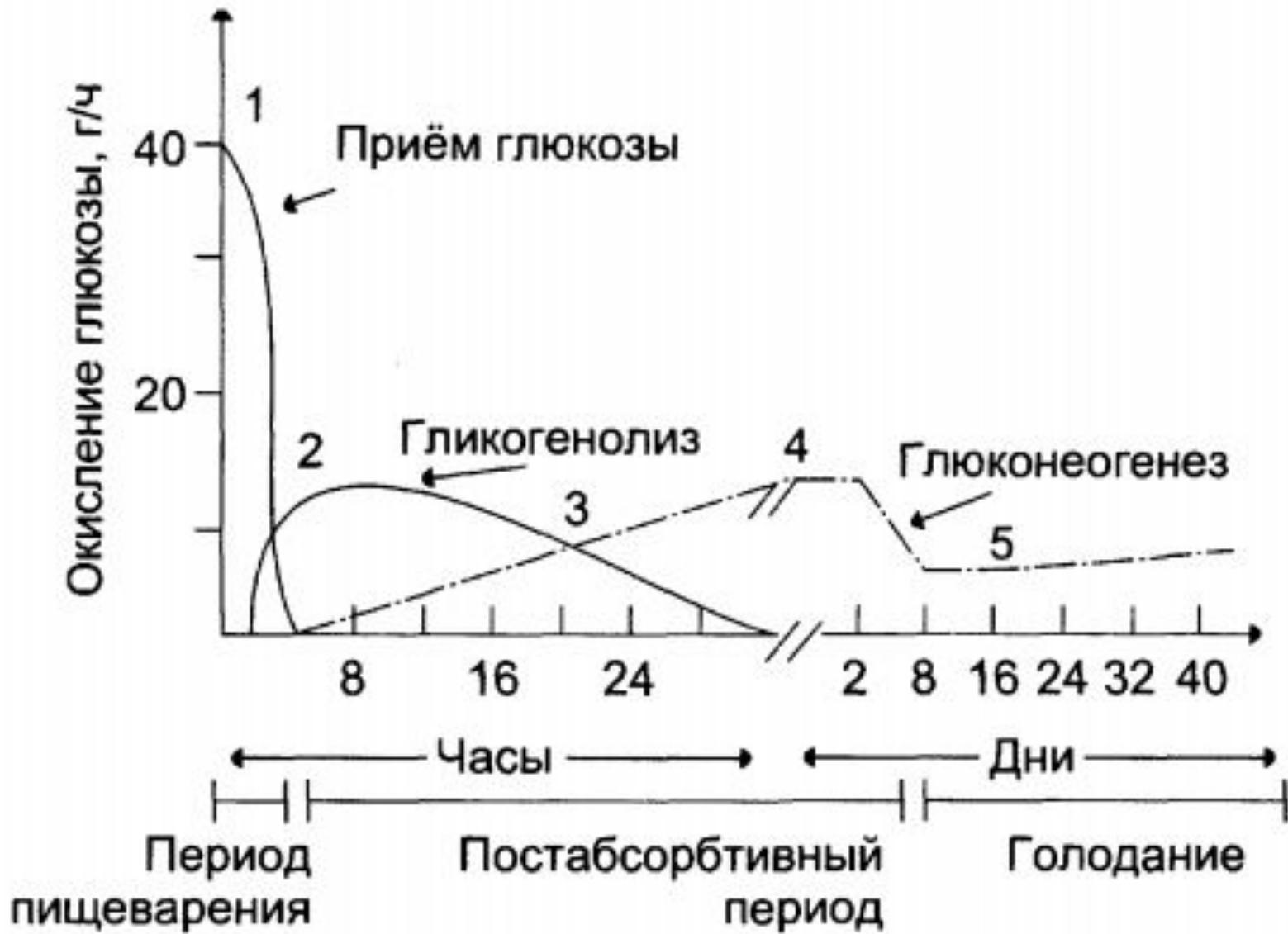
- аллостерических механизмов регуляции активности ключевых ферментов;
- ковалентной модификации ферментов путем фосфорилирования (дефосфорилирования) с участием инсулина и глюкагона;
- индукции (репрессии) синтеза ключевых ферментов, катализирующих реакции субстратных циклов.



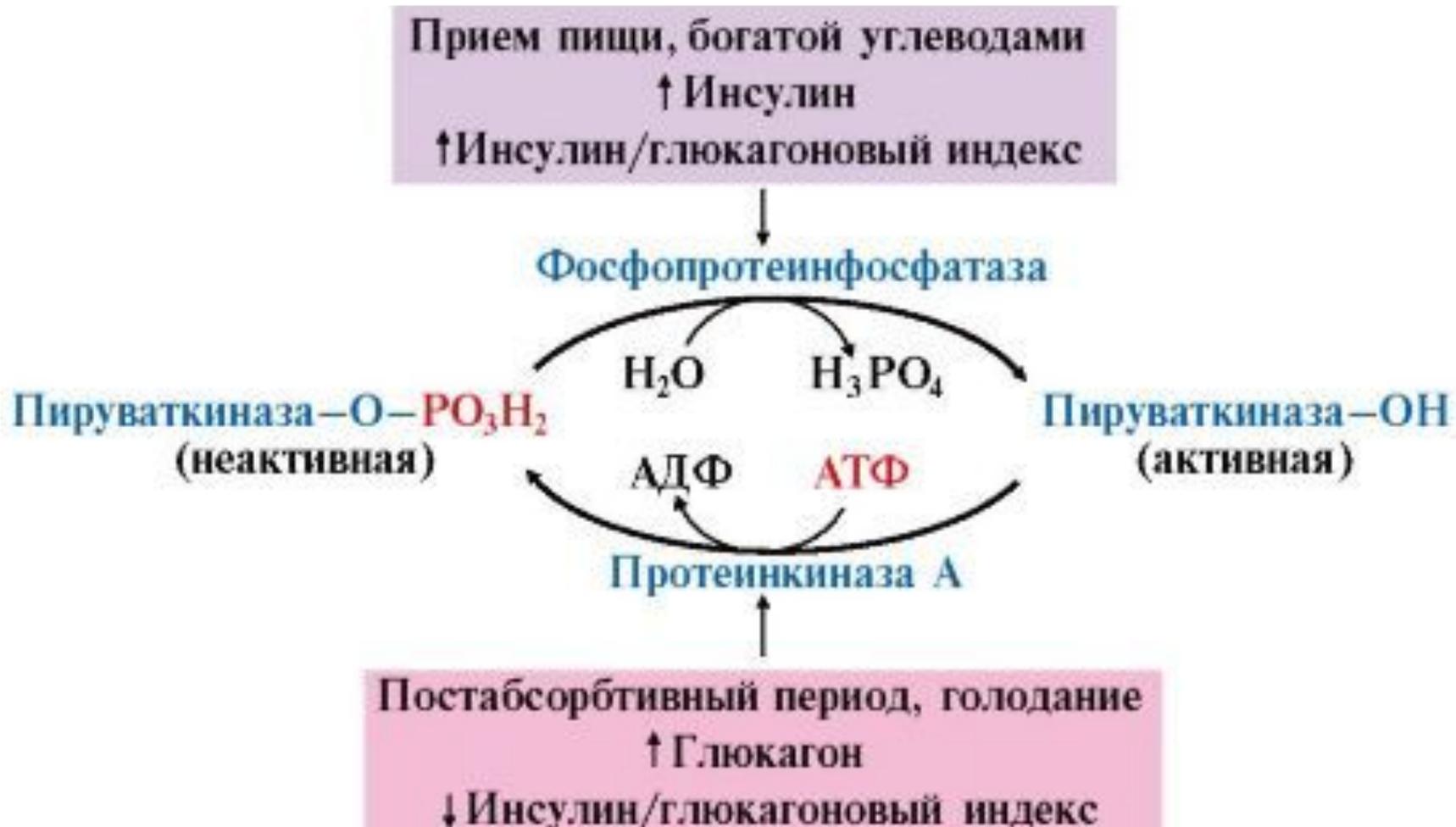
**Пищеварение**  
 ↑ Инсулин/глюкагоновый индекс

**Голодание**  
 ↓ Инсулин/глюкагоновый индекс

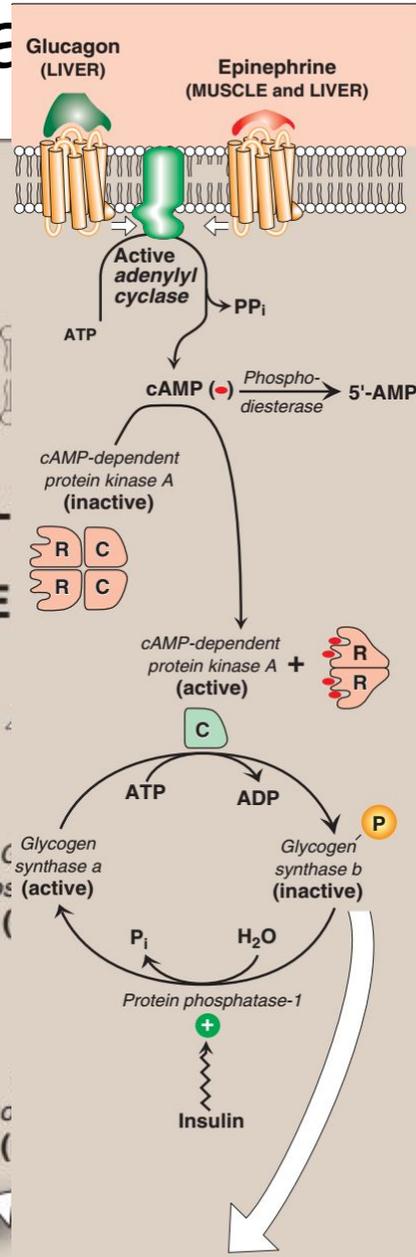




## Регуляция пируваткиназы в печени

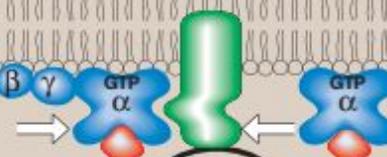


# Механизм действия глюкагона адреналина



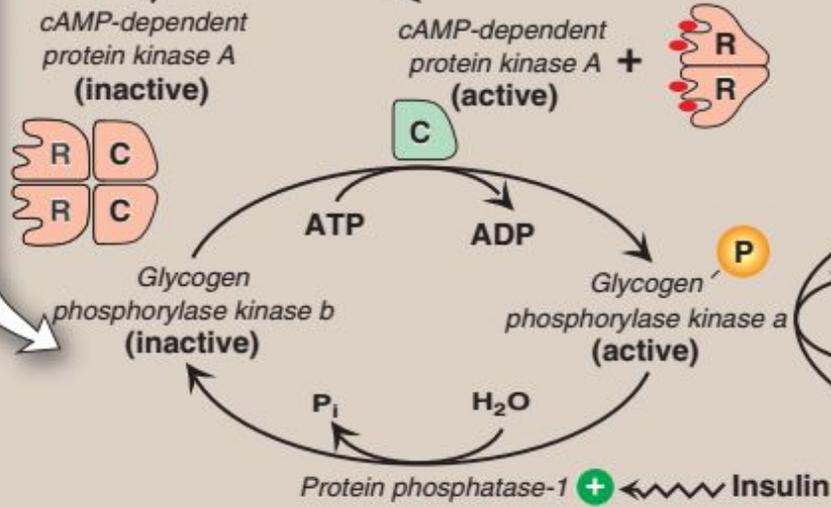
Glucagon bound to glucagon receptor (LIVER)

Epinephrine bound to  $\beta$ -adrenergic receptor (MUSCLE and LIVER)



## ROLE OF CALCIUM IN MUSCLE

During muscle contraction,  $Ca^{2+}$  is released from the sarcoplasmic reticulum.  $Ca^{2+}$  binds to the calmodulin subunit of *phosphorylase kinase*, activating it without phosphorylation. *Phosphorylase kinase* can then activate *glycogen phosphorylase*, causing glycogen degradation.

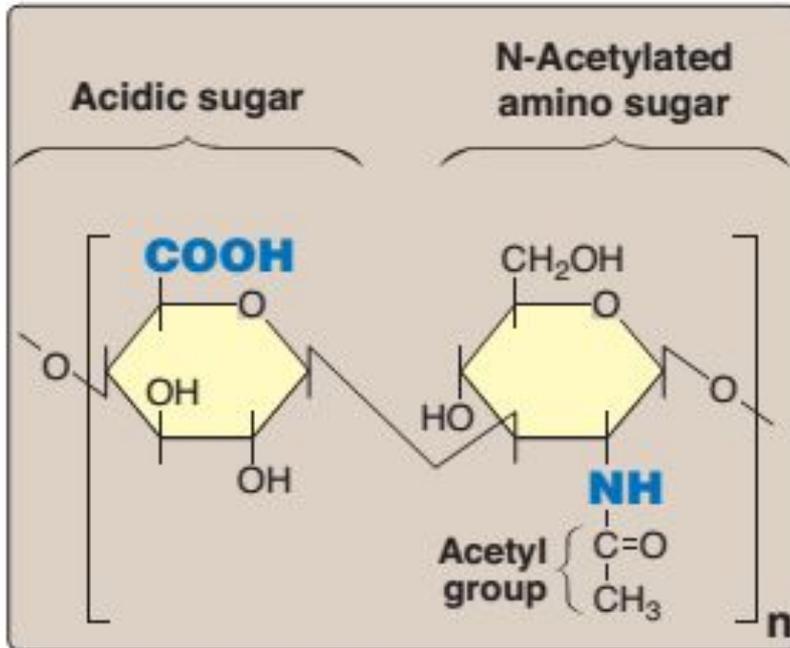


## ROLE OF AMP IN MUSCLE

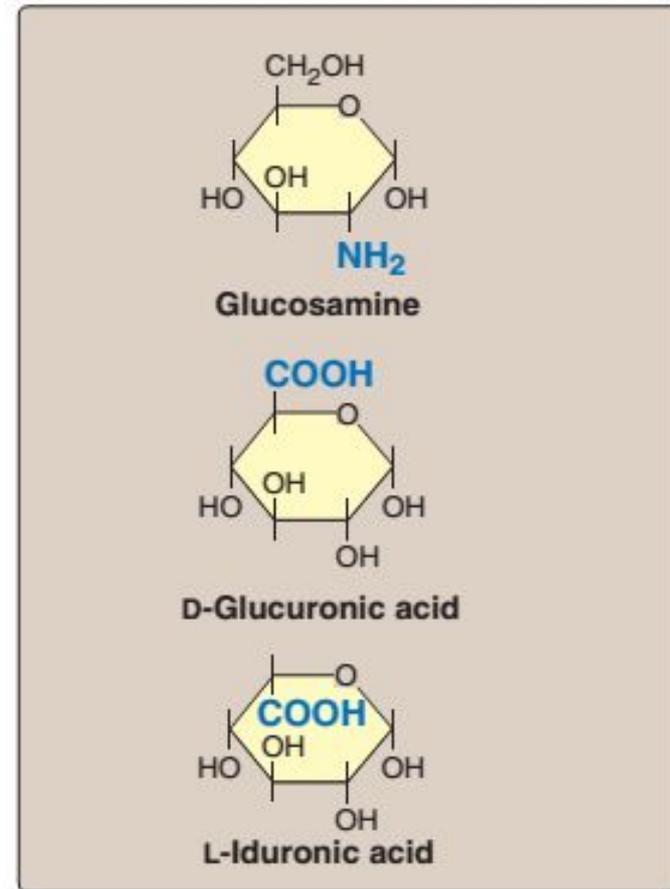
In muscle under extreme conditions of anoxia and depletion of ATP, AMP activates *glycogen phosphorylase b* without it being phosphorylated.

GLYCOGEN SYNTHESIS IS INHIBITED

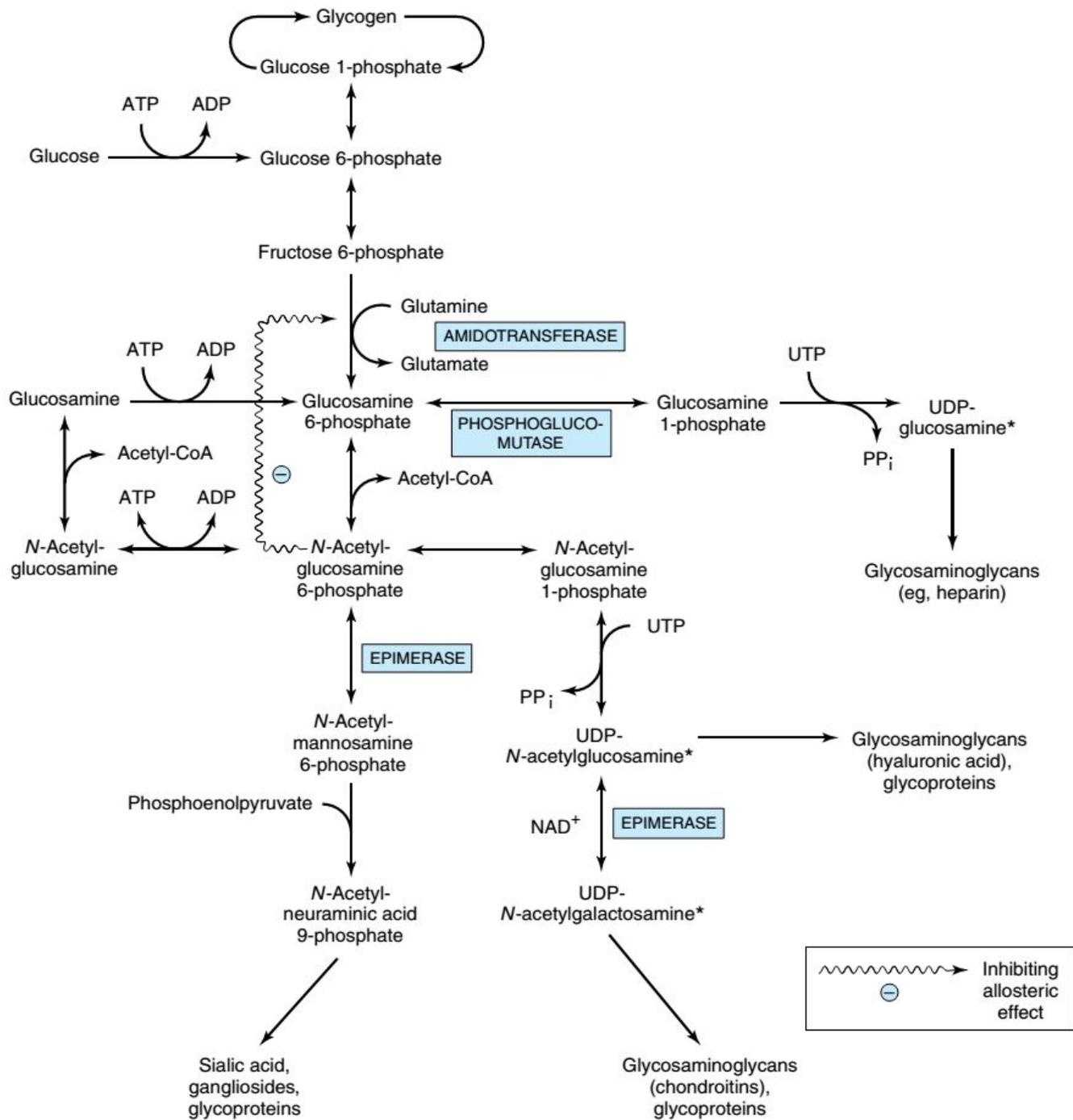
# Структурные компоненты ГАГ



**Figure 14.1**  
Repeating disaccharide unit.

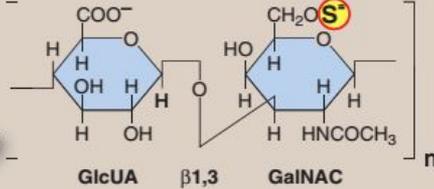
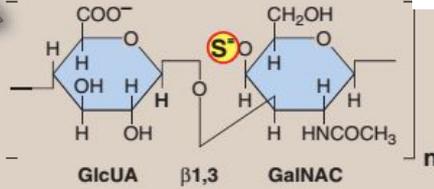


**Figure 14.2**  
Some monosaccharide units found  
in glycosaminoglycans.



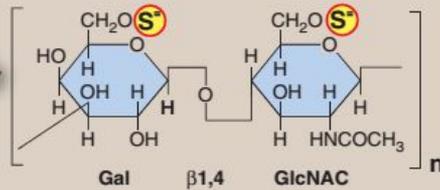
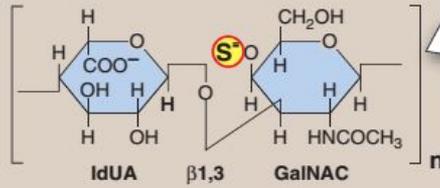
### CHONDROITIN 4- AND 6-SULFATES

- Disaccharide unit: N-acetylgalactosamine with sulfate on either C-4 or C-6, and glucuronic acid.
- Most abundant GAGs in the body.
- Found in cartilage, tendons, ligaments, and aorta.
- Form proteoglycan aggregates, often aggregating noncovalently with hyaluronic acid.
- In cartilage, they bind collagen and hold fibers in a tight, strong network.



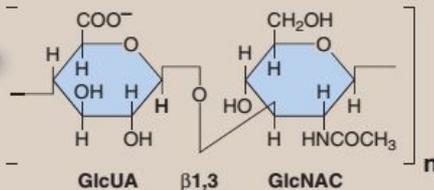
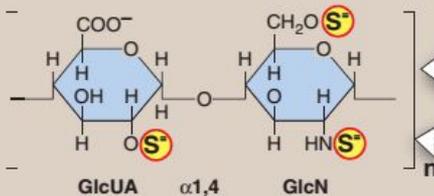
### KERATAN SULFATES I and II

- Disaccharide unit: N-acetylglucosamine and galactose (no uronic acid). Sulfate content is variable and may be present on C-6 of either sugar.
- Most heterogeneous GAGs because they contain additional monosaccharides such as L-fucose, N-acetylneuraminic acid, and mannose.
- KS II is found in loose connective tissue proteoglycan aggregates with chondroitin sulfate. KS I is found in cornea.



### HYALURONIC ACID (HYALURONATE)

- Disaccharide unit: N-acetylglucosamine and glucuronic acid.
- Different from other GAGs: Unsulfated, not covalently attached to protein, and only GAG not limited to animal tissue, but also found in bacteria.
- Serves as a lubricant and shock absorber.
- Found in synovial fluid of joints, vitreous humor of the eye, the umbilical cord, loose connective tissue and cartilage.



### DERMATAN SULFATE

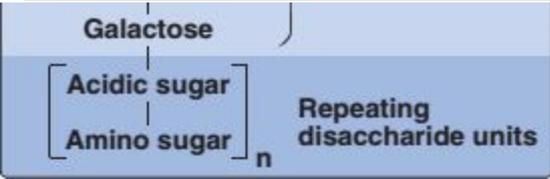
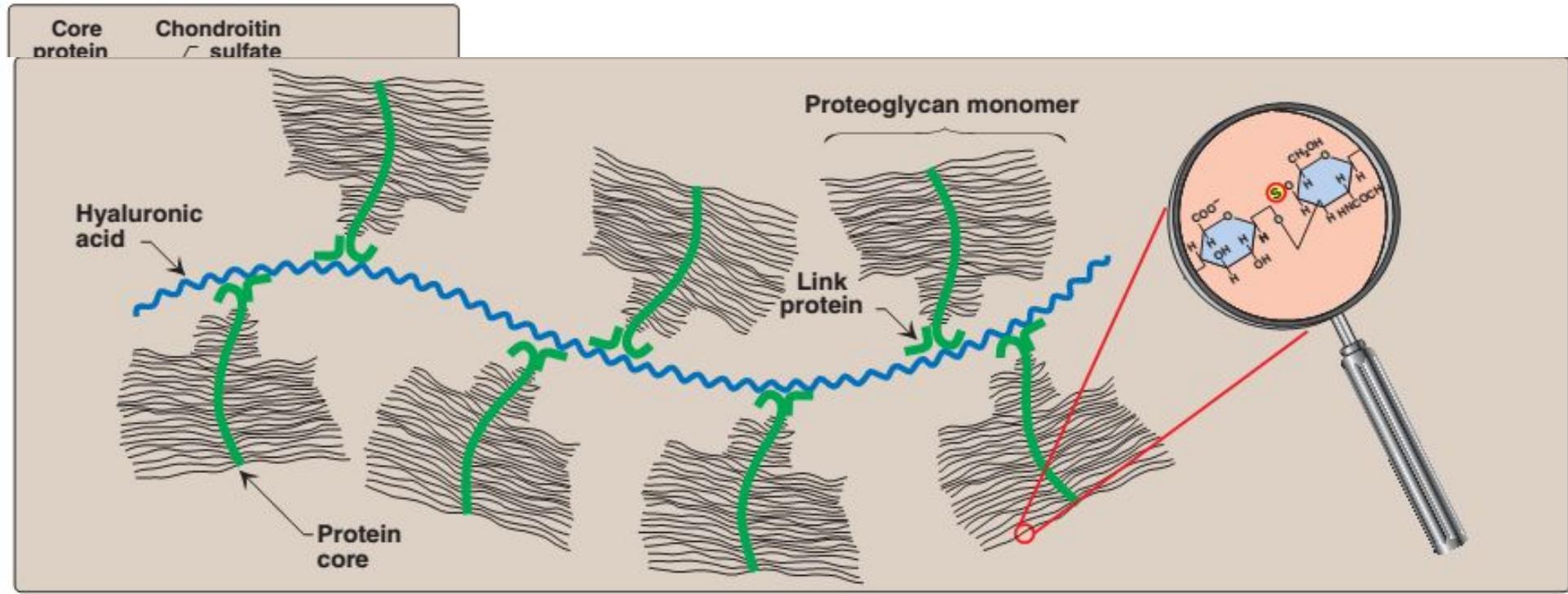
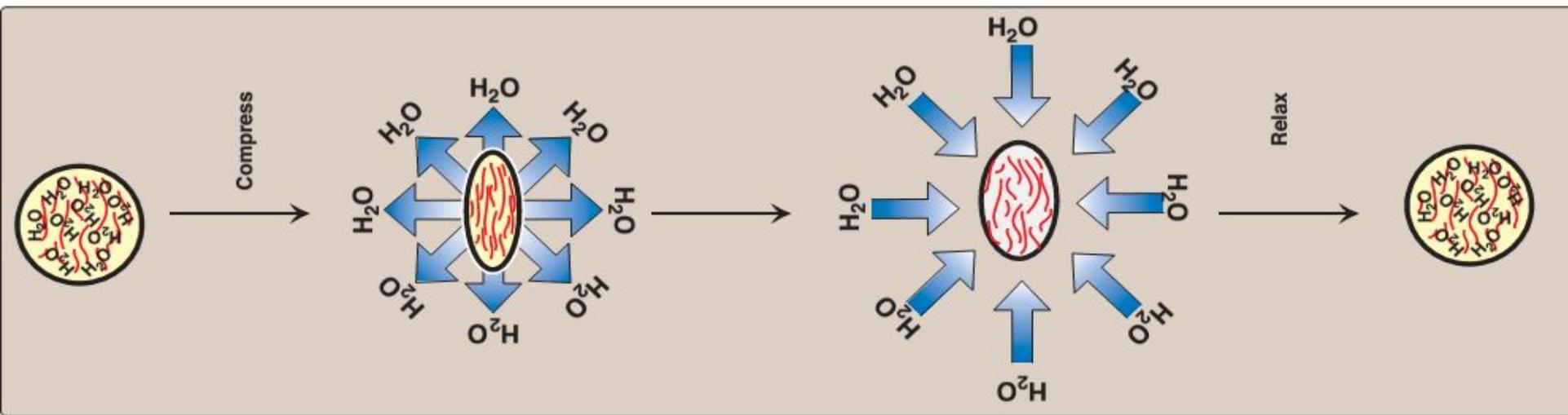
- Disaccharide unit: N-acetylgalactosamine and L-iduronic acid (with variable amounts of glucuronic acid).
- Found in skin, blood vessels, and heart valves.

### HEPARIN

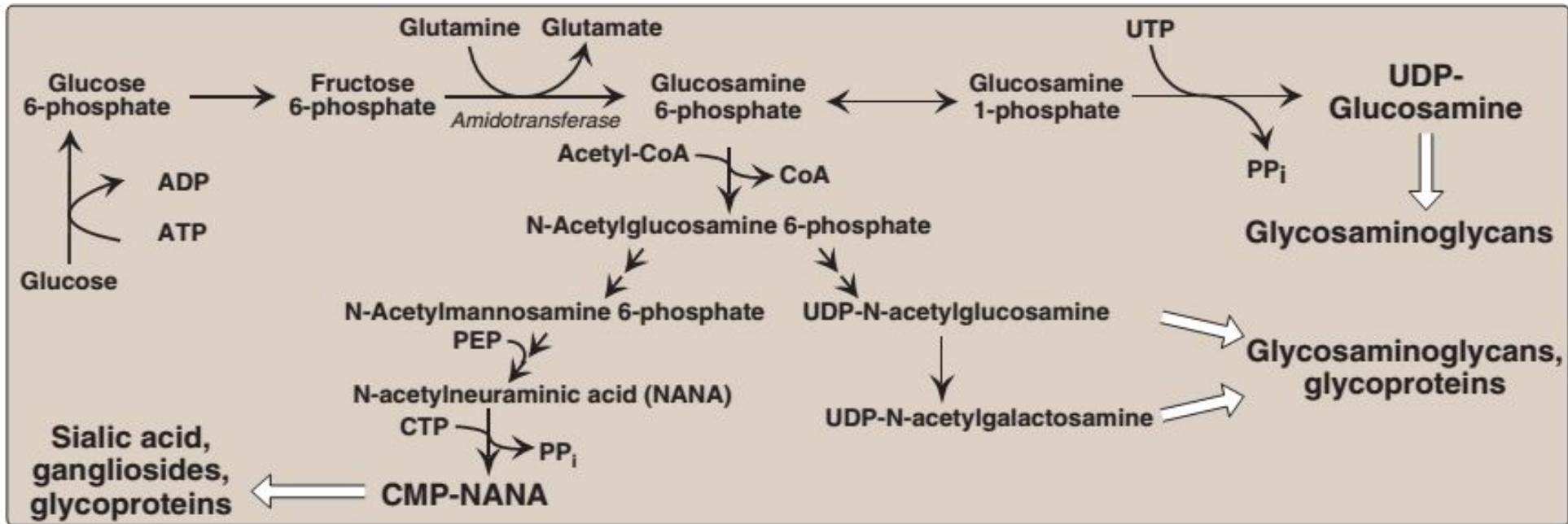
- Disaccharide unit: Glucosamine and glucuronic or iduronic acid. Most glucosamine residues are bound in sulfamide linkages. Sulfate is also found on C-3 or C-6 of glucosamine and C-2 of uronic acid (an average of 2.5 S per disaccharide unit).
- $\alpha$ -Linkage joins the sugars.
- Unlike other GAGs that are extracellular compounds, heparin is an intracellular component of mast cells that line arteries, especially in liver, lungs, and skin.
- Serves as an anticoagulant.

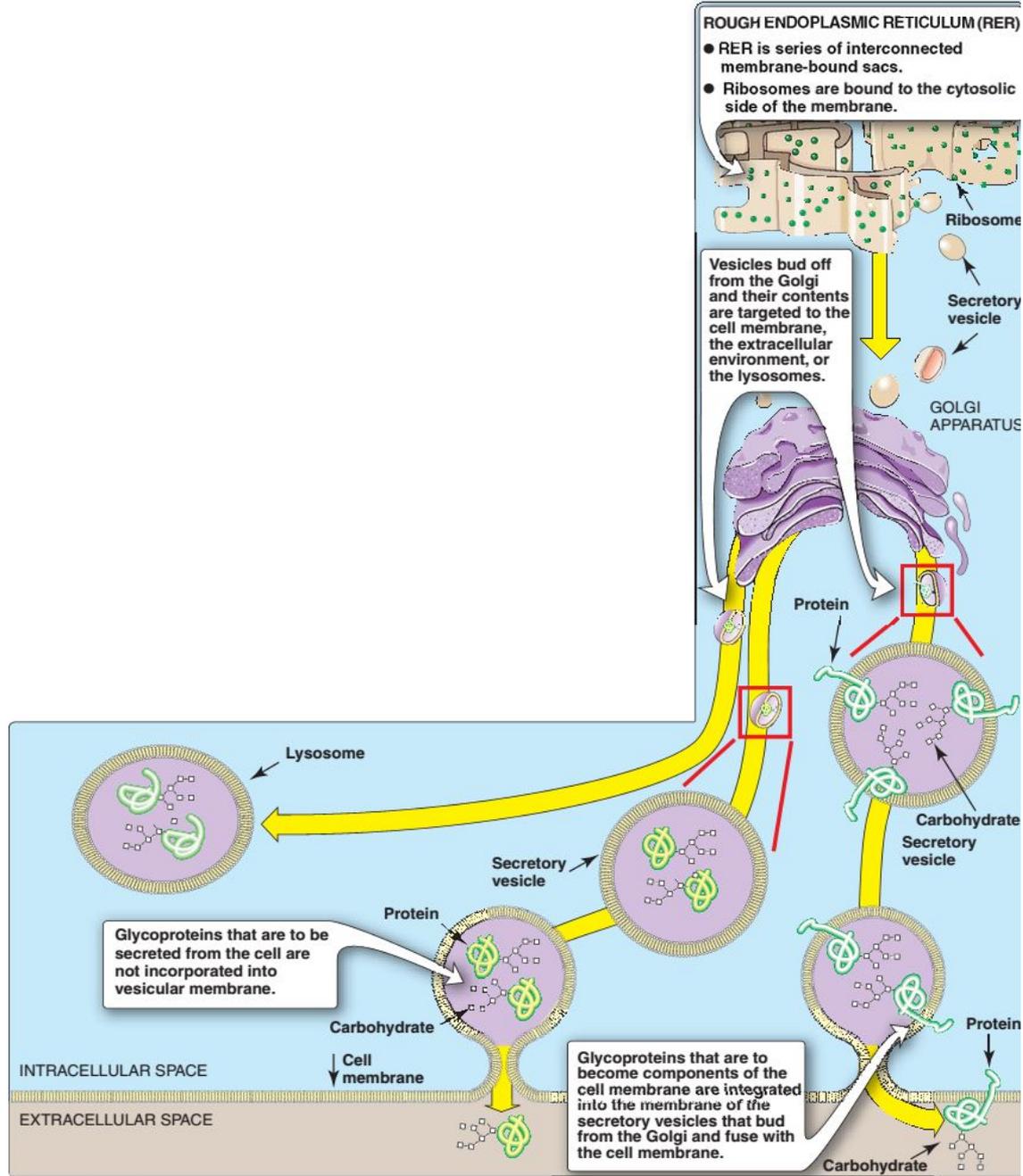
### HEPARAN SULFATE

- Disaccharide unit: Same as heparin except some glucosamines are acetylated and there are fewer sulfate groups.
- Extracellular GAG, found in basement membrane and as a ubiquitous component of cell surfaces.



# Схема синтеза ГАГ





**Figure 14.15**

Transport of glycoproteins through the Golgi apparatus and their subsequent release or incorporation into a lysosome or the cell membrane.