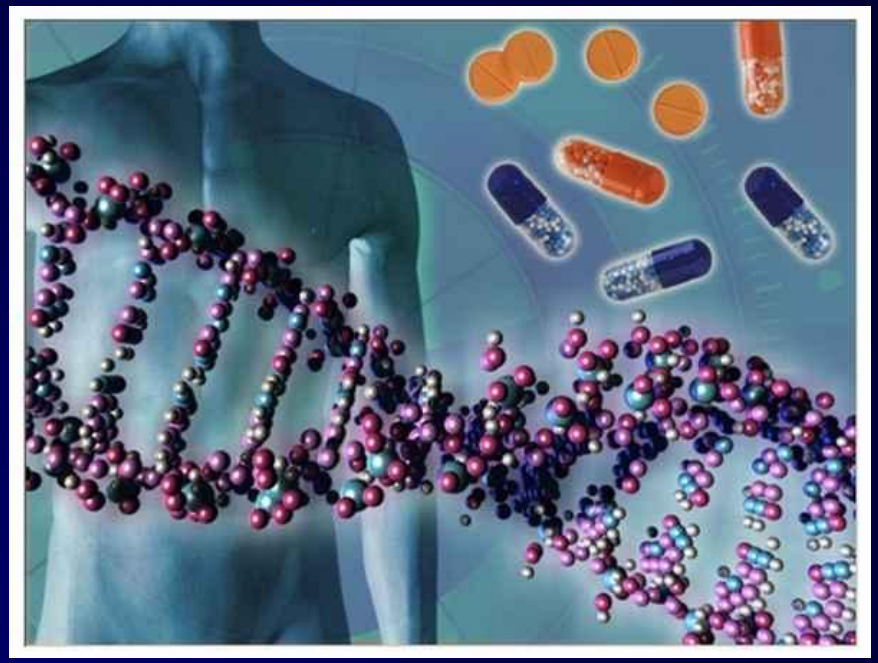
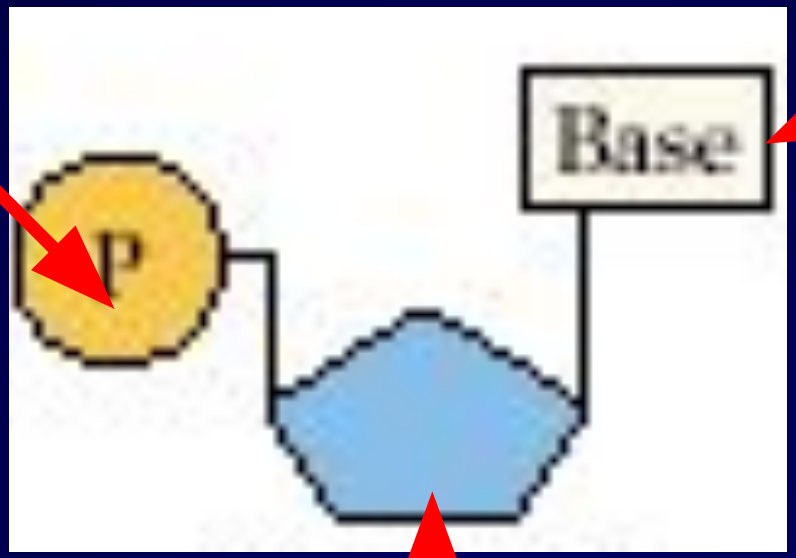


Лекция №3

Структурная и химическая организация ДНК и РНК. Ген как единица наследственности. Этапы биосинтеза белка

Строение нуклеотида

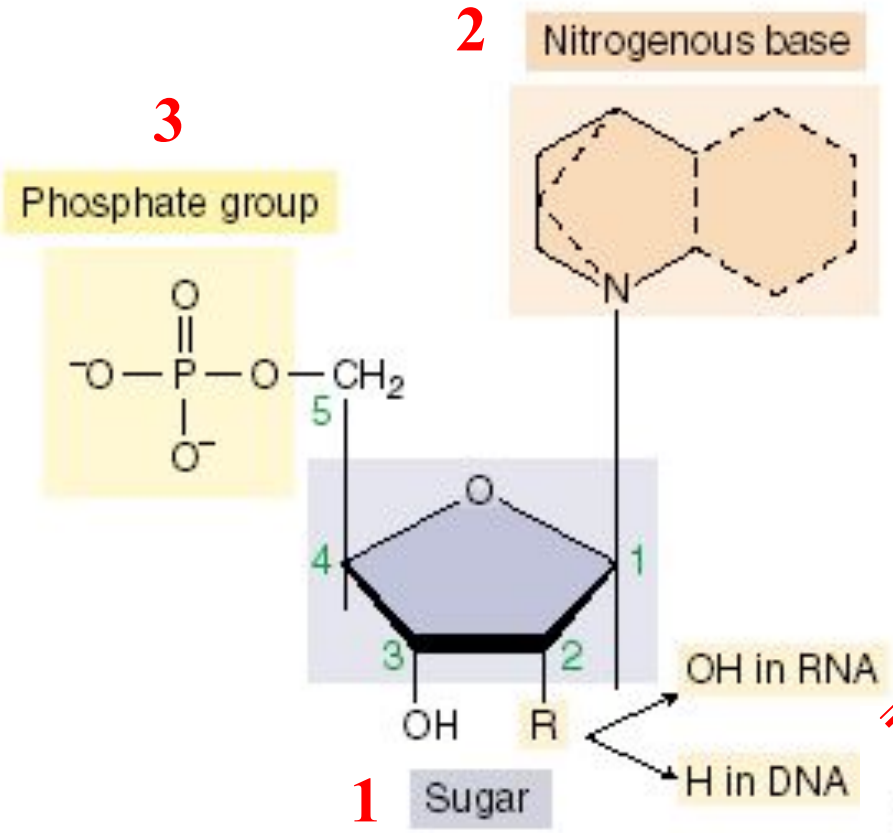
3 - Остаток фосфорной кислоты

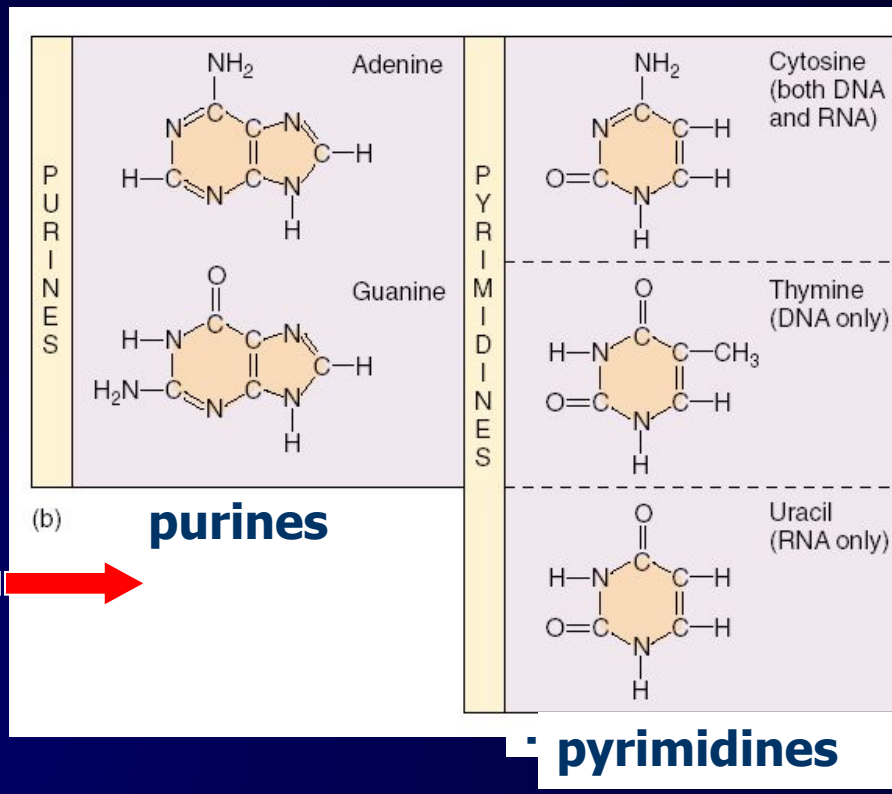


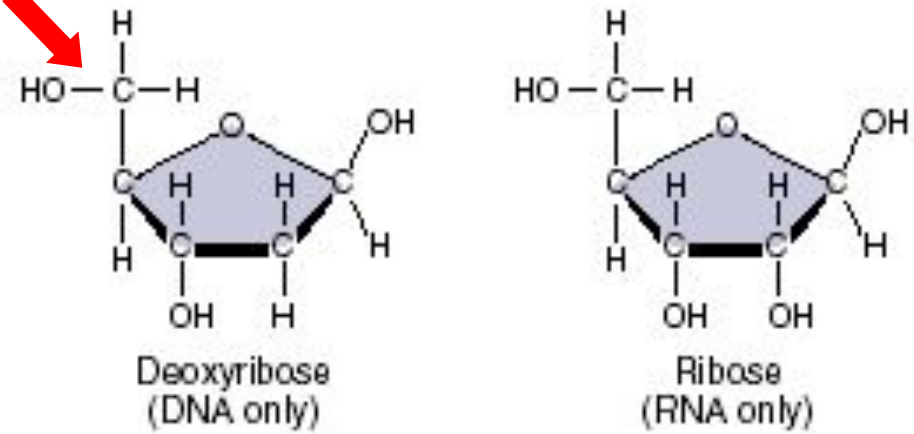
2 - Азотистое основание

1 - Сахар

Строение нуклеотида







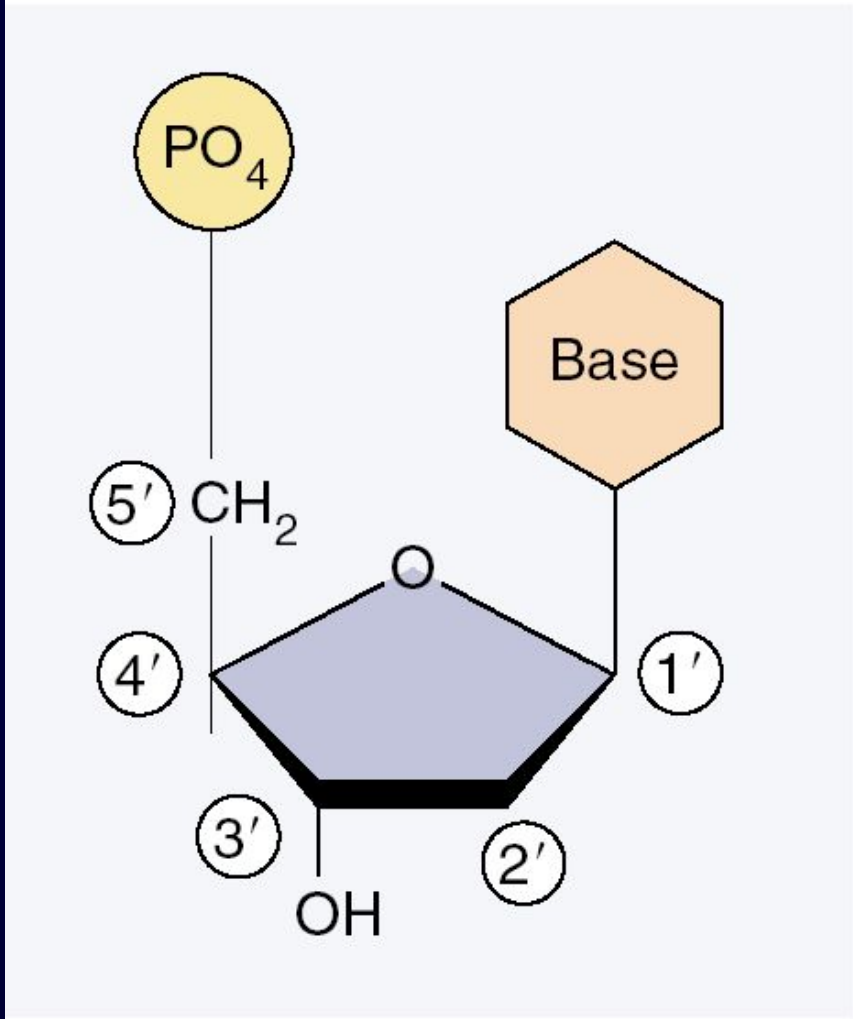
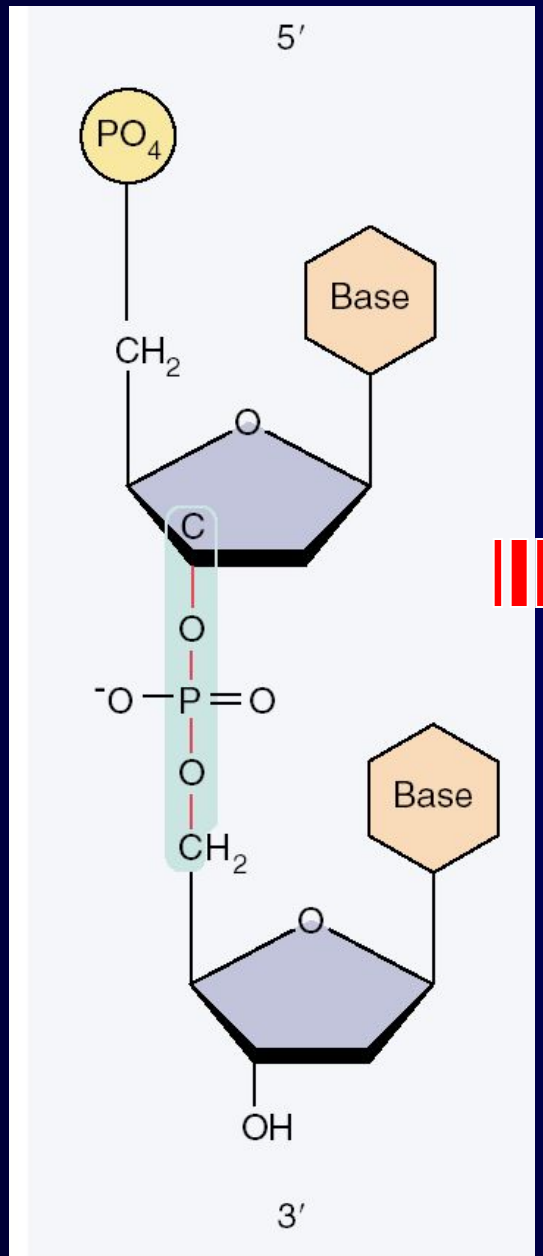
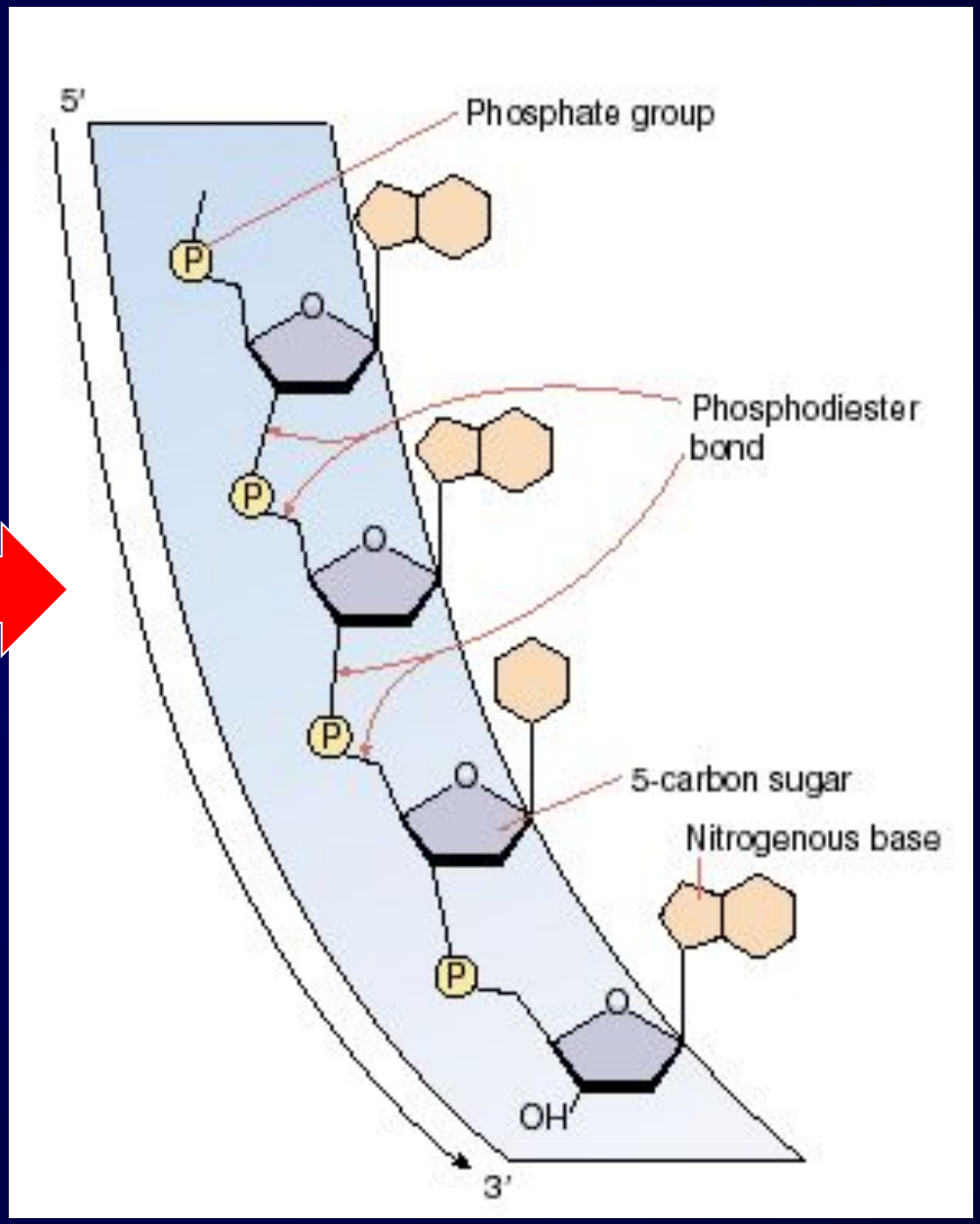


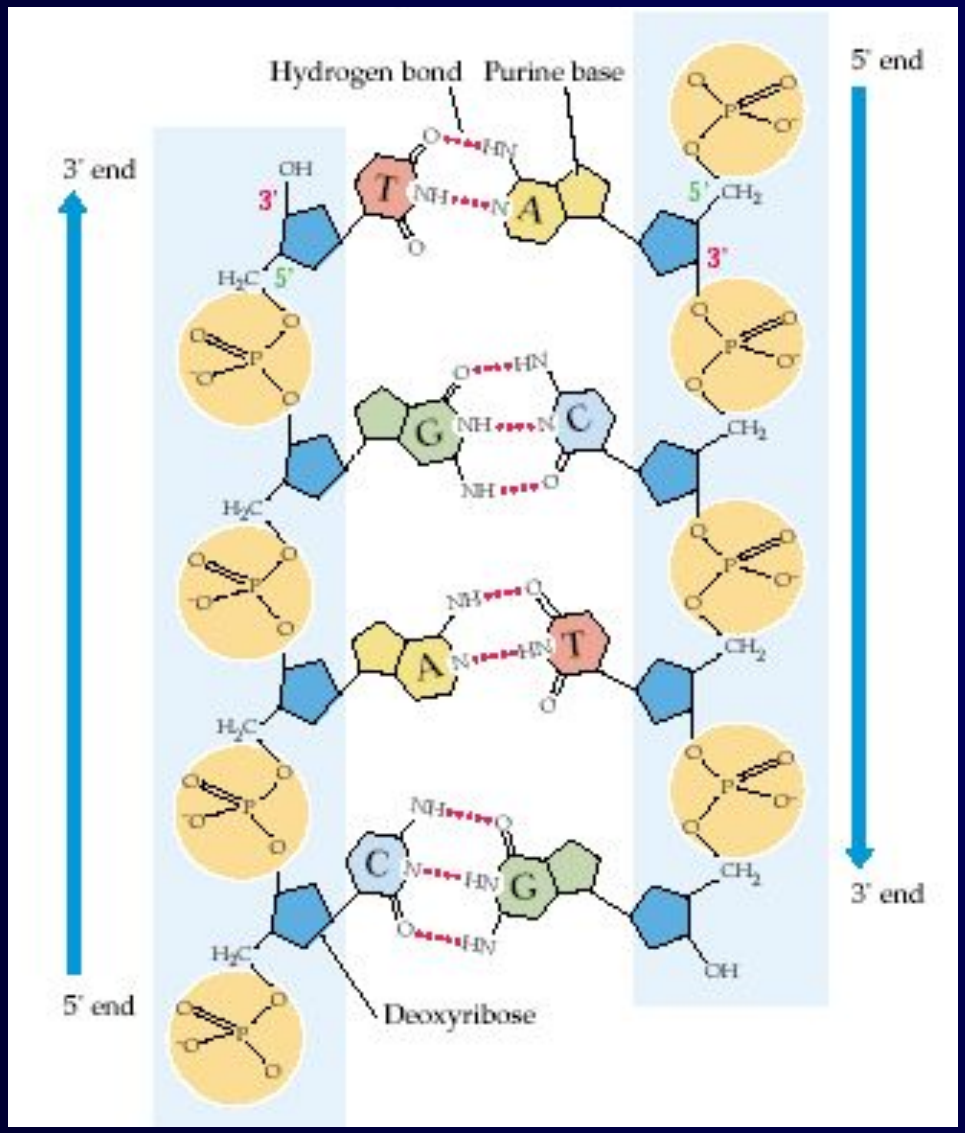
FIGURE 14.7
Numbering the carbon atoms in a nucleotide. The carbon atoms in the sugar of the nucleotide are numbered 1′ to 5′, proceeding clockwise from the oxygen atom. The "prime" symbol (′) indicates that the carbon belongs to the sugar rather than the base.

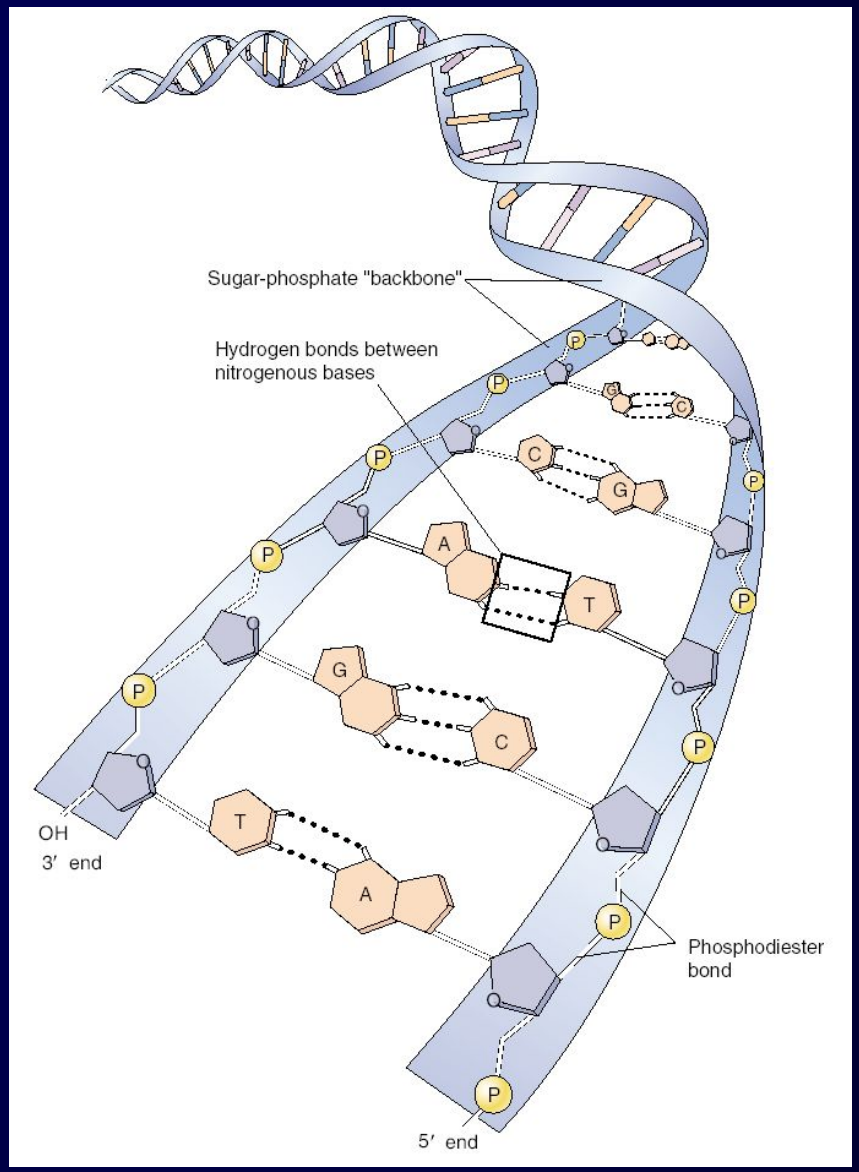
I структура ДНК – полинуклеотидная цепь



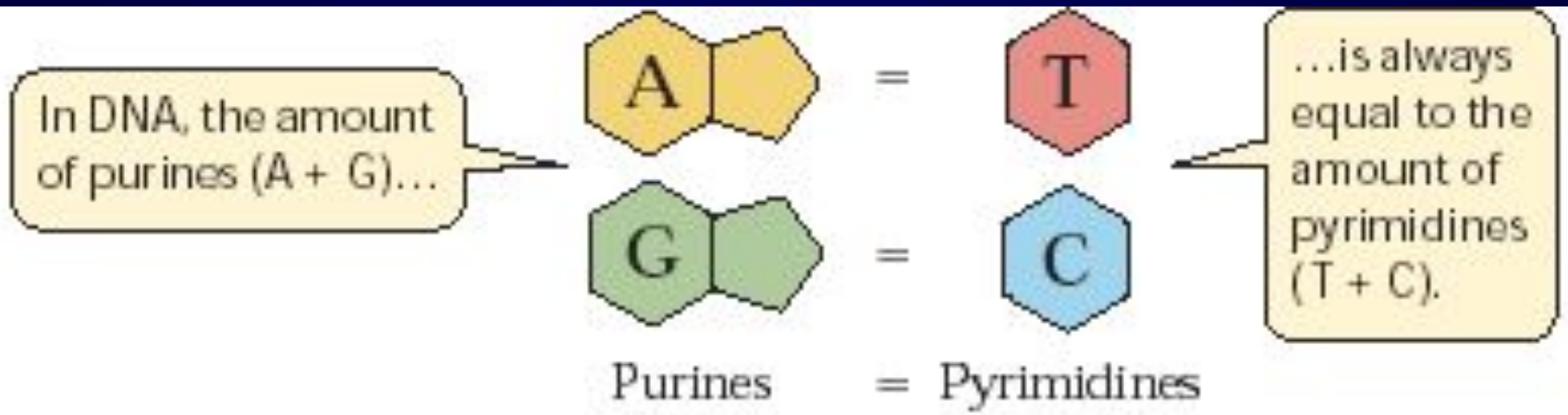


II структура ДНК – две комплементарные и антипараллельные цепи



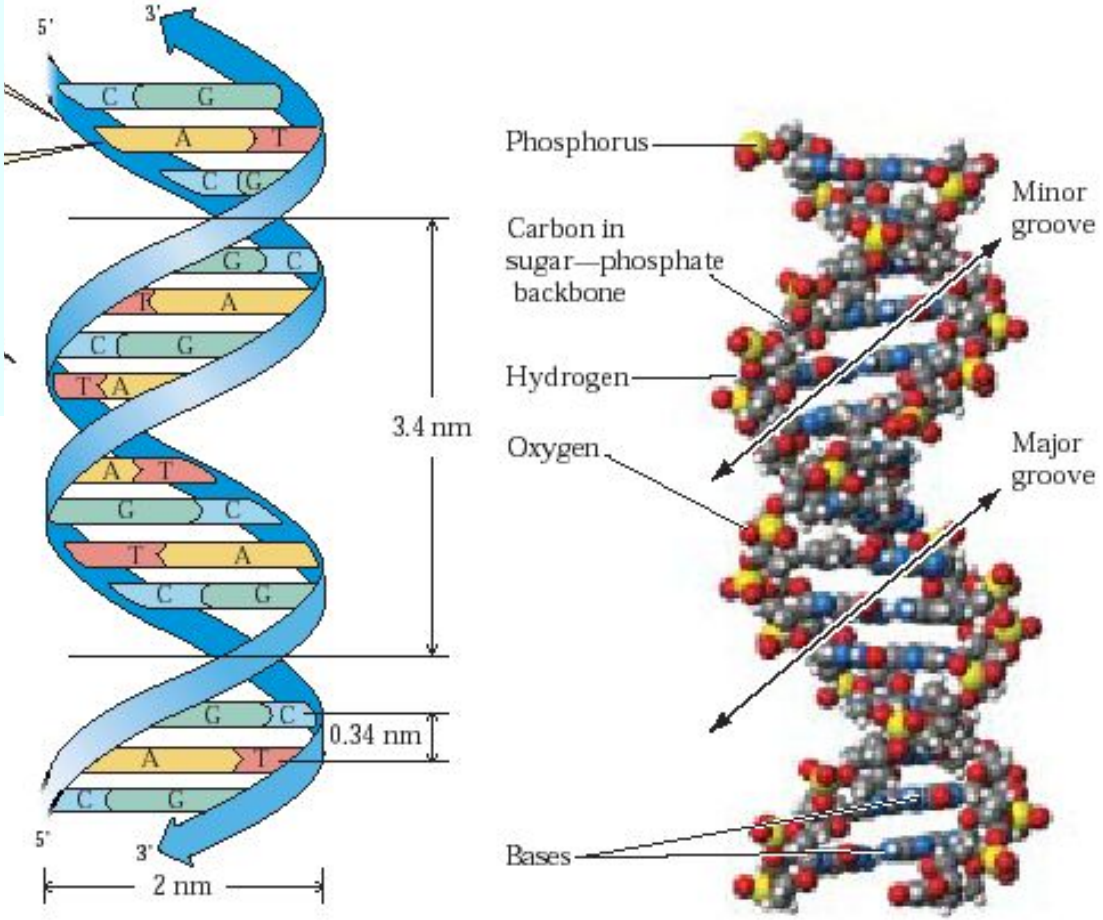


Правило Чаргаффа



11.5 Chargaff's Rule In DNA, the total abundance of purines is equal to the total abundance of pyrimidines.

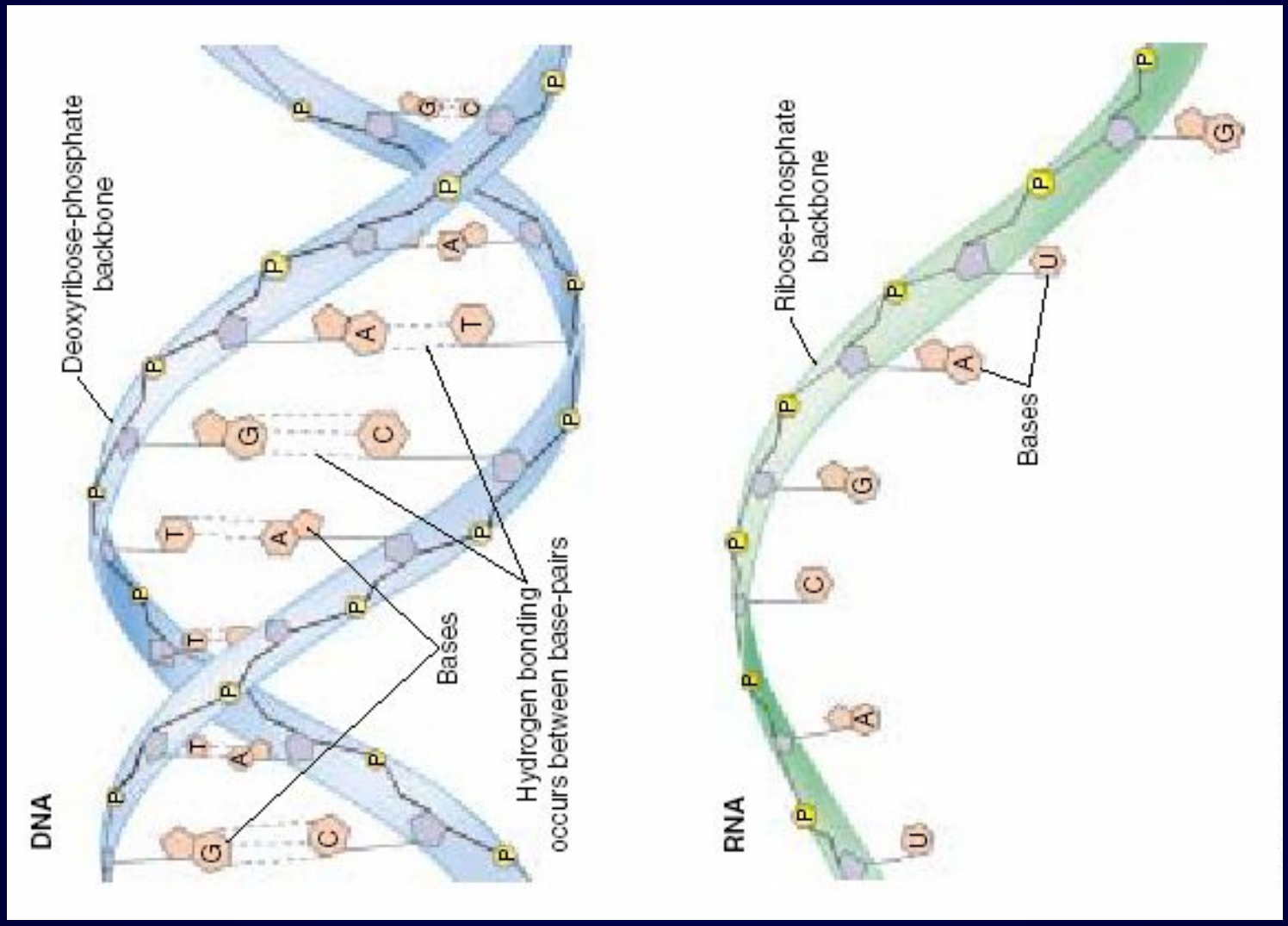
В 1953 г. Два молодых ученых из Кембриджского университета Джеймс Уотсон и Фрэнсис Крик представили трехмерную модель молекулы ДНК – двухцепочечная правозакрученная спираль



11.6 DNA Is a Double Helix (*a*) Francis Crick and James Watson proposed that the DNA molecule has a double helical structure. (*b*) Biochemists can now pinpoint the position of every atom in a DNA macromolecule. To see that the essential features of the original Watson–Crick model have been verified, follow with your eyes the double helical chains of sugar–phosphate groups and note the horizontal rungs of the bases (see also Figure 3.27).

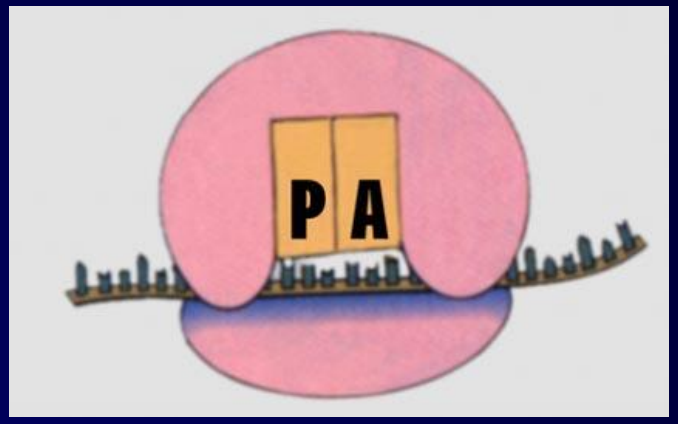
Основные отличия ДНК от РНК

ДНК **РНК**

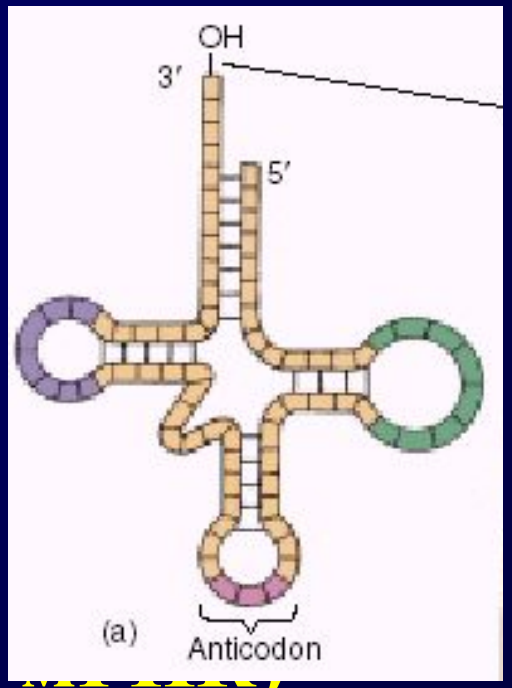


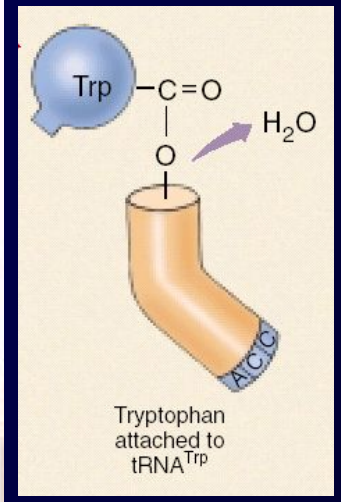
Виды РНК:

1.Рибосомальная (рРНК)



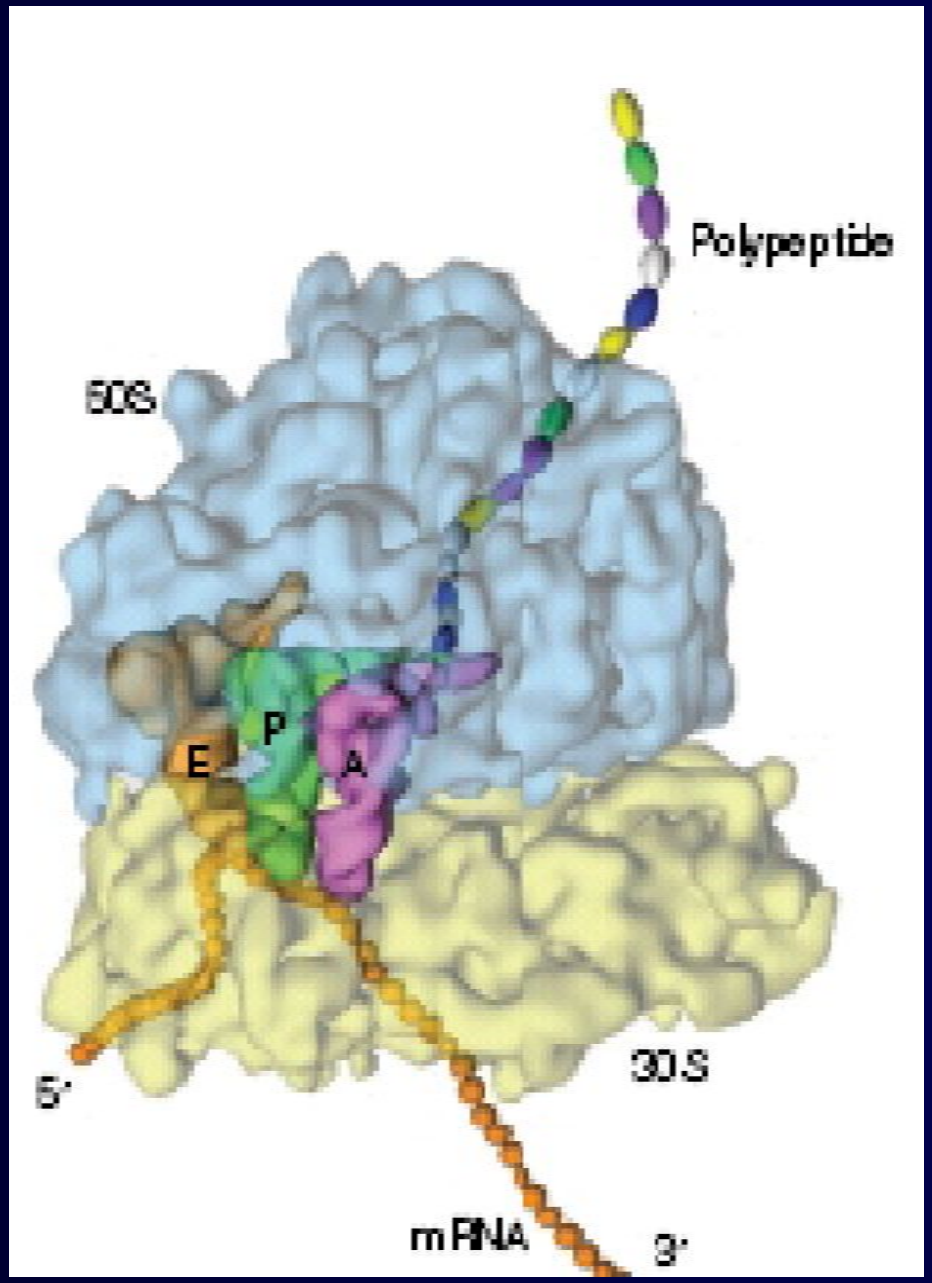
2.Транспортная (тРНК)

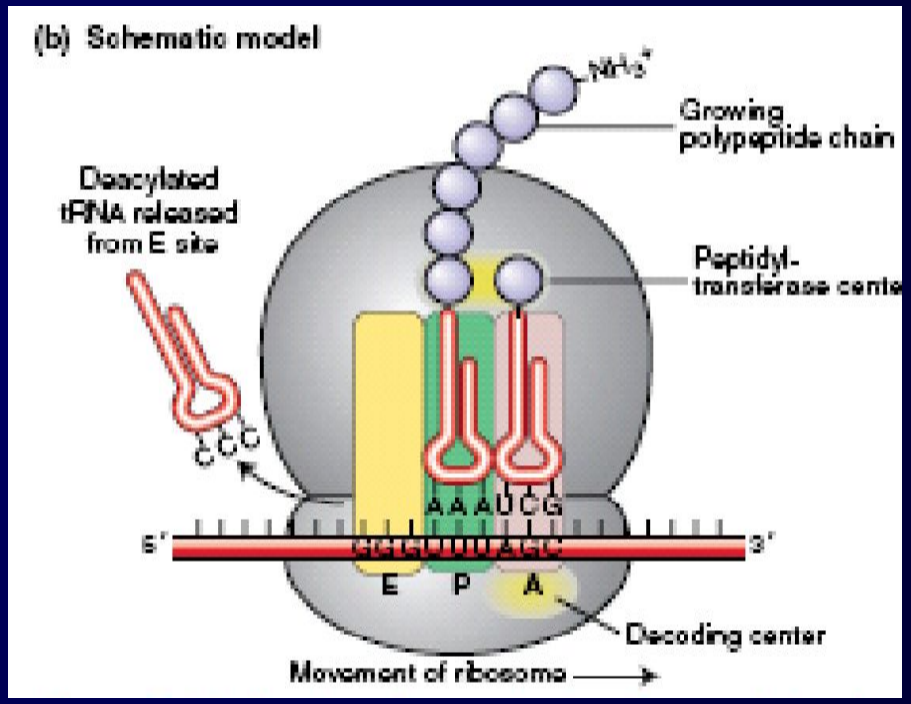




3.Информационная (иРНК, мРНК)

Все виды РНК предназначены для биосинтеза белка





Основные Функции ДНК:

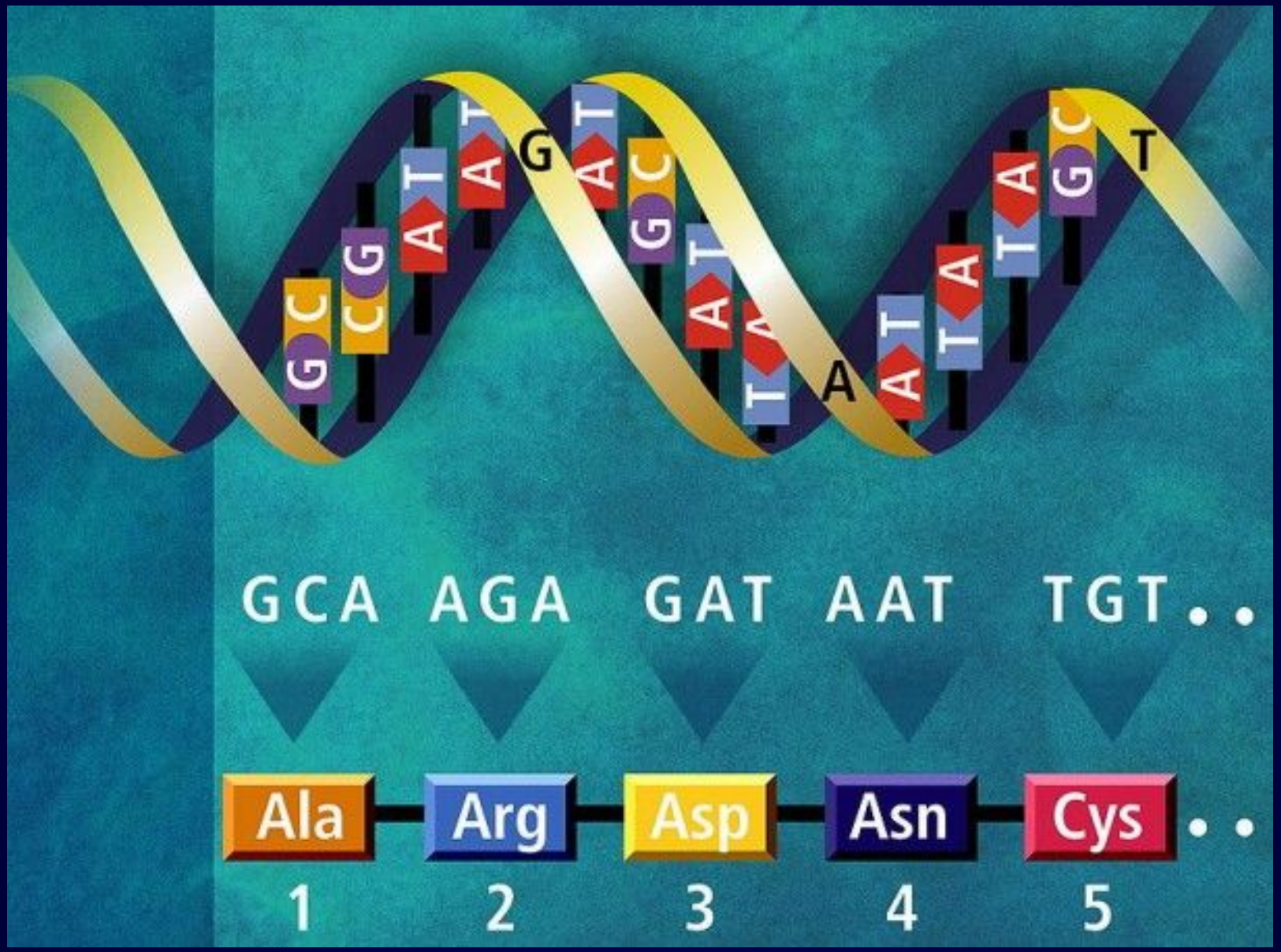
1. Хранение генетической информации
2. Передача генетической информации
3. Реализация генетической информации

1. Хранение генетической информации – в виде генетического кода

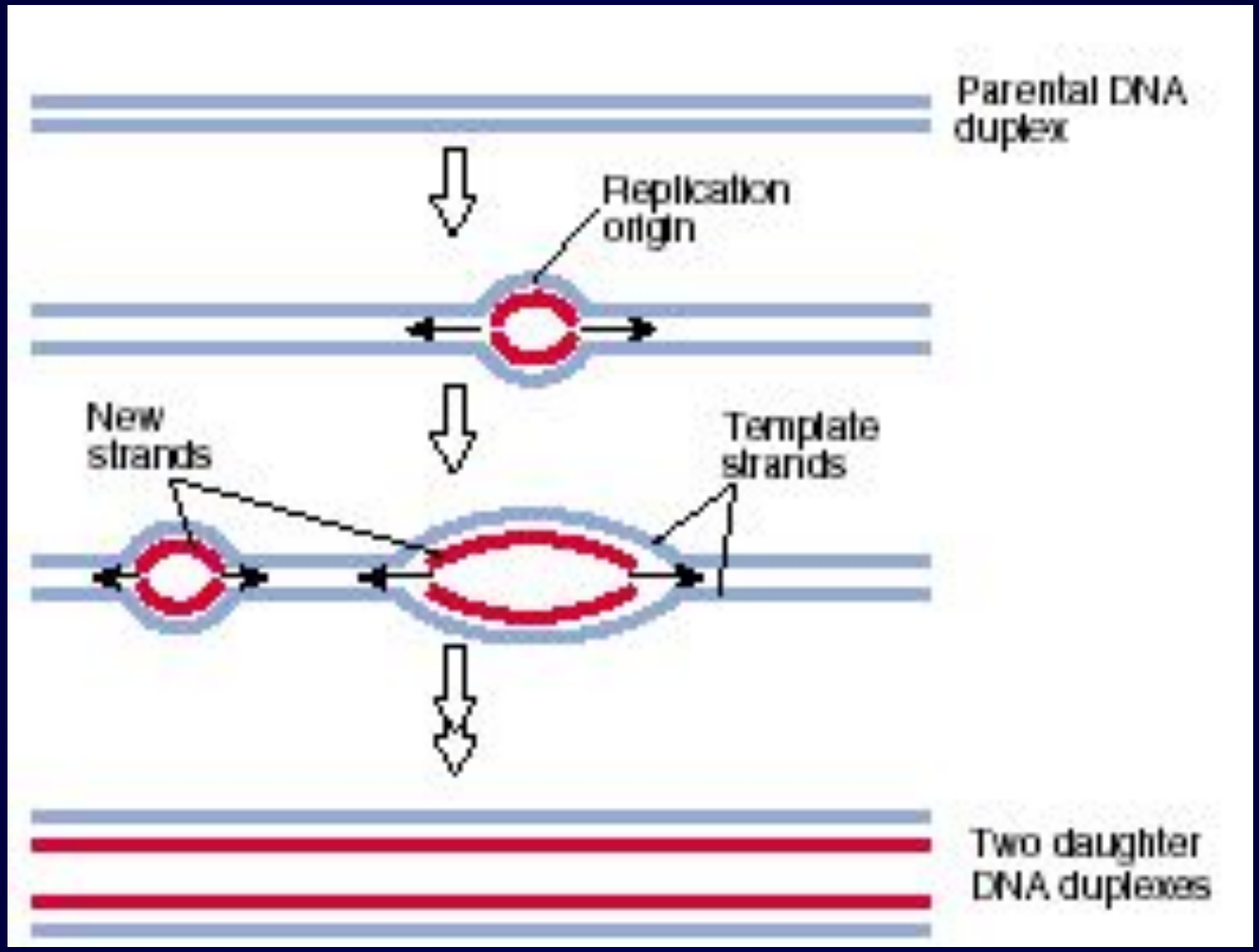
Триплетные кодоны мРНК и соответствующие им аминокислоты

Table 15.1 The Genetic Code

First Letter	Second Letter: U		C		A		G		Third Letter
U	UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine	UCA		UAA	Stop	UGA	Stop	A
	UUG		UCG		UAG	Stop	UGG	Tryptophan	G
C	CUU	Leucine	CCU	Proline	CAU	Histidine	CGU	Arginine	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine	ACU	Threonine	AAU	Asparagine	AGU	Serine	U
	AUC		ACC		AAC		AGC		C
	AUA	Methionine; Start	ACA		AAA	Lysine	AGA	Arginine	A
	AUG		ACG		AAG		AGG		G
G	GUU	Valine	GCU	Alanine	GAU	Aspartate	GGU	Glycine	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamate	GGA		A
	GUG		GCG		GAG		GGG		G

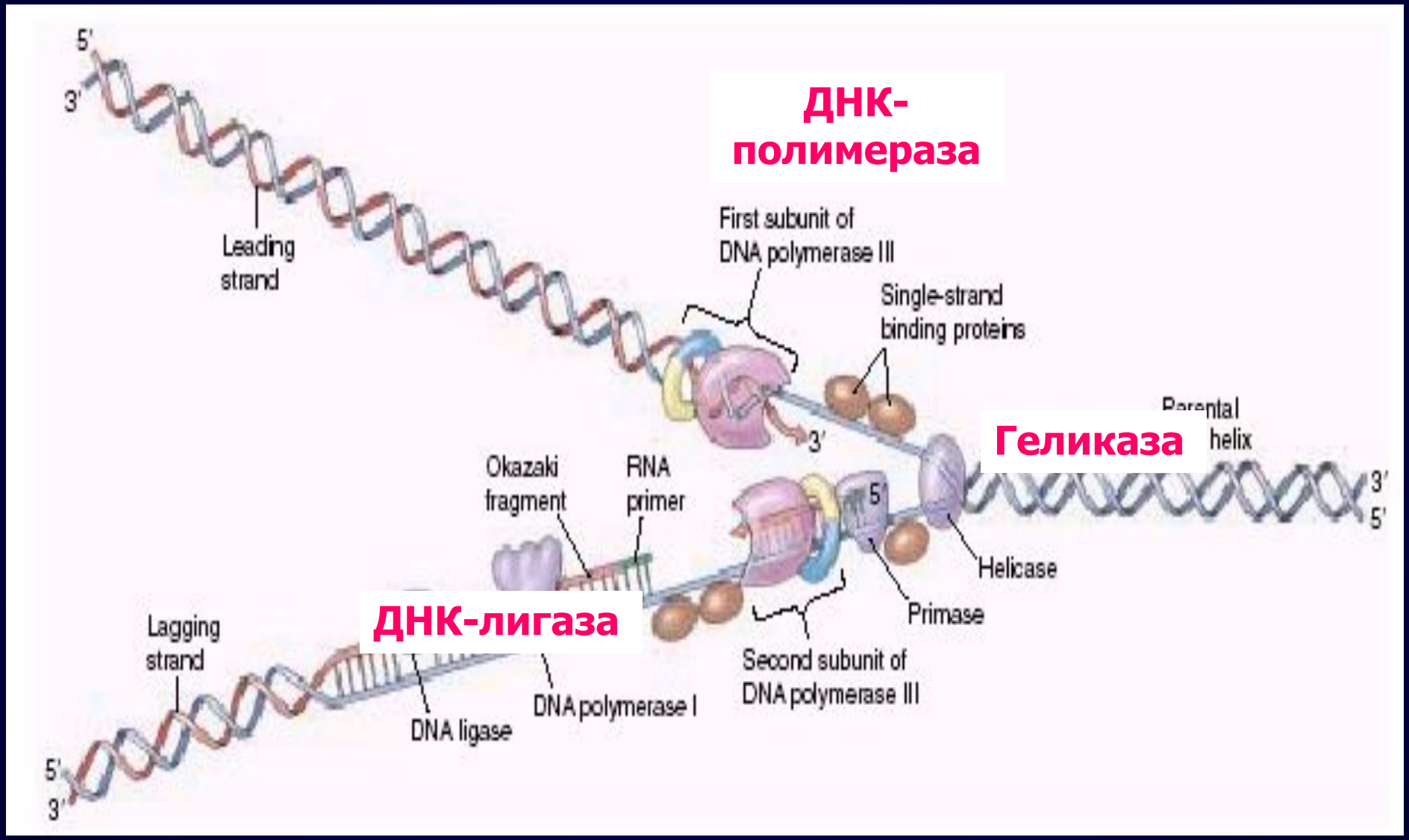

GCA AGA GAT AAT TGT..
Ala
Arg
Asp
Asn
Cys
1
2
3
4
5

2. Передача генетической информации путем репликации ДНК



А. Начало репликации ДНК с формированием репликационного глазка и репликационной вилки

Репликационная вилка



Условная схема репликации молекулы ДНК.

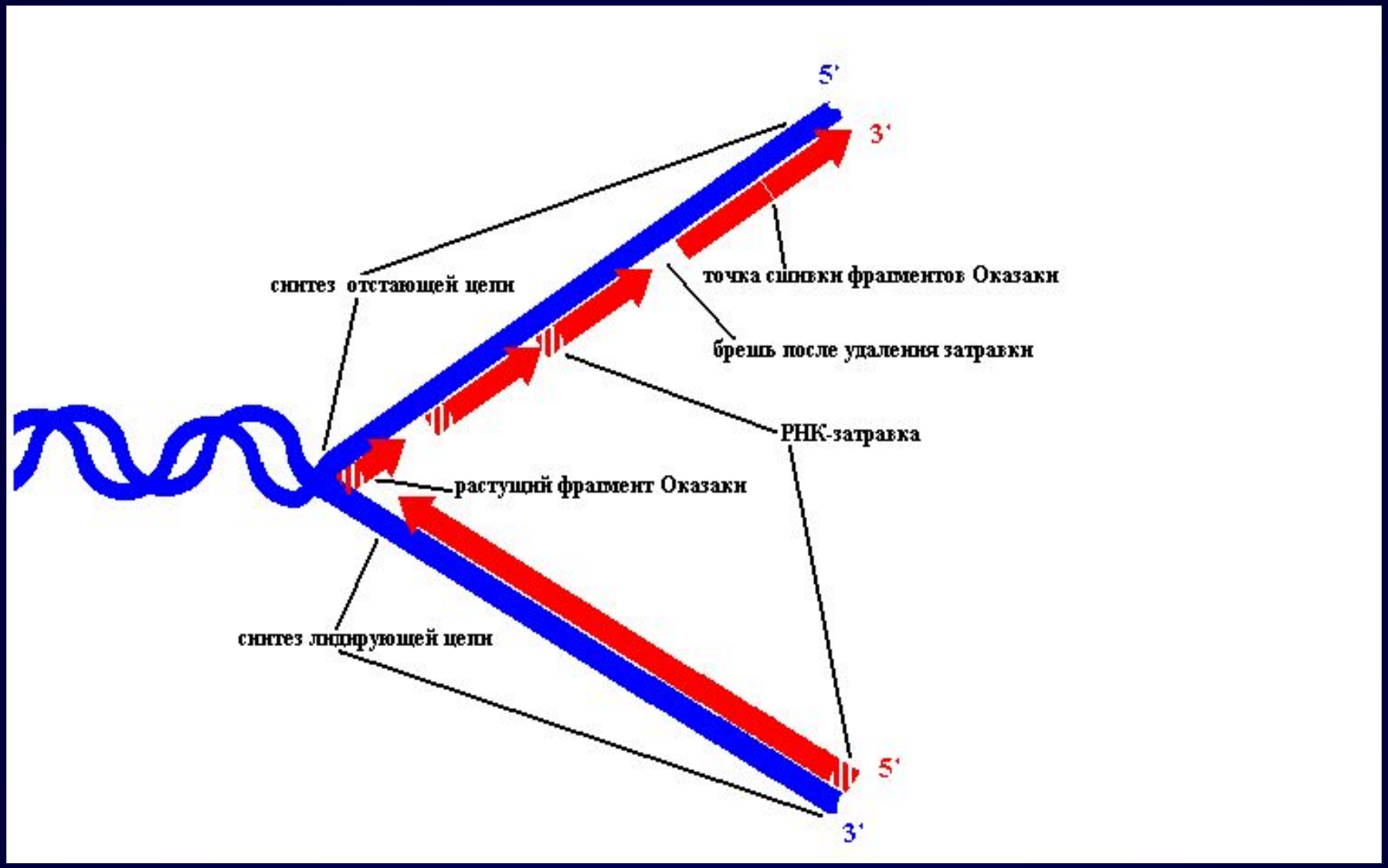


Схема образования "дочерних" цепей ДНК в репликативной вилке. Лидирующая цепь синтезируется непрерывно; отстающая цепь сшивается из фрагментов Оказаки после удаления РНК-затравок и заделывания брешей.

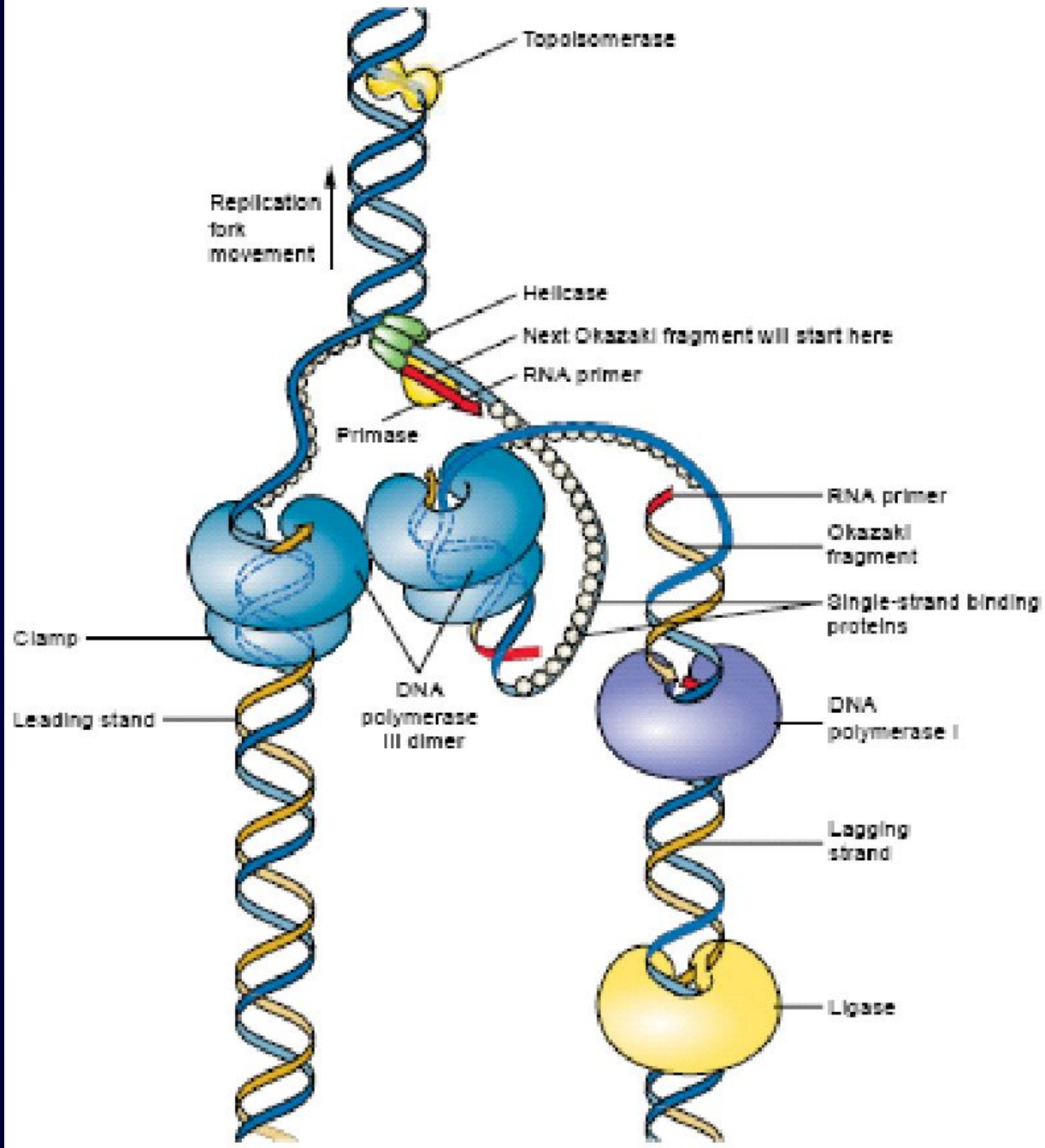


Figure 7-18 Details of the replisome and accessory proteins at the replication fork. Topoisomerase and helicase unwind and open the double helix in preparation for DNA replication. Once unwound, single-strand binding proteins prevent the double helix from reforming. The figure is a representation of the so-called trombone model (named for its resemblance to a trombone owing to the looping of the lagging strand) showing how the two catalytic cores of the replisome are envisioned to interact to coordinate the numerous events of leading- and lagging-strand replication. [Adapted from Geoffrey Cooper, *The Cell*. Sinauer Associates, 2000.]

3. Реализация генетической информации

Центральная догма молекулярной биологии:

ДНК

↓

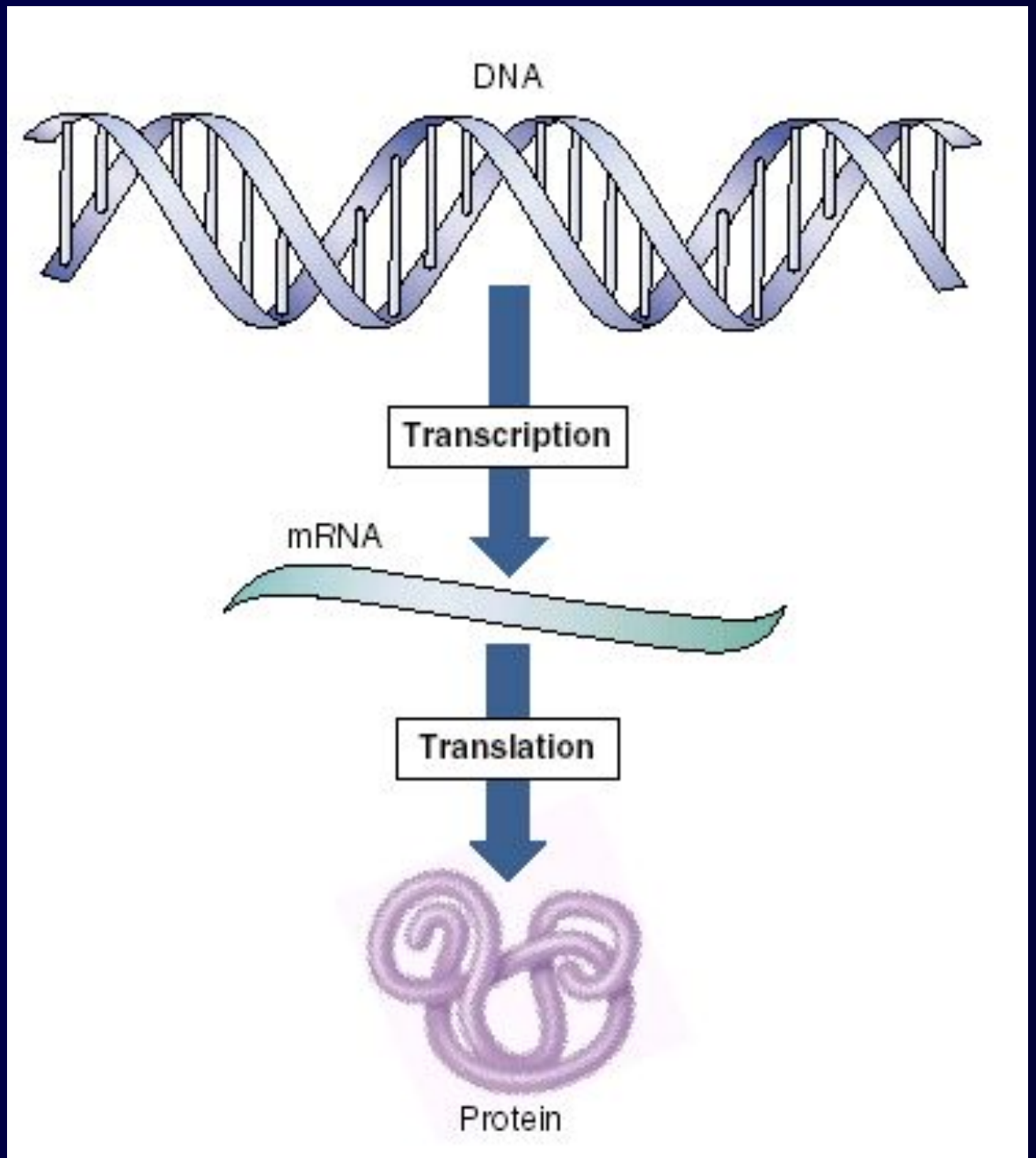
РНК

↓

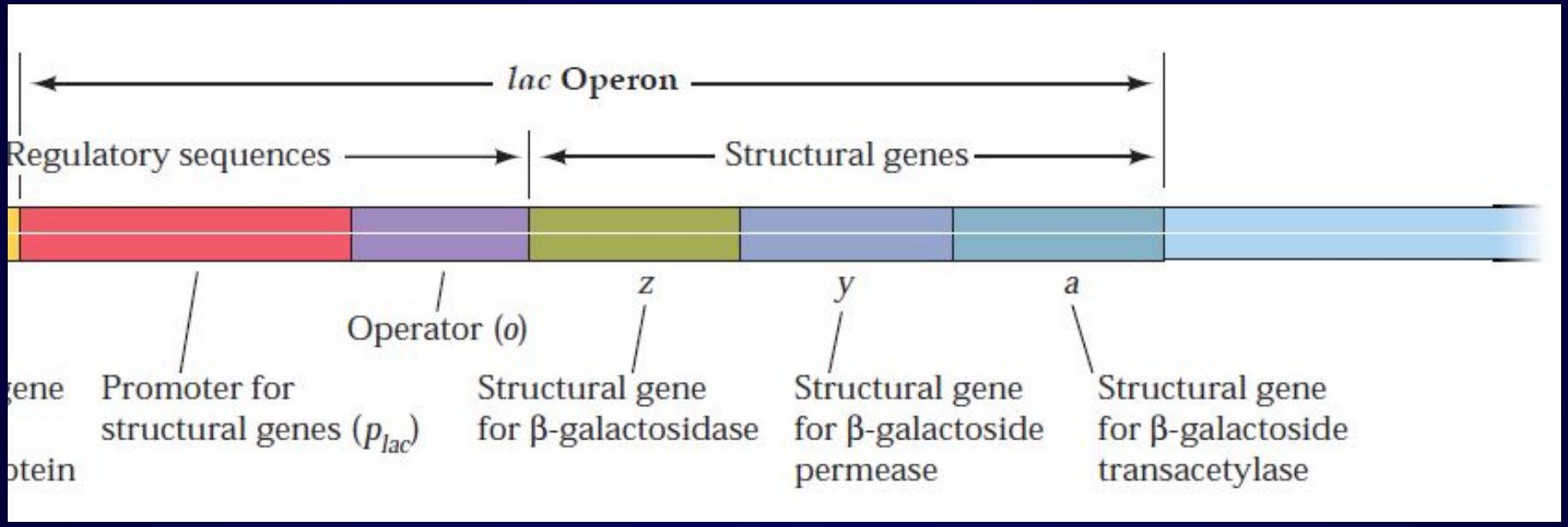
Белок

↓

Признак



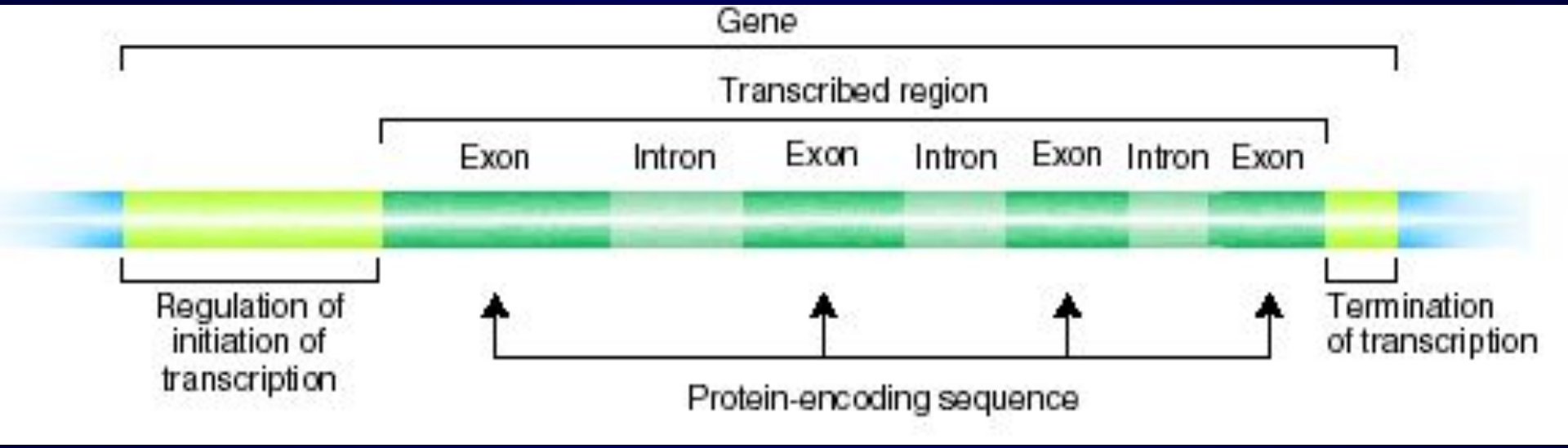
Генетическая система прокариот – оперон - может кодировать несколько белков



13.16 The *lac* Operon of *E. coli* The *lac* operon of *E. coli* is a segment of DNA that includes a promoter, an operator, and the three structural genes that code for lactose-metabolizing enzymes.

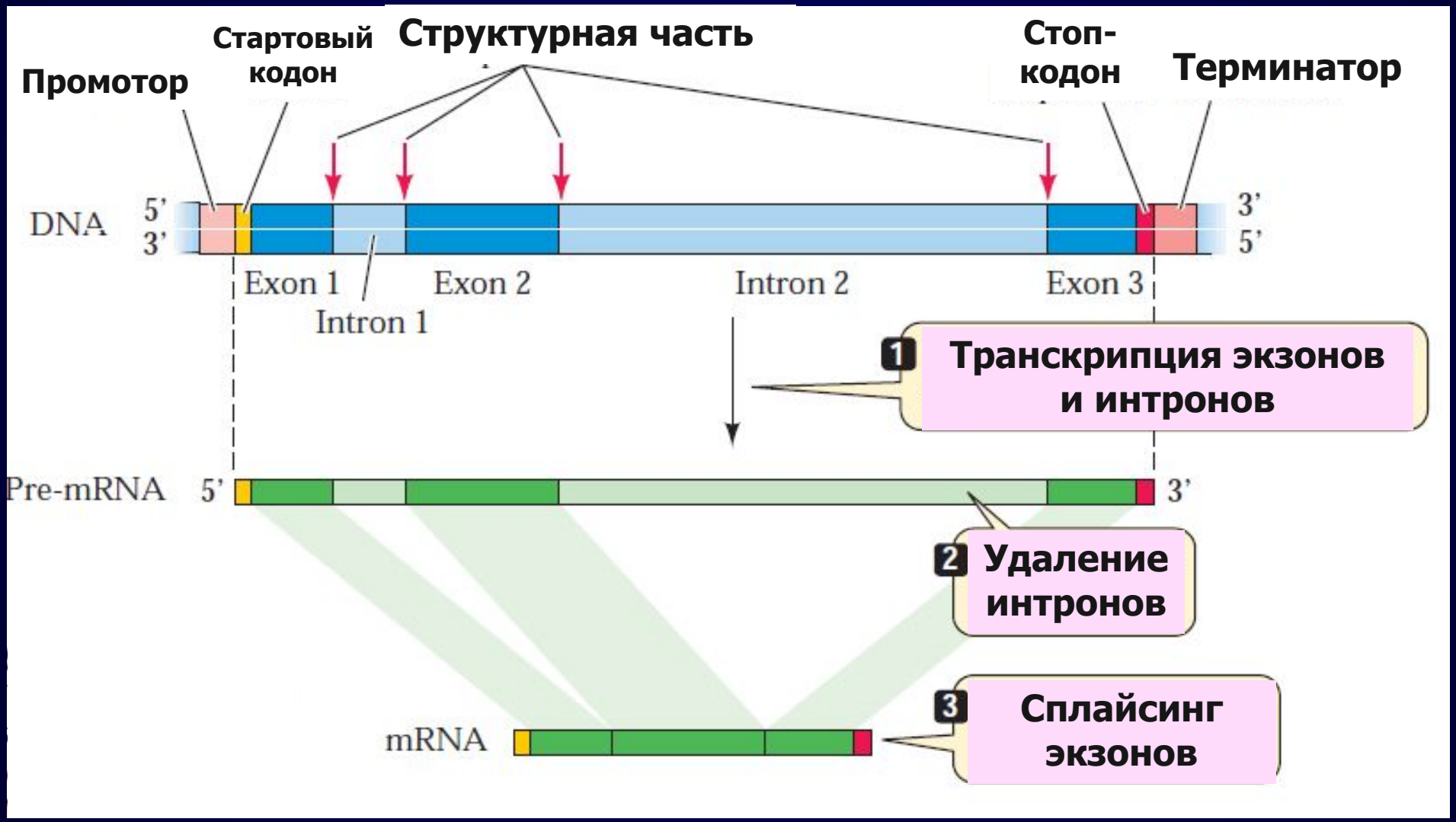
Генетическая система эукариот – транскриптон – кодирует только один белок

транскриптон



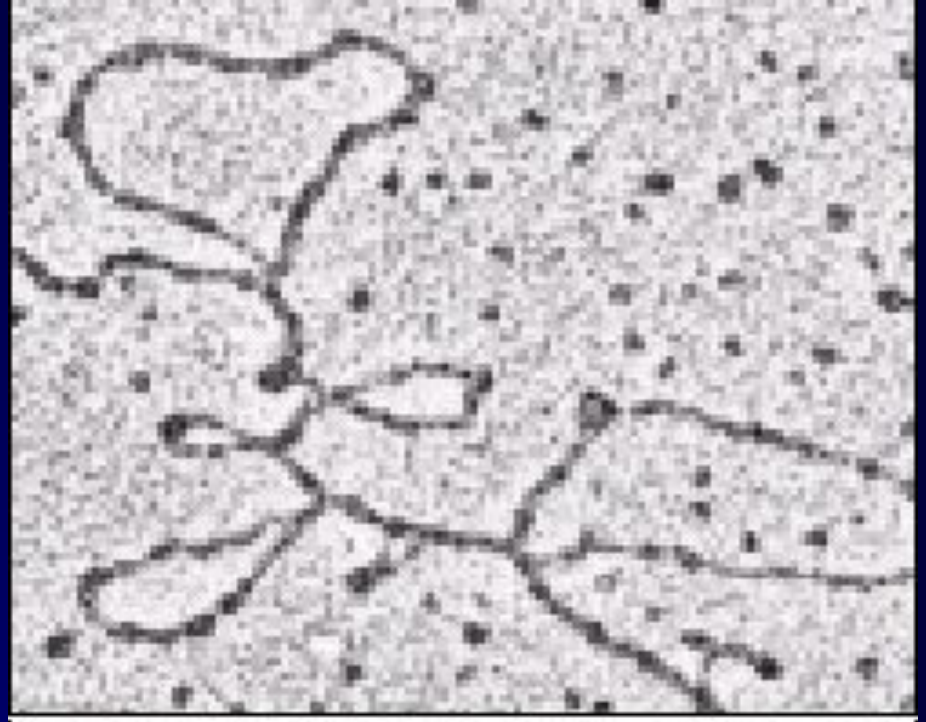
<u>Гены эукариот</u> имеют прерывистую структуру (кодирующий фрагмент – экзон, некодирующий фрагмент – интрон) и кодируют только один белок

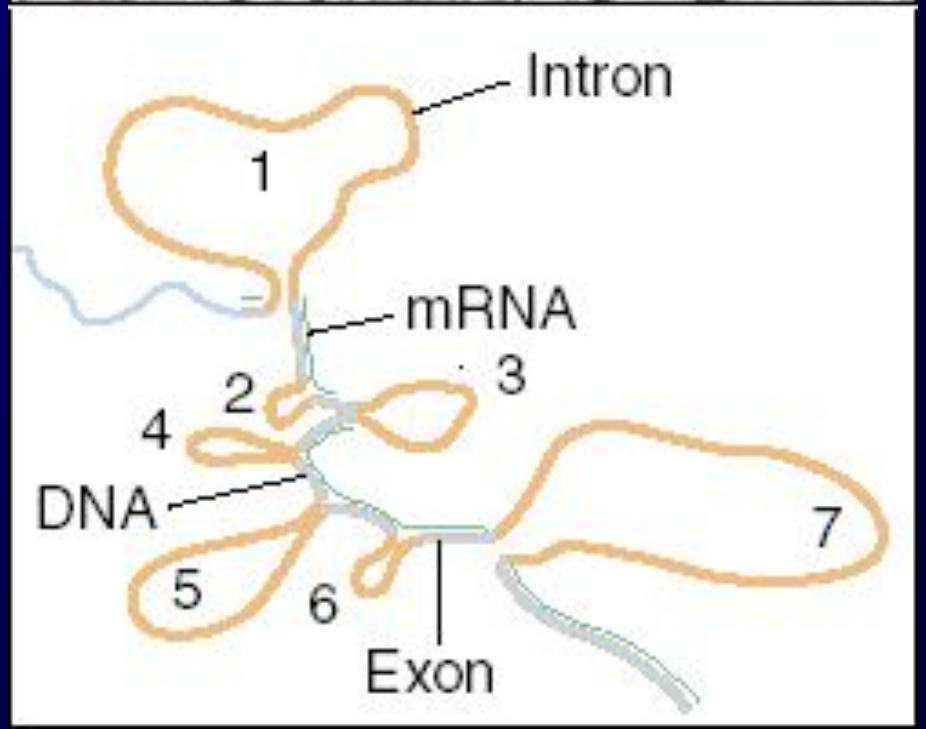
Генетическая система эукариот – транскриптон – кодирует только один белок



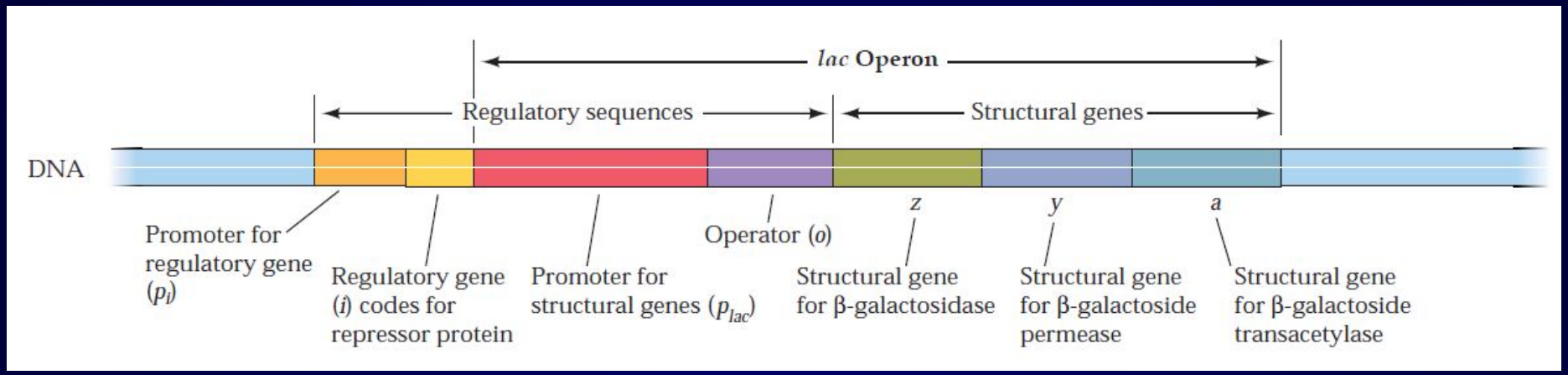
Этапы созревания про-мРНК:

Процессинг и Сплайсинг.



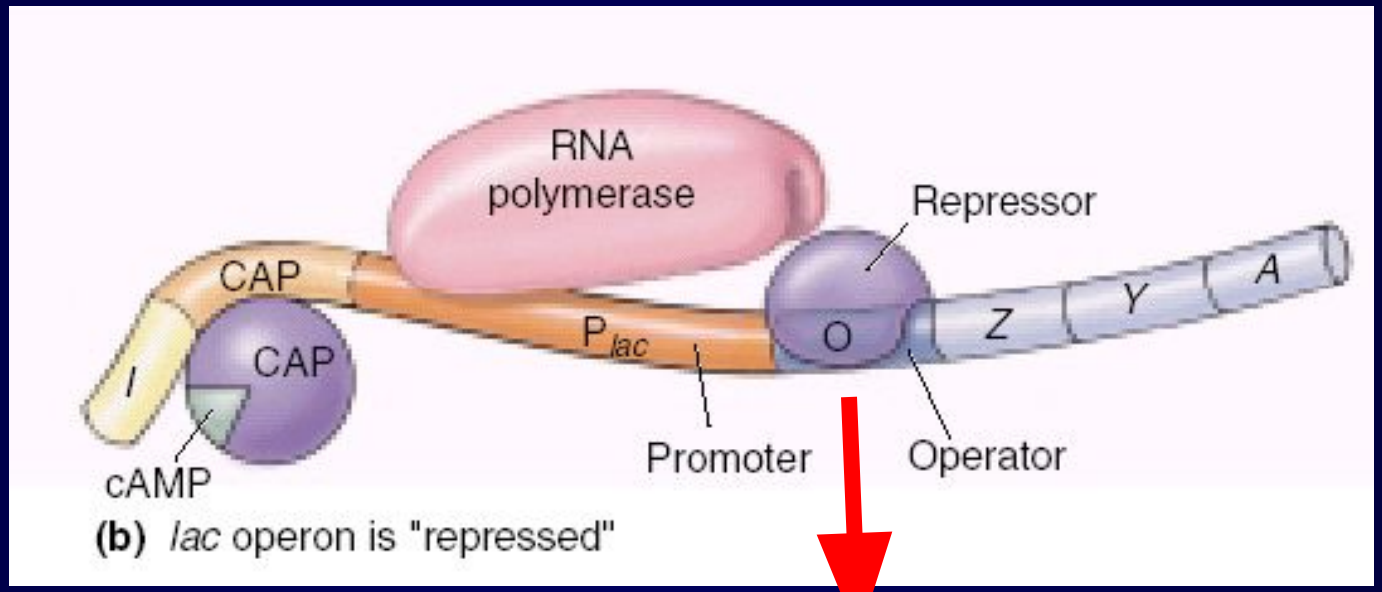


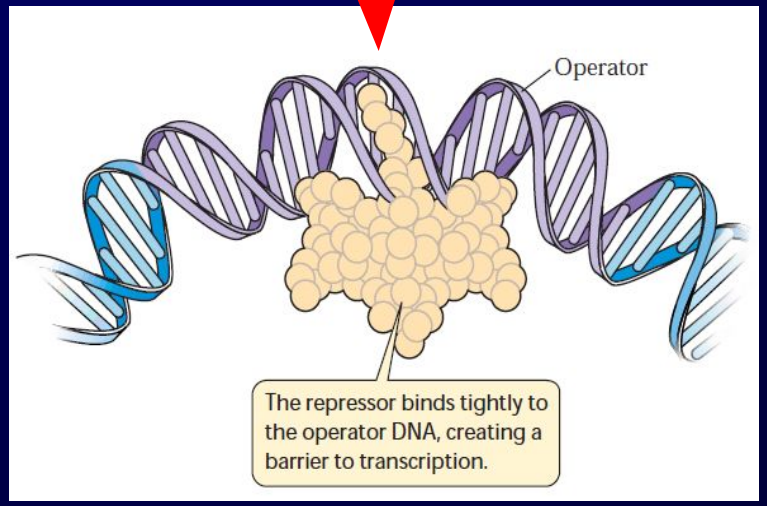
Регуляция экспрессии генов прокариот (на примере лактозного оперона).



Регуляция экспрессии генов прокариот по принципу обратной связи (на примере лактозного оперона).

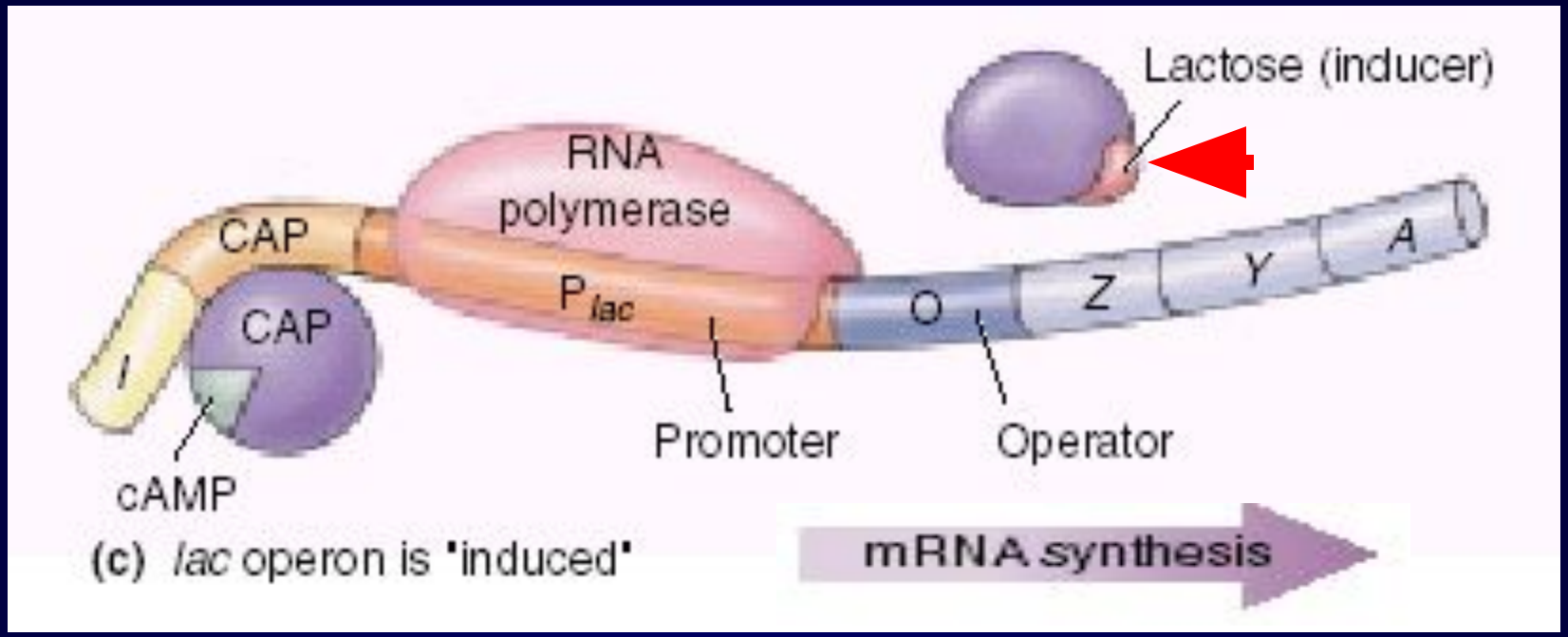
1. Ген не работает





Белок-репрессор блокирует оператор. Транскрипция невозможна

2. Ген работает



1. Индуктор связывается с белком-репрессором.
2. Оператор освобождается.
3. Промотор соединяется с РНК-полимеразой.
4. Начинается транскрипция

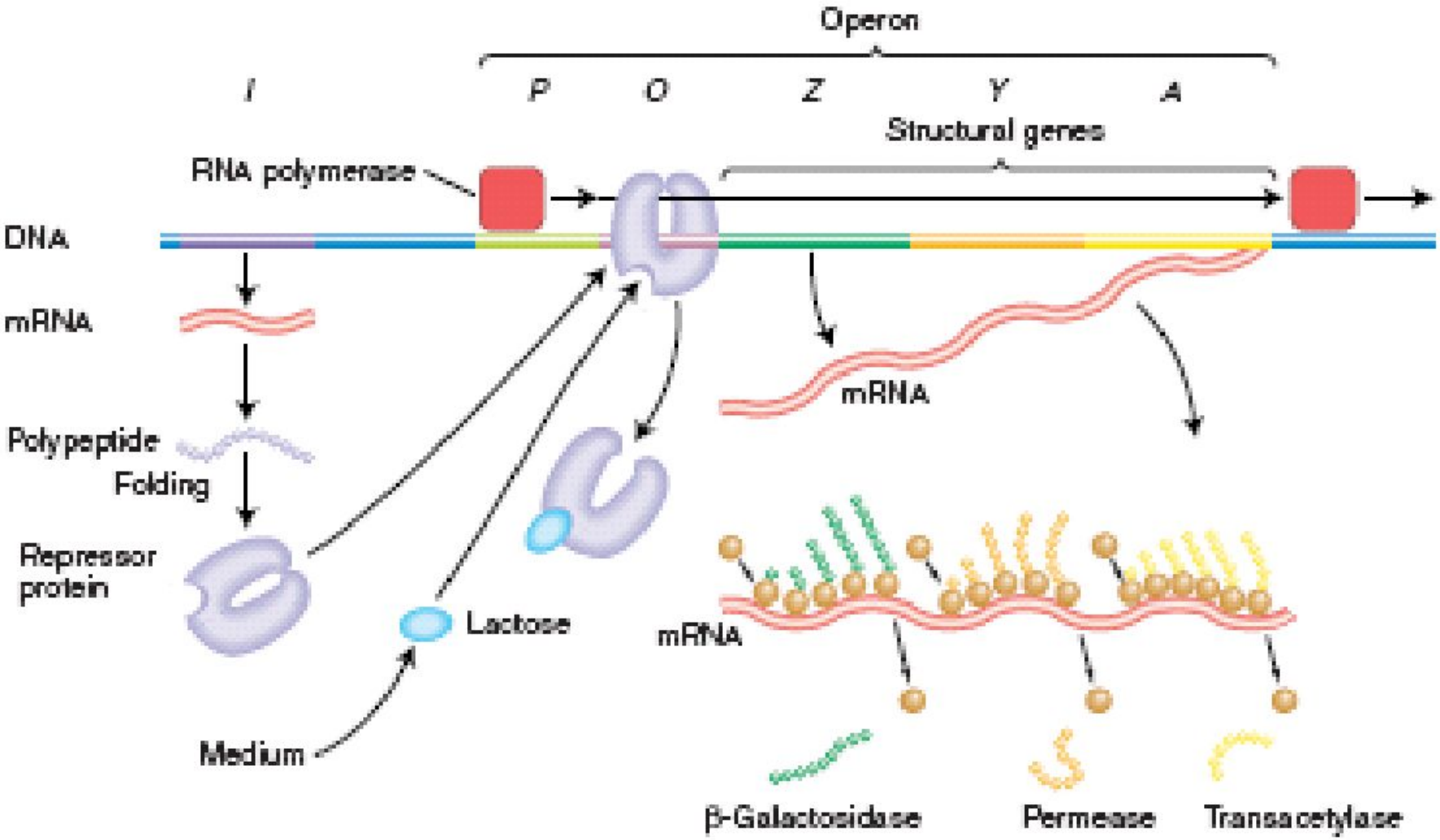


Figure 10-6 Regulation of the *lac* operon. The *I* gene continually makes repressor. In the absence of lactose, the repressor binds to the *O* (operator) region and blocks transcription. Lactose binding changes the shape of the repressor so that the repressor no longer binds to *O*. The RNA polymerase is then able to transcribe the *Z*, *Y*, and *A* structural genes, and so the three enzymes are produced.

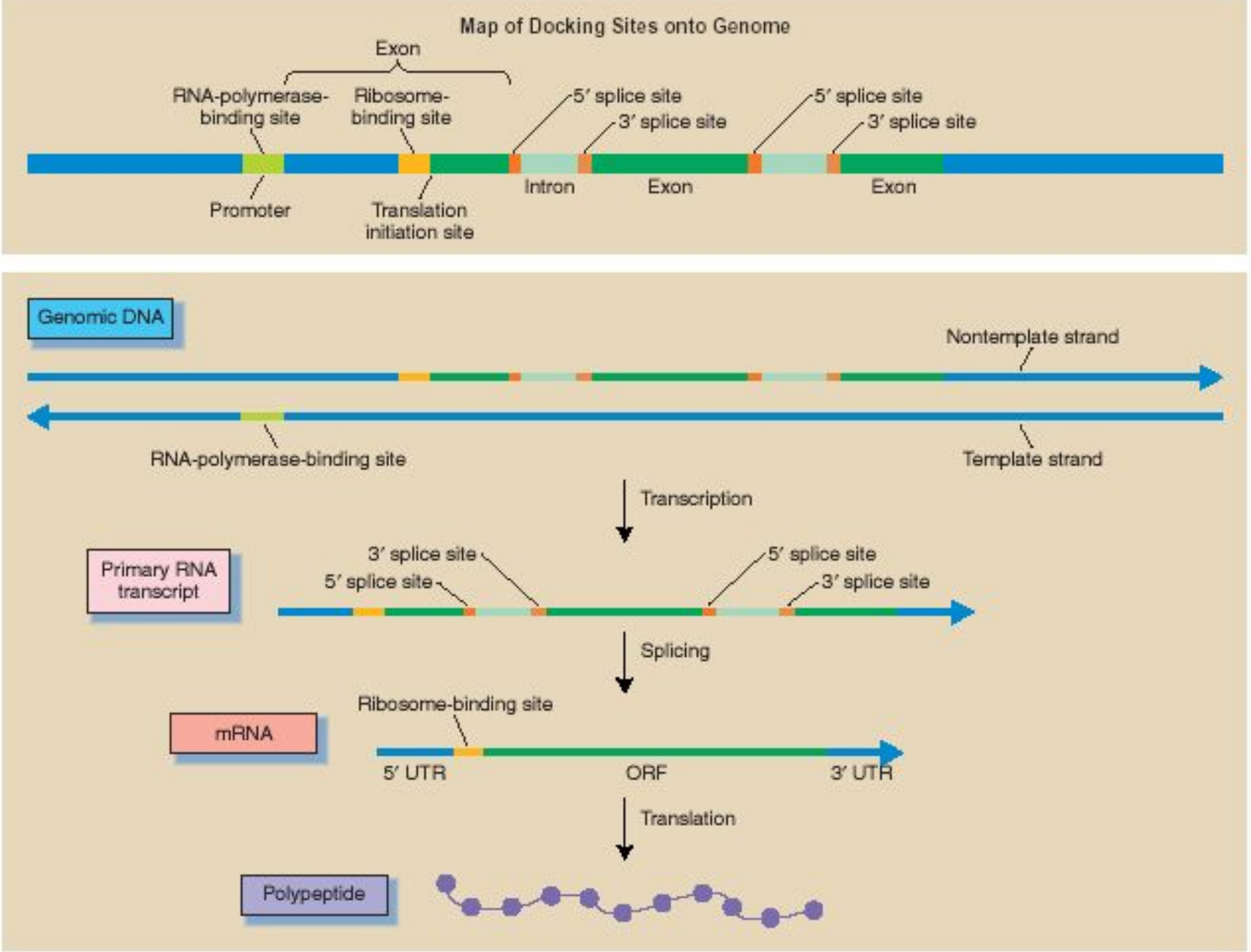
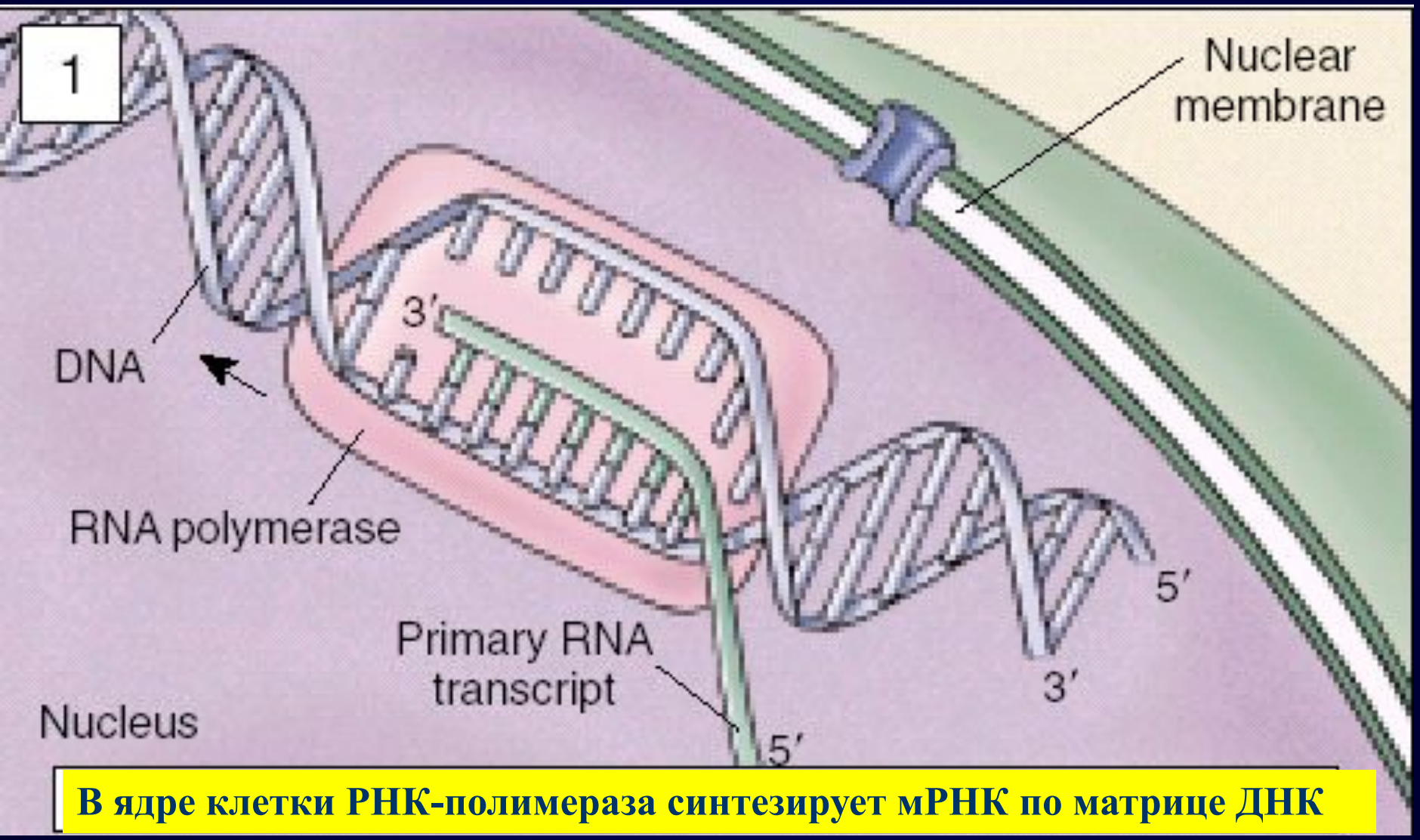


Figure 12-21 Eukaryotic information transfer from gene to polypeptide chain. Note the DNA and RNA "docking sites" that are bound by protein complexes to initiate the events of transcription, splicing, and translation.

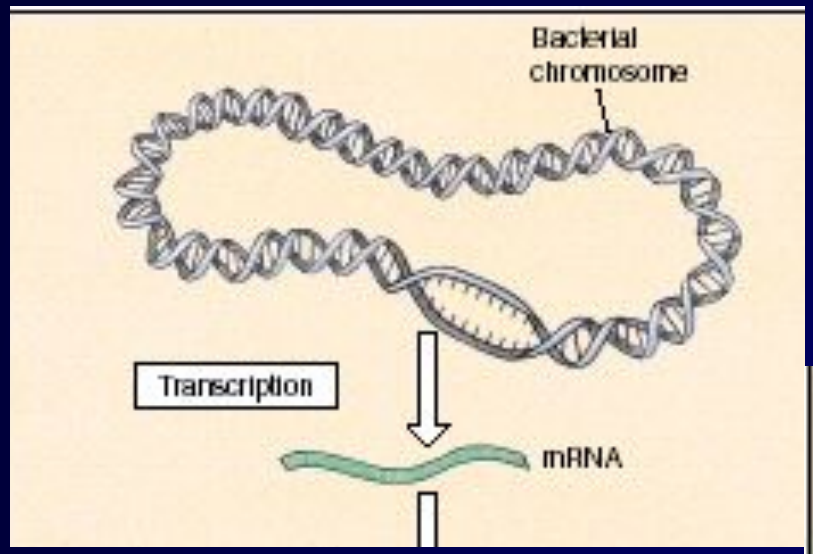
Этапы биосинтеза белка.

1. Транскрипция.



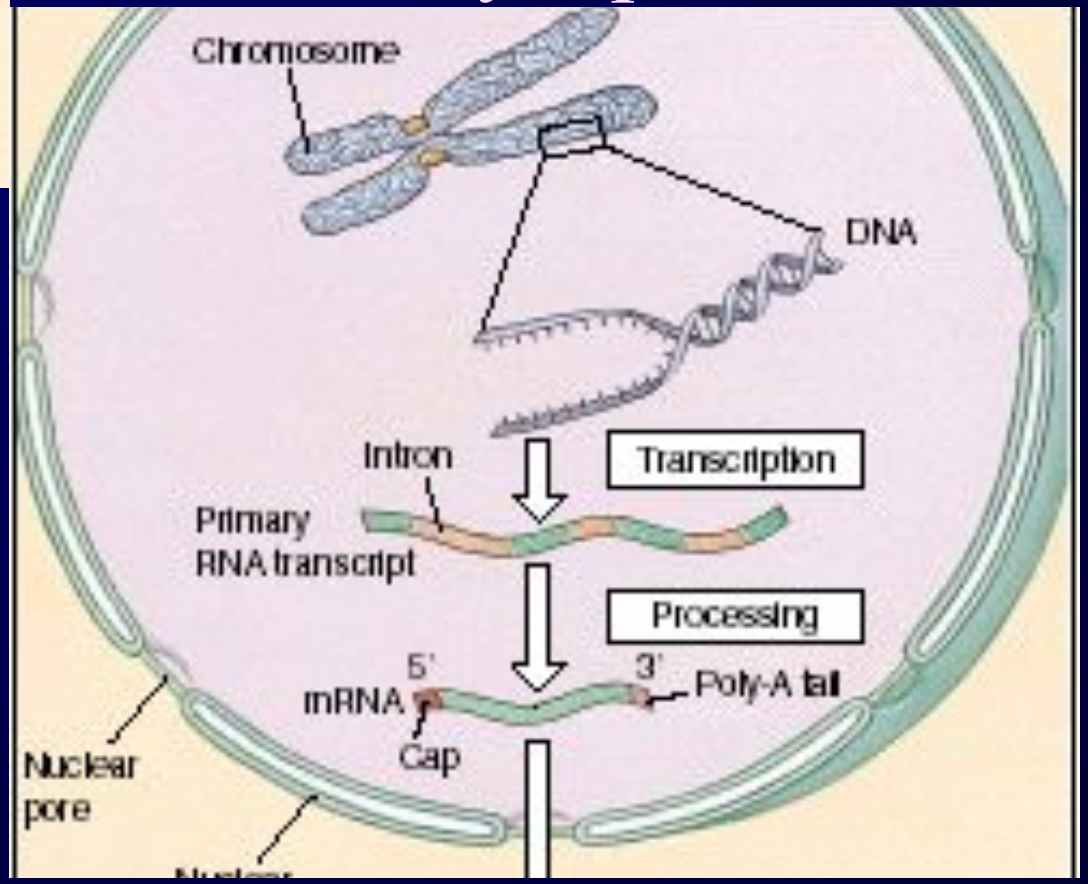
В ядре клетки РНК-полимераза синтезирует мРНК по матрице ДНК

1. Транскрипция:

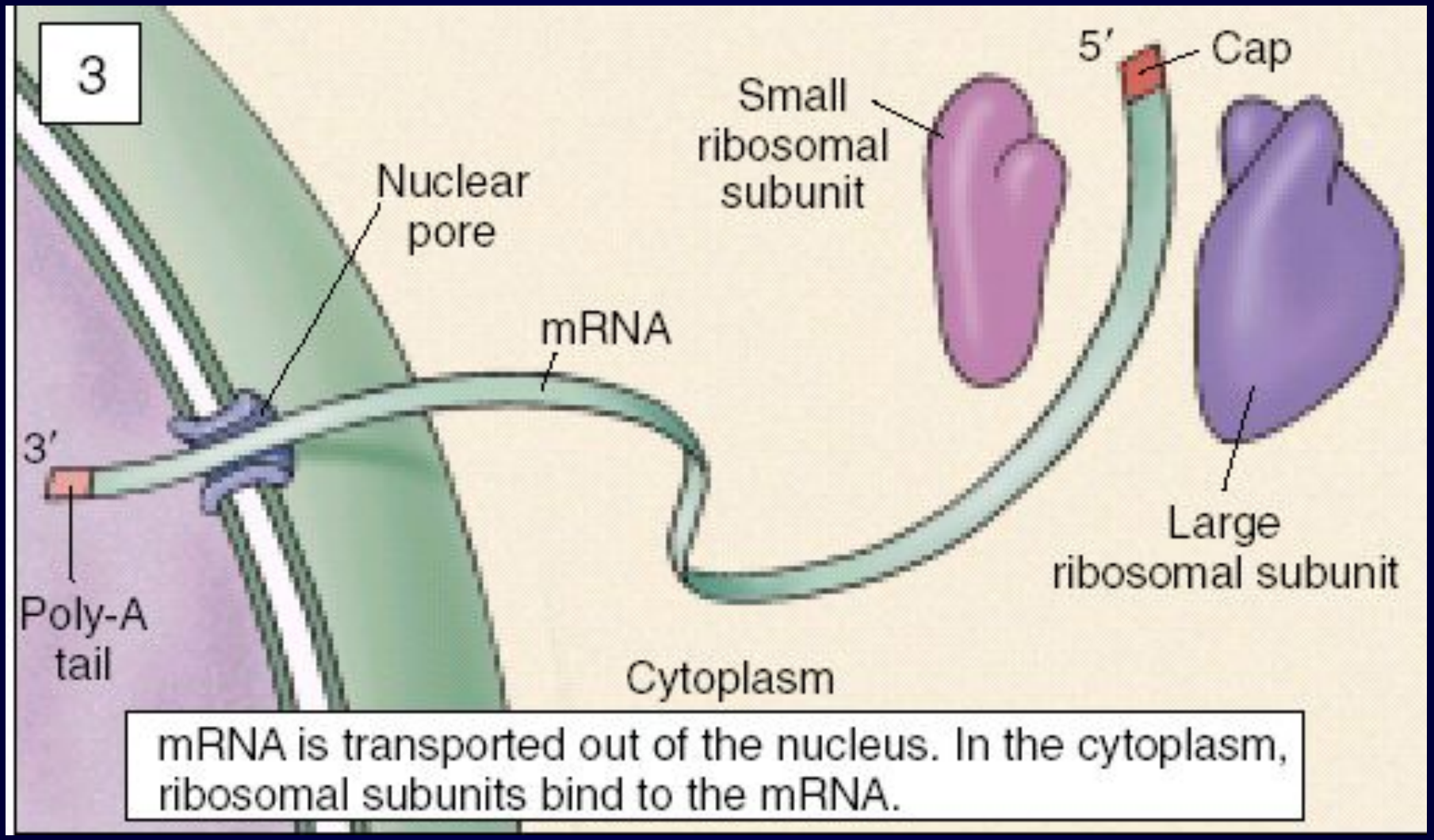


У прокариот

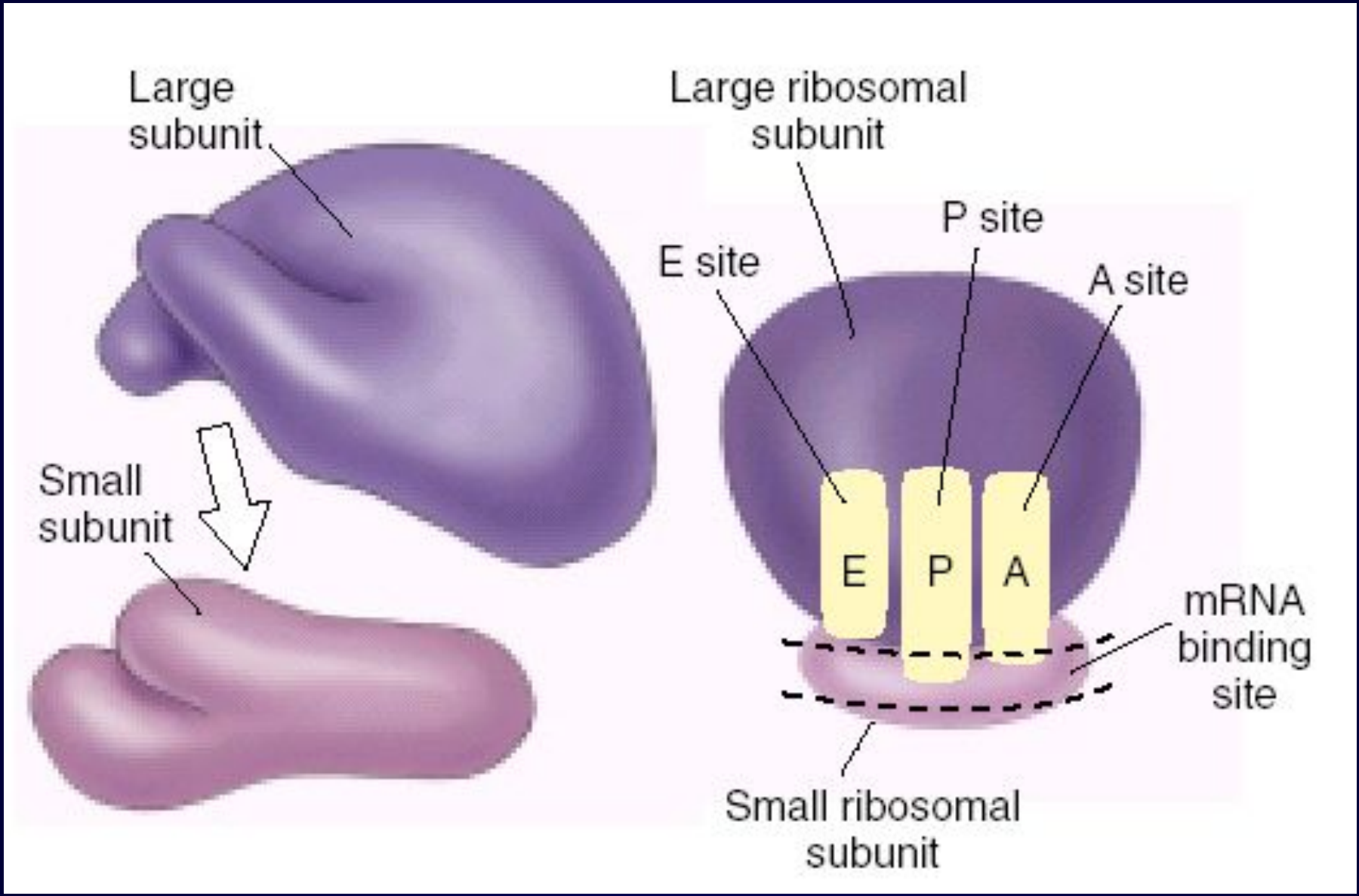
У эукариот



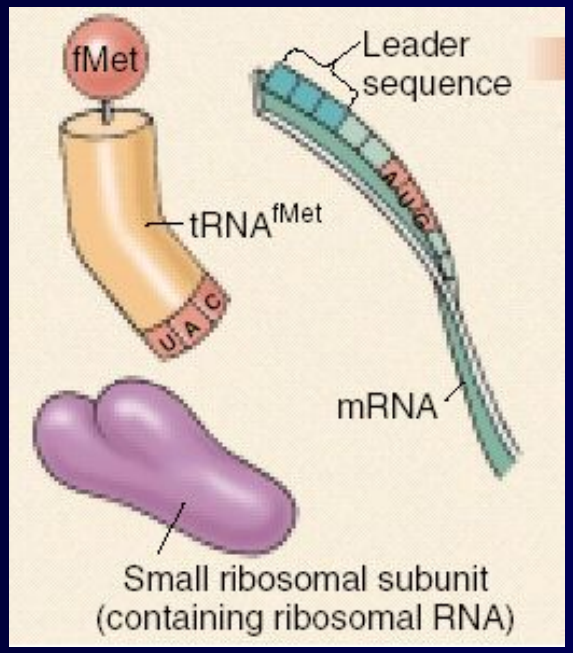
2. Трансляция:

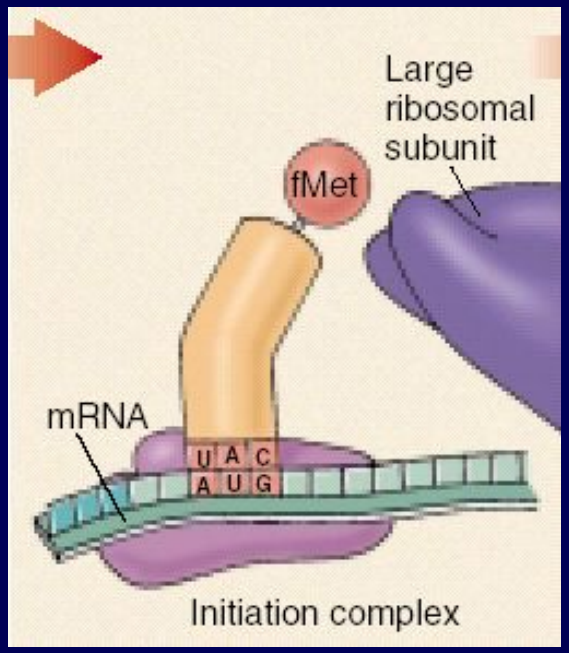


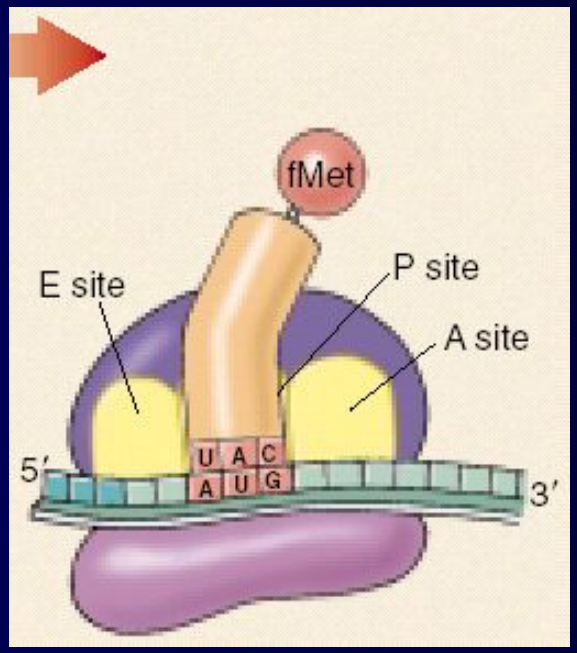
мРНК транспортируется из ядра в цитоплазму, где связывается вначале с малой, затем – с большой рибосомными субъединицами


Large subunit
Small subunit
Large ribosomal subunit
E site
P site
A site
E
P
A
mRNA binding site
Small ribosomal subunit

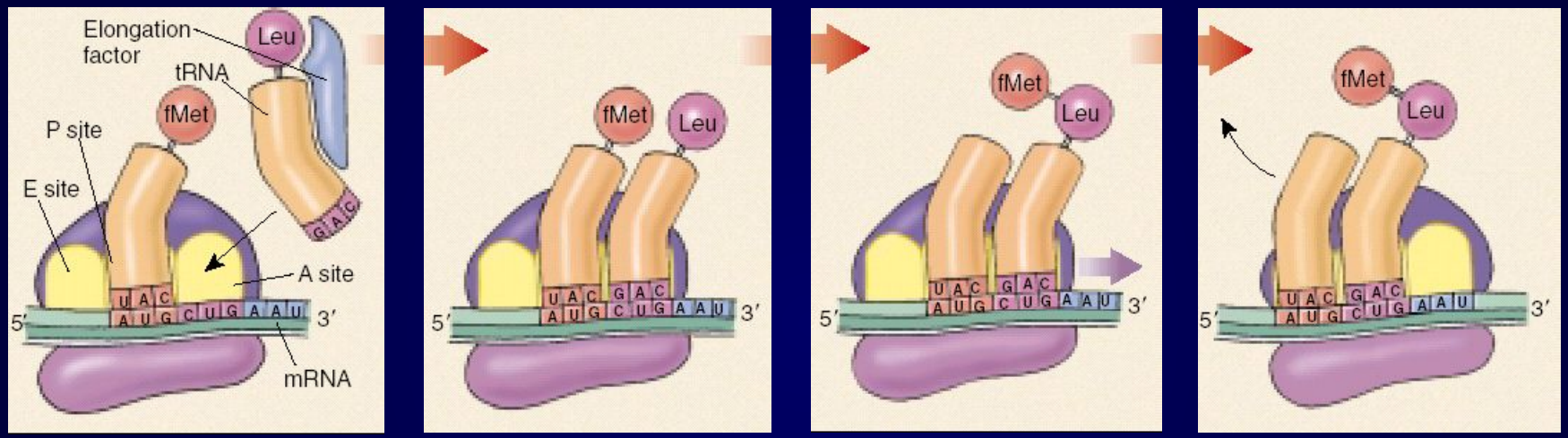
1 - Инициация.


fMet
Leader sequence
tRNA^fMet
U A C
A U G
mRNA
Small ribosomal subunit (containing ribosomal RNA)


Large ribosomal subunit
fMet
mRNA
U A C
A U G
Initiation complex


fMet
E site
P site
A site
5′
3′
U A C
A U G

2 – Элонгация.



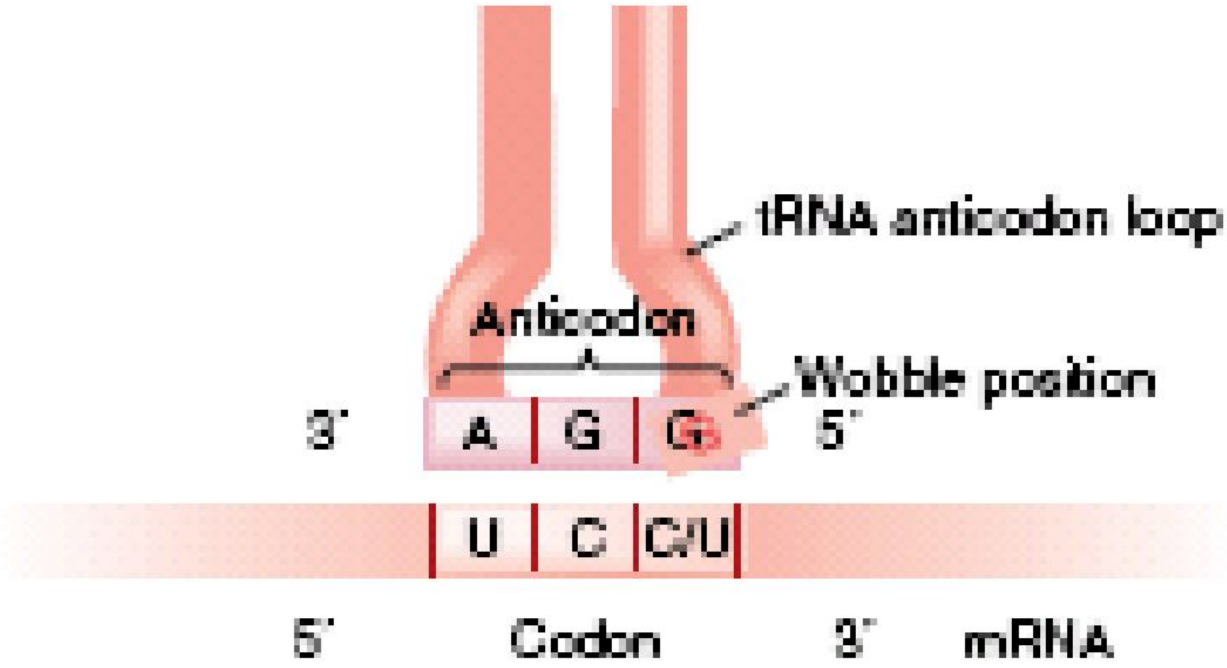
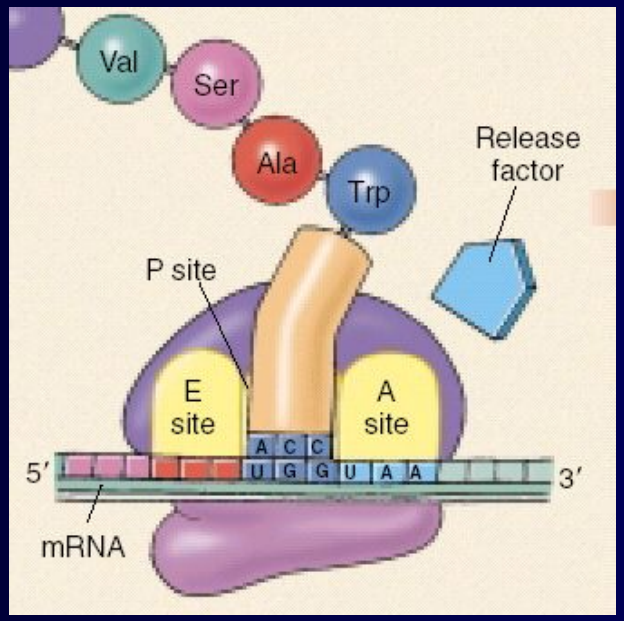
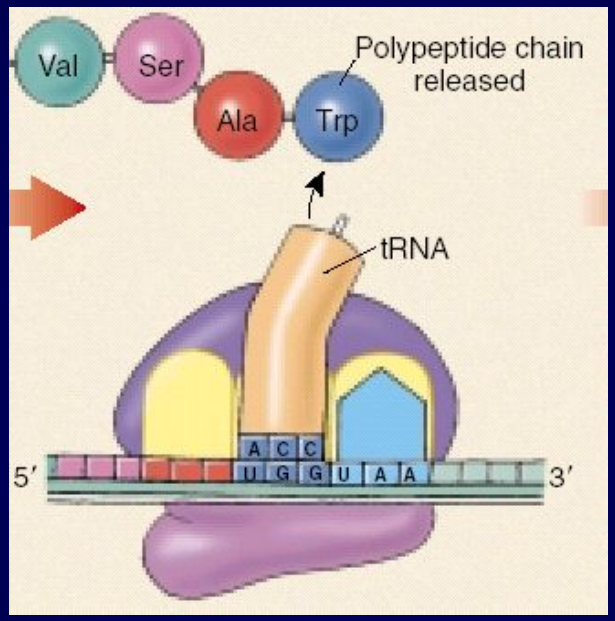
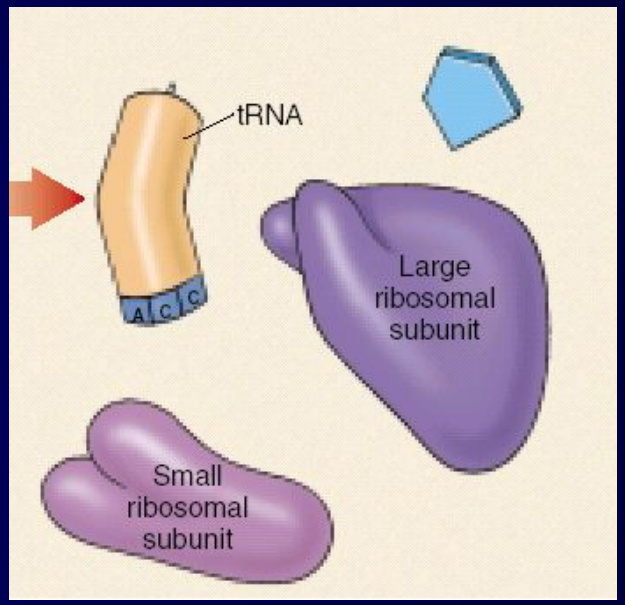


Figure 9-12 Wobble. In the third site (5′ end) of the anticodon, G can take either of two wobble positions, thus being able to pair with either U or C. This ability means that a single tRNA species carrying an amino acid (in this case, serine) can recognize two codons—UCU and UCC—in the mRNA.

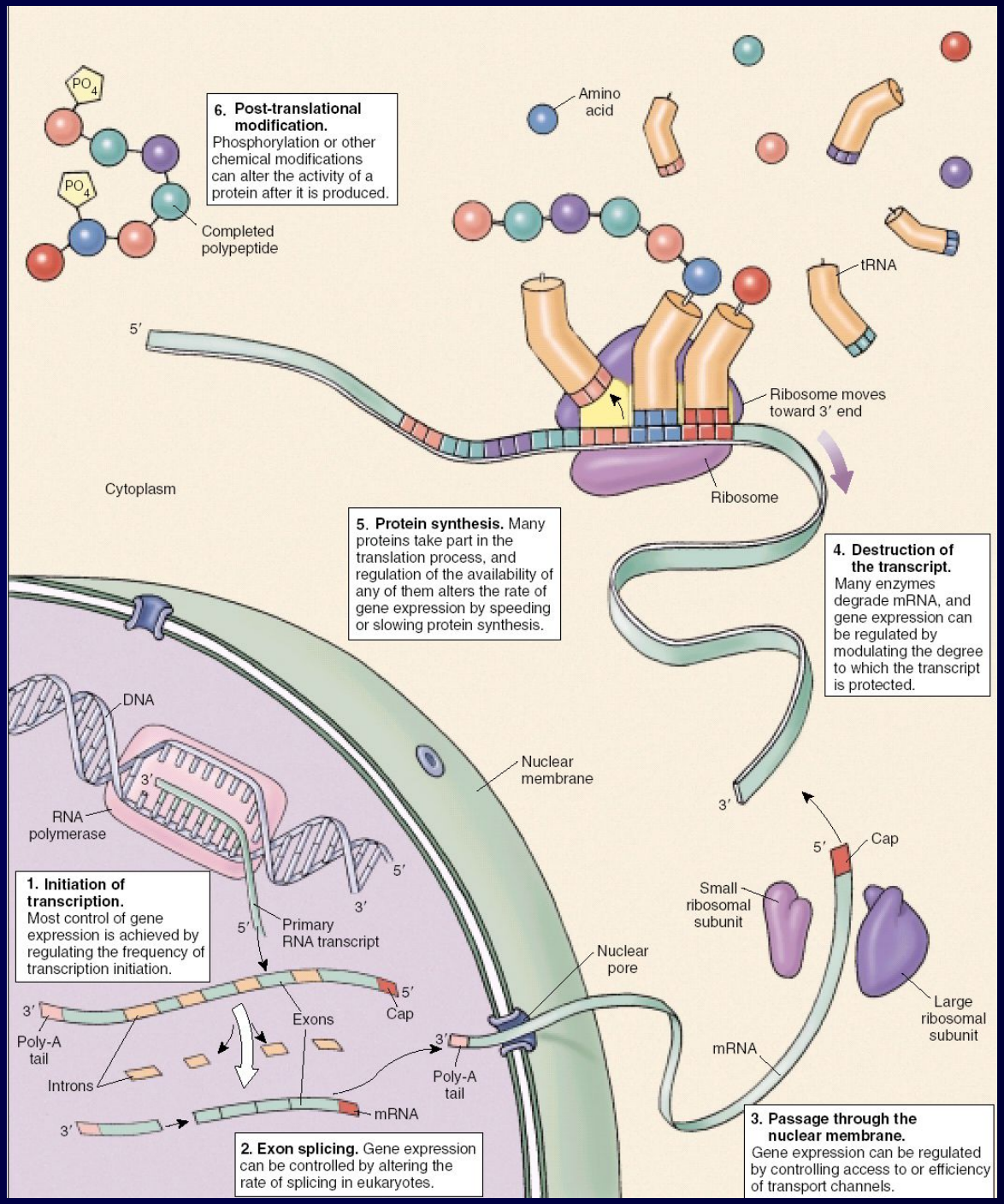
3 - Терминация.







Этапы биосинтеза белка



Полирибосома

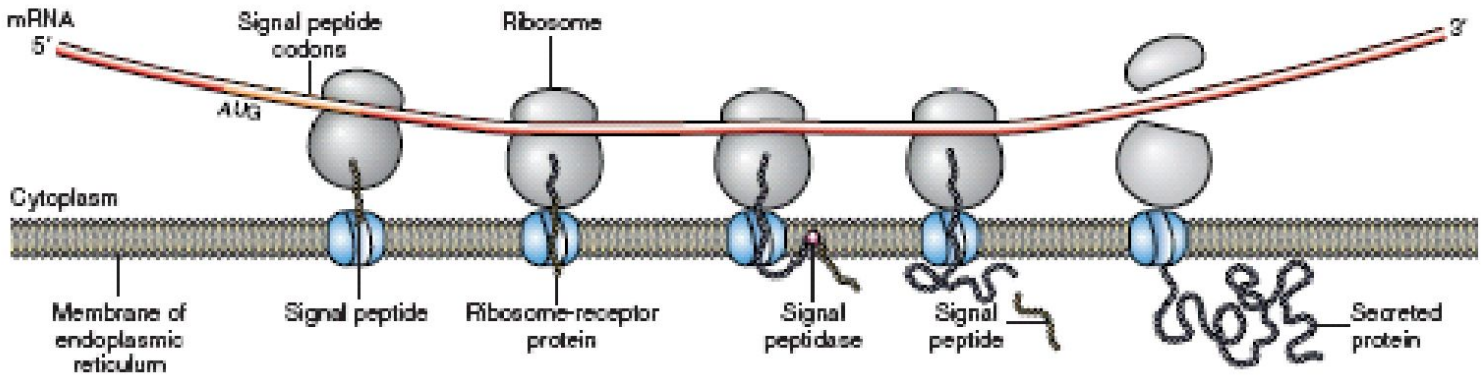
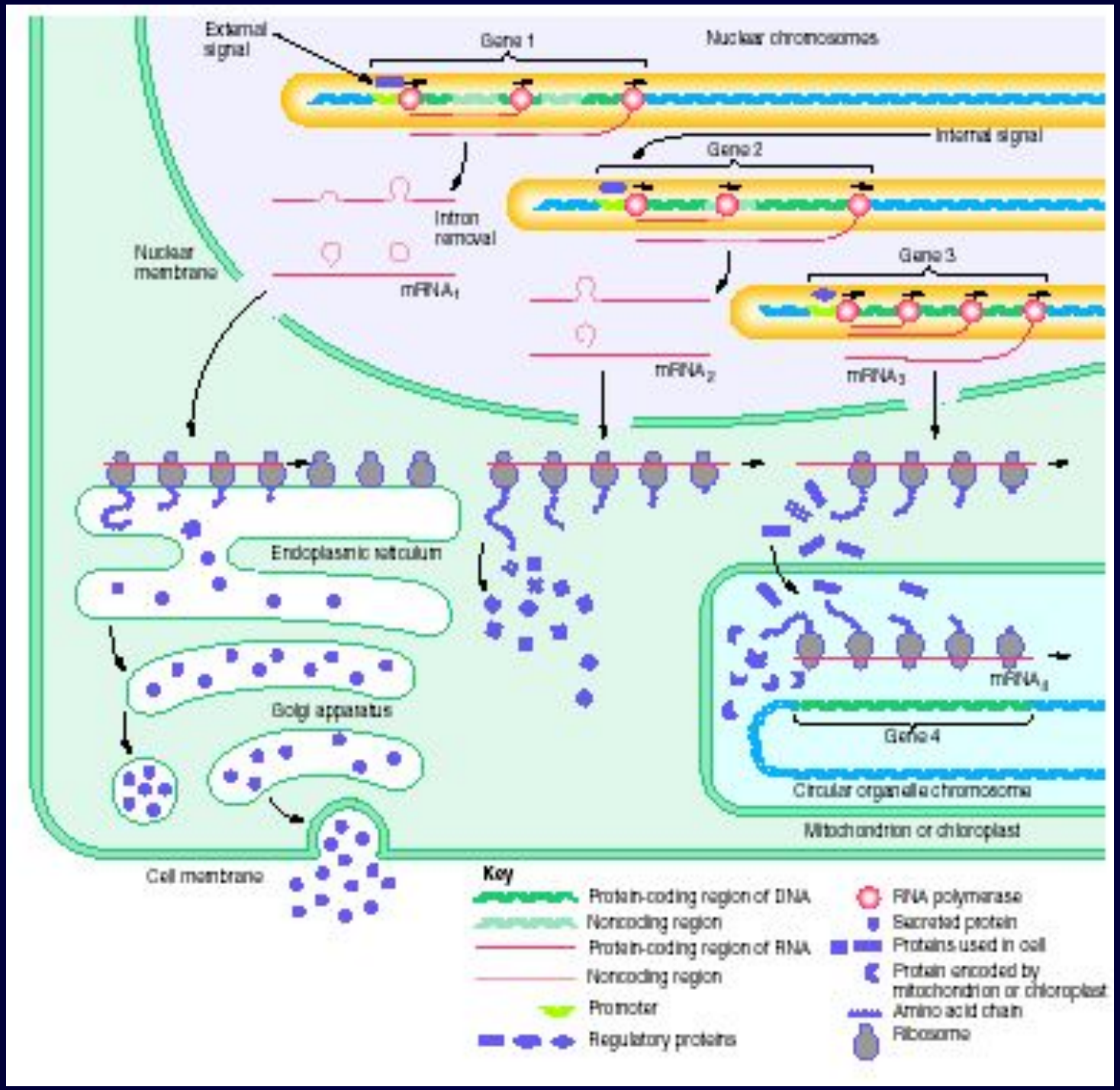
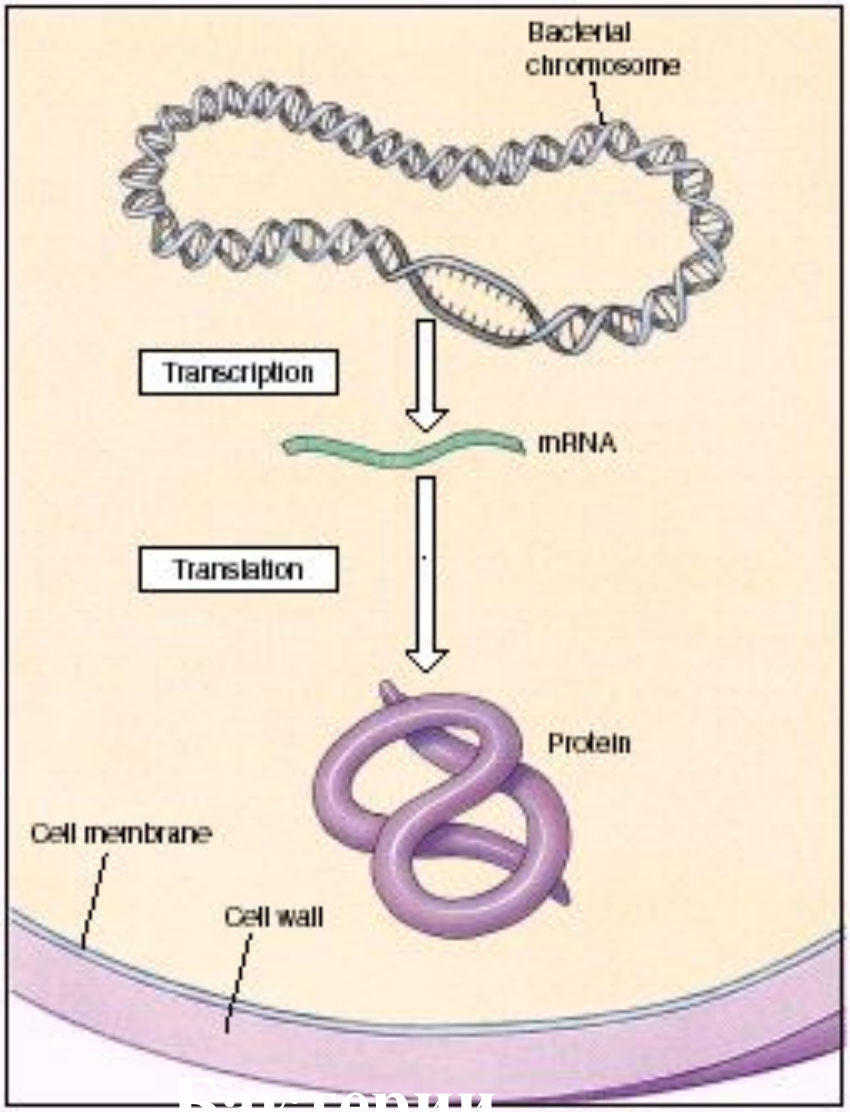


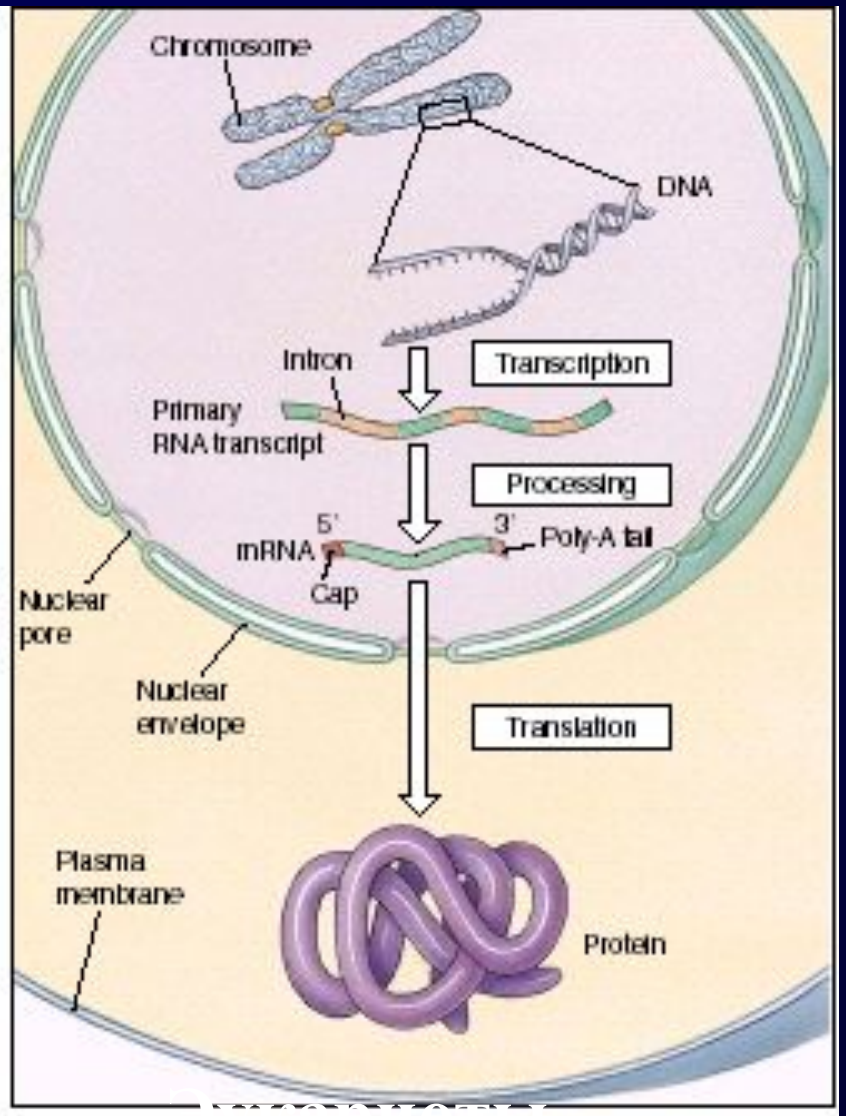
Figure 9-24 Signal sequences. Proteins destined to
an amino-terminal sequence that is rich in hydrophob
binds to the membrane and draws the remainder of th
bilayer. The signal sequence is cleaved from the prote
called *signal peptidase*.


External signal
Gene 1
Nuclear chromosomes
Internal signal
Gene 2
Intron removal
Nuclear membrane
Gene 3
mRNA1
mRNA2
mRNA3
Endoplasmic reticulum
Golgi apparatus
mRNA4
Gene 4
Circular organelle chromosome
Mitochondrion or chloroplast
Cell membrane
Key
Protein-coding region of DNA
Noncoding region
Protein-coding region of RNA
Noncoding region
Promoter
Regulatory proteins
RNA polymerase
Secreted protein
Proteins used in cell
Protein encoded by mitochondrion or chloroplast
Amino acid chain
Ribosome

Особенности реализации генетической информации у прокариот и эукариот.



(a)



(b)

Особенности организации наследственного материала у про− и эукариот

	Прокариоты	Эукариоты
ДНК	Одна кольцевая молекула	Линейная ДНК хромосом
Локализация ДНК	В цитоплазме	В ядре
Число точек начала репликации	Одна	Много
Скорость репликации	1000 нукл|сек	50 нукл\сек
Структура гена	Непрерывность	Мозаичная, прерывистая
Число транскрибирующих белков	Несколько (полицистрон)	Всегда 1 полипептид
Сплайсинг (созревание м−РНК)	Не требуется	Требуется
Ген− регулятор	Один	Несколько
Индукторы транскрипции	Ферменты	гормоны