

random[plasmid]

Deoxyribonucleic acid
(DNA) is a nucleic acid that contains the genetic
instructions used in the development and functioning
of all known living organisms and some viruses. The
main role of DNA molecules is the long-term storage of
information. DNA is often compared to a set of
blueprints, or a recipe, or a code, since it contains the
instructions needed to construct other components of
cells, such as proteins and RNA molecules. The DNA
segments that carry this genetic information are called
genes, but other DNA sequences have structural
purposes, or are involved in regulating the use of this
genetic information.

Chemically, DNA consists of two long polymers of simple units called nucleotides, with backbones made of sugars and phosphate groups joined by ester bonds. These two strands run in opposite directions to each other and are therefore anti-parallel. Attached to each sugar is one of four types of molecules called bases. In the sequence of these four bases along the backbone that encodes information. This information is read using the genetic code, which specifies the sequence of the amino acids within proteins. The code is read by copying stretches of DNA into the related nucleic acid RNA, in a process called transcription.

Within cells, DNA is organized into long structures called chromosomes. These chromosomes are duplicated before cells divide, in a process called DNA replication. Eukaryotic organisms (animals, plants, fungi, and protists) store most of their DNA inside the cell nucleus and some of their DNA in organelles, such as mitochondria and chloroplasts [1]. In contrast, prokaryotes (bacteria and archaea) store their DNA on a single chromosome in the cytoplasm. Within the chromosomes, chromatin proteins such as histones compact and organize DNA. These compact structures guide the interactions between DNA and other proteins, helping control which parts of the DNA are transcribed.

DNA is a long molecule made from repeating units called nucleotides. The length of a DNA molecule is 22 to 26 Angstroms. The length of a nucleotide is 3.3 Å (0.33 nm) long. The length of an individual repeating unit is very small.

[illegible]

The backbone of the DNA strand is made from alternating phosphate and sugar residues.[10]

phosphate groups that form phosphodiester bonds between the third and fifth carbon atoms of adjacent deoxyribose sugars. In a double helix, the phosphate groups are located on the outside of the structure, forming the backbone of the DNA molecule.

...directly
...and para-
...called the
...with the 5' end
...the 3' end a termi-
...difference between
...2-deoxyribose
...pentose sugar
...The DNA
...between
...bases attached to the

DNA exists in many possible conformations that include A-DNA, B-DNA, and Z-DNA forms, although only B-DNA and Z-DNA have been directly observed in functional organisms [10]. The conformation that DNA adopts depends on the hydration level, DNA sequence, the amount and direction of supercoiling, chemical modifications of the bases, the type and concentration of metal ions, as well as the presence of polyanions in solution [29].

The first published reports of A-DNA X-ray diffraction patterns—and also B-DNA used analyses based on Patterson transforms that provided only a limited amount of structural information for oriented fibers of DNA [30,31]. An alternate analysis was proposed by Wilkins et al in 1953, for the hybrid B-DNA X-ray diffraction/scattering patterns of highly hydrated DNA fibers in terms of squares of Bessel functions [32] in the same journal. Watson and Crick presented their molecular modeling analysis of the DNA X-ray diffraction pattern to suggest that the structure was a double helix [7].

Although the 'B-DNA form' is most common under the conditions found in cells, it is not a well-defined conformation but a family of related DNA conformations [34] that occur at the high hydration levels present in living cells. Their corresponding X-ray diffraction and scattering patterns are characteristic of molecular paracrystals with a significant degree of disorder [35] [36].

Compared to B-DNA, the A-DNA form is a wider right-handed spiral, with a shallow, wide minor groove and a narrower, deeper major groove. The A form occurs under non-physiological conditions in partially dehydrated samples of DNA, while in the cell it may be produced in hybrid pairings of DNA and RNA strands, as well as in enzyme-DNA complexes [17][18]. Segments of DNA where the bases have been chemically modified by methylation may undergo a larger change in conformation and adopt the Z form.

Самара 2015

Ознакомление с историей открытия нуклеиновых кислот, уровнями структурной организации и функциями ДНК.



Швейцарский биолог Йоган Фридрих
Мишер
Открыл нуклеиновые кислоты
в 1868 г.

«nucleus» - ядро
нуклеин содержит кислый
компонент, который
известен теперь как ДНК

Genetic information is encoded in DNA sequences. These sequences have structural purposes, or are involved in regulating the use of this genetic information.

Chemically, DNA consists of two long polymers of single units called nucleotides, which are linked together by sugar-phosphate groups. These two strands run in opposite directions to each other and are therefore anti-parallel. Attached to each sugar is one of four types of molecules called bases. It is the sequence of these four bases along the backbone that encodes information. This information is read using the genetic code, which specifies the sequence of the amino acids within proteins. The code is read by copying stretches of DNA into the related messenger RNA, in a process called transcription.

When cells, DNA is organized into long structures called chromosomes. These chromosomes are duplicated before cells divide, in a process called DNA replication. Eukaryotic organisms (animals, plants, fungi, and protists) store most of their DNA inside the cell nucleus and some of their DNA as organelles, such as mitochondria and chloroplasts. In contrast, prokaryotes (bacteria and archaea) store their DNA only in the cytoplasm. Within the chromosomes, chromatin proteins such as histones compact and organize DNA. These compact structures guide the interactions between DNA and other proteins, helping control which parts of the DNA are transcribed.

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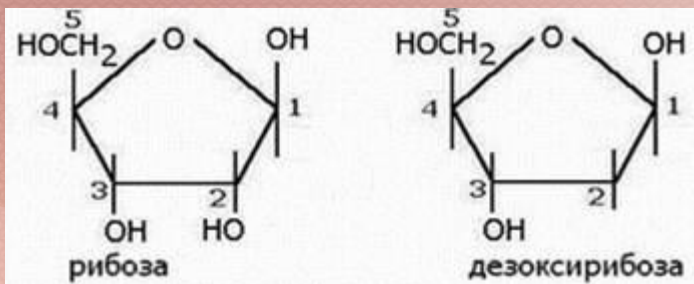
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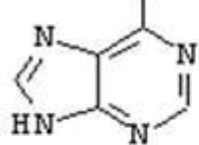
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Нуклеотид

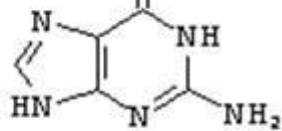
Моносахариды



Пуриновые основания

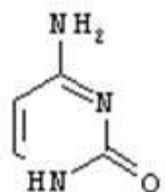


аденин

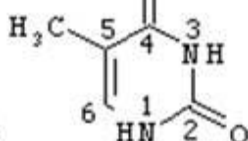


гуанин

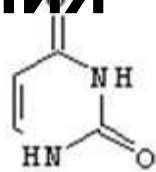
Пиримидиновые основания



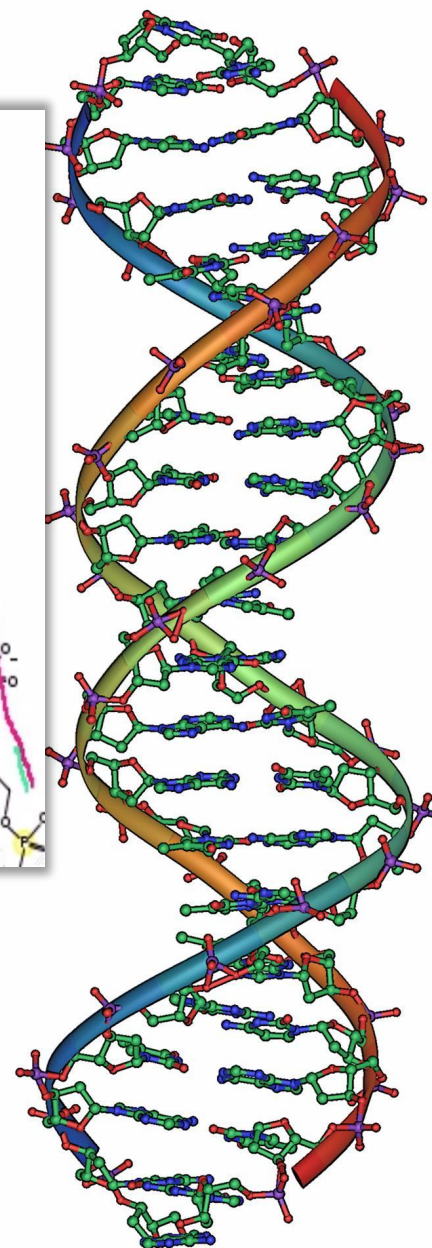
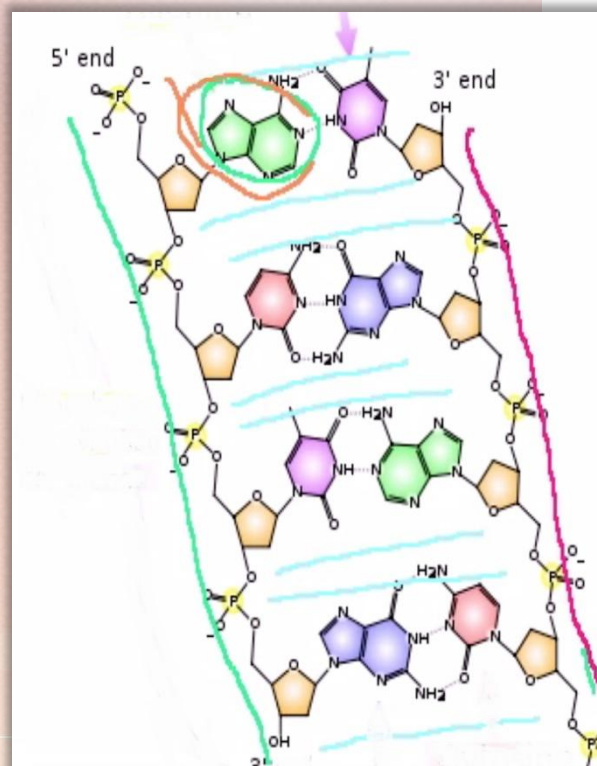
цитозин



тимин



урацил

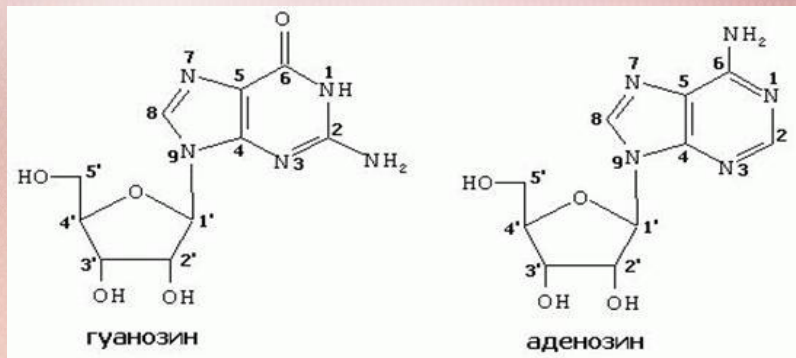


1 оборот спирали = 10 комплементарных пар = 3,4 нм

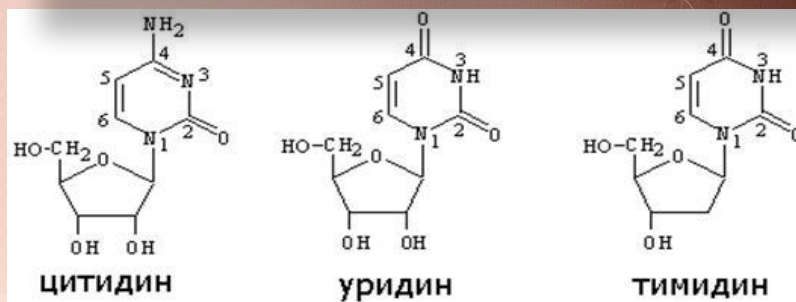
2 нм

Нуклеозиды

Пуриновые



Пиримидиновые

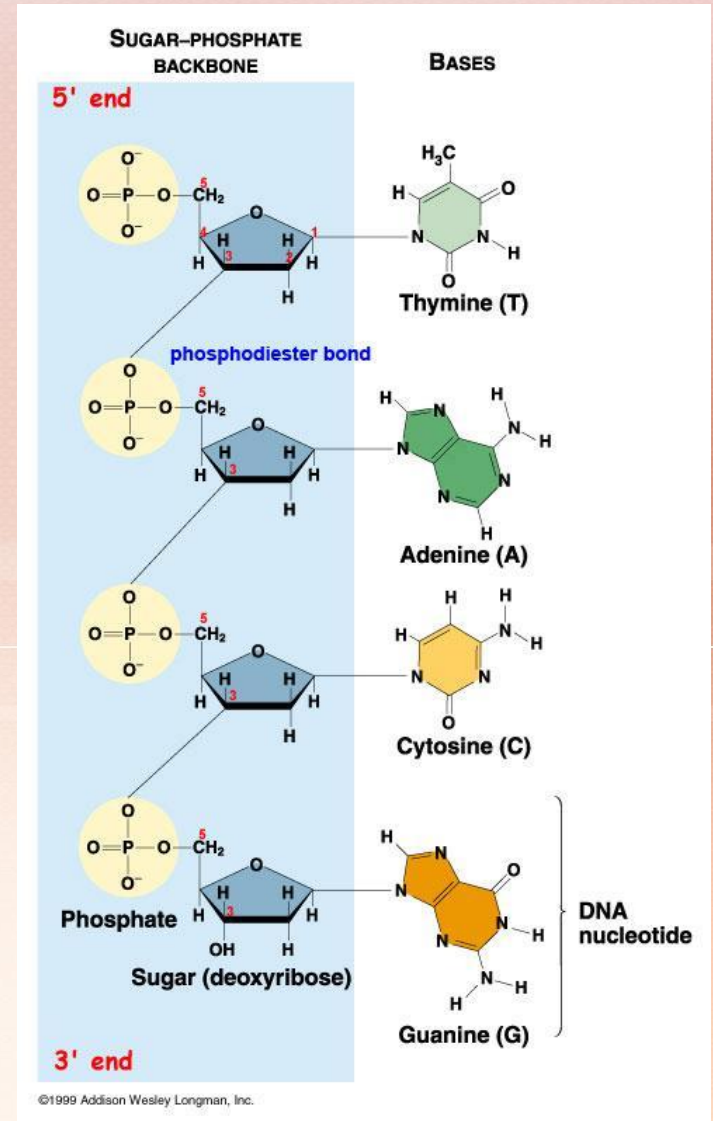
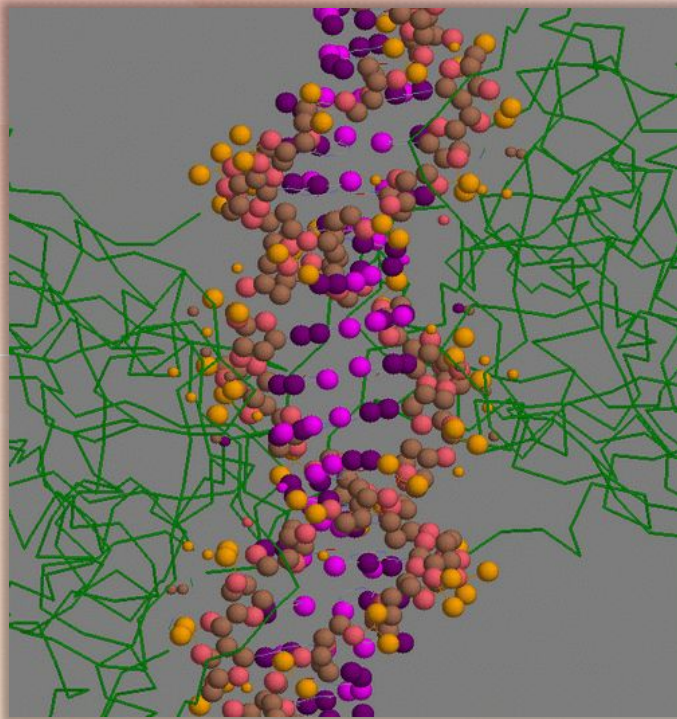


Азотистые основания	Нуклеозиды	Нуклеотиды	
Полное название	Сокращенное название		
Аденин	Аденозин	Аденозинмонофосфат	АМФ
Гуанин	Гуанозин	Гуанозинмонофосфат	ГМФ
Цитозин	Цитидин	Цитидинмонофосфат	ЦМФ
Урацил	Уридин	Уридинмонофосфат	УМФ
Тимин	Тимидин	тиминмонофосфат	ТМФ

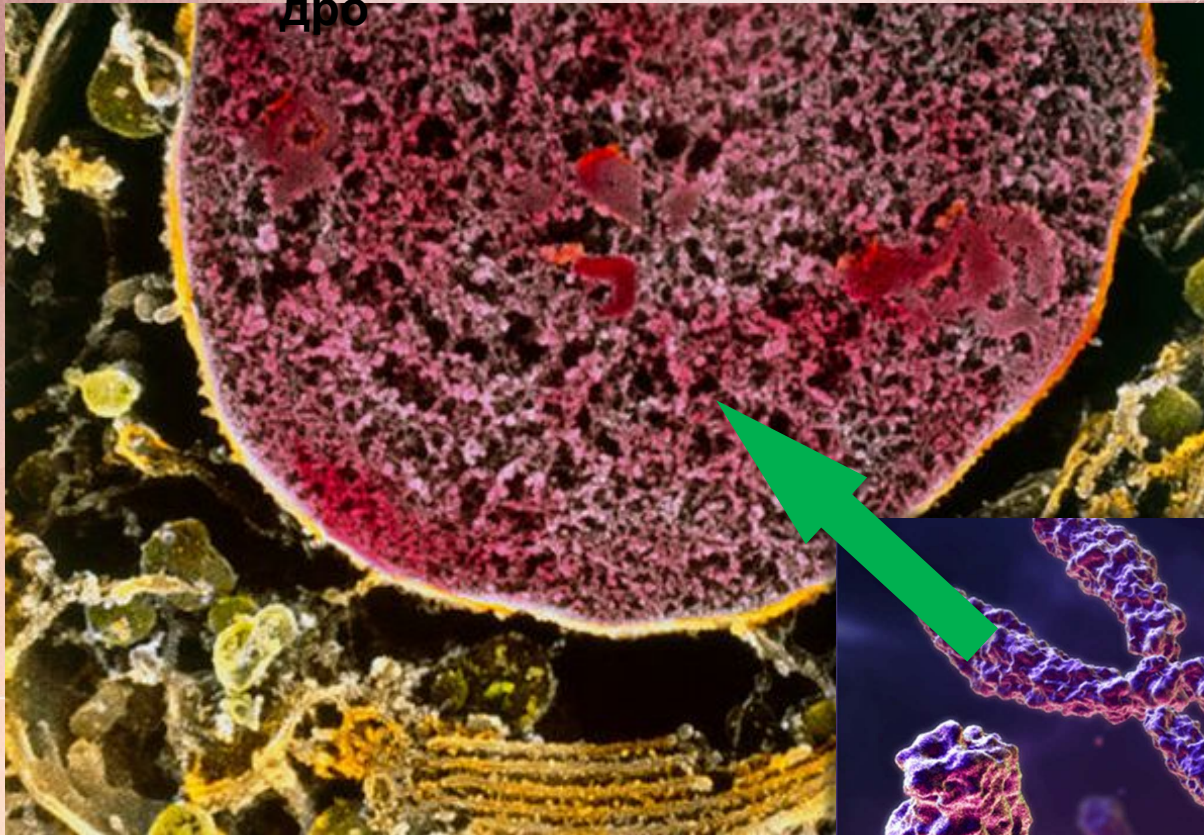
ДНК и РНК обладают первичной, вторичной, третичной структурами.

Первичная структура ДНК– последовательность нуклеотидов в молекуле ДНК.

5'-НО-Г-А-А-Т-Ц-Т-А-Ц-А-...3'



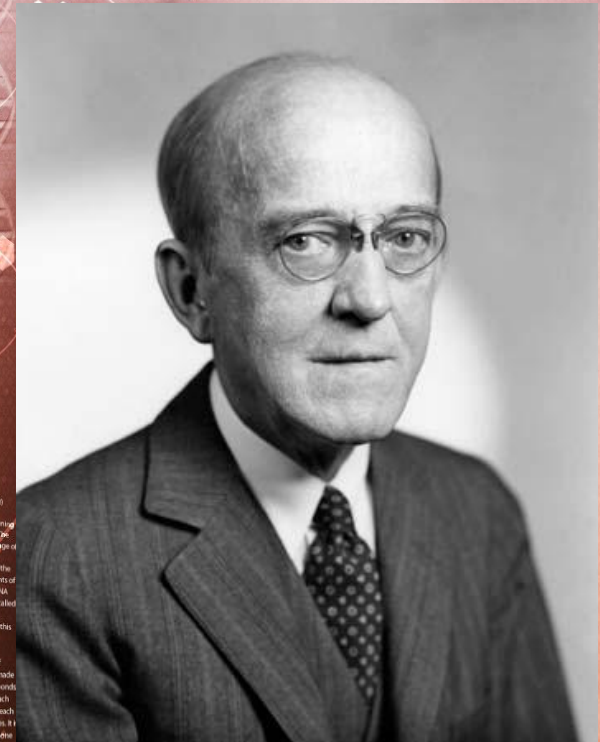
Срез клетки через клеточное ядро



Информация ДНК наследуется

В 1943 г. Освальд Эвери и его сотрудники из Рокфеллеровского института обнаружили, что непатогенный (неболезнетворный) штамм бактерии пневмококка может быть трансформирован в патогенный простым добавлением ДНК, выделенной из патогенных пневмококков (свойство патогенности наследуется).

Вывод: ДНК может содержать генетическую информацию.



Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms and some viruses. The main role of DNA molecules is the long-term storage of information. DNA is often compared to a set of blueprints or a recipe, as a code, since it contains the instructions needed to construct other components of cells, such as proteins and RNA molecules. The DNA segments that carry this genetic information are called genes, but other DNA sequences have structural purposes, or are involved in regulating the use of this genetic information.

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Some of the DNA strand is made of a sugar-phosphate and sugar residues (10).

Although the B-DNA form is most common in the conditions found in cells, it is not a well-defined conformation, but a family of related DNA conformations (14) that occur at the high hydration level present in living cells. Their corresponding X-ray diffraction and EM scattering patterns are discussed in (15).

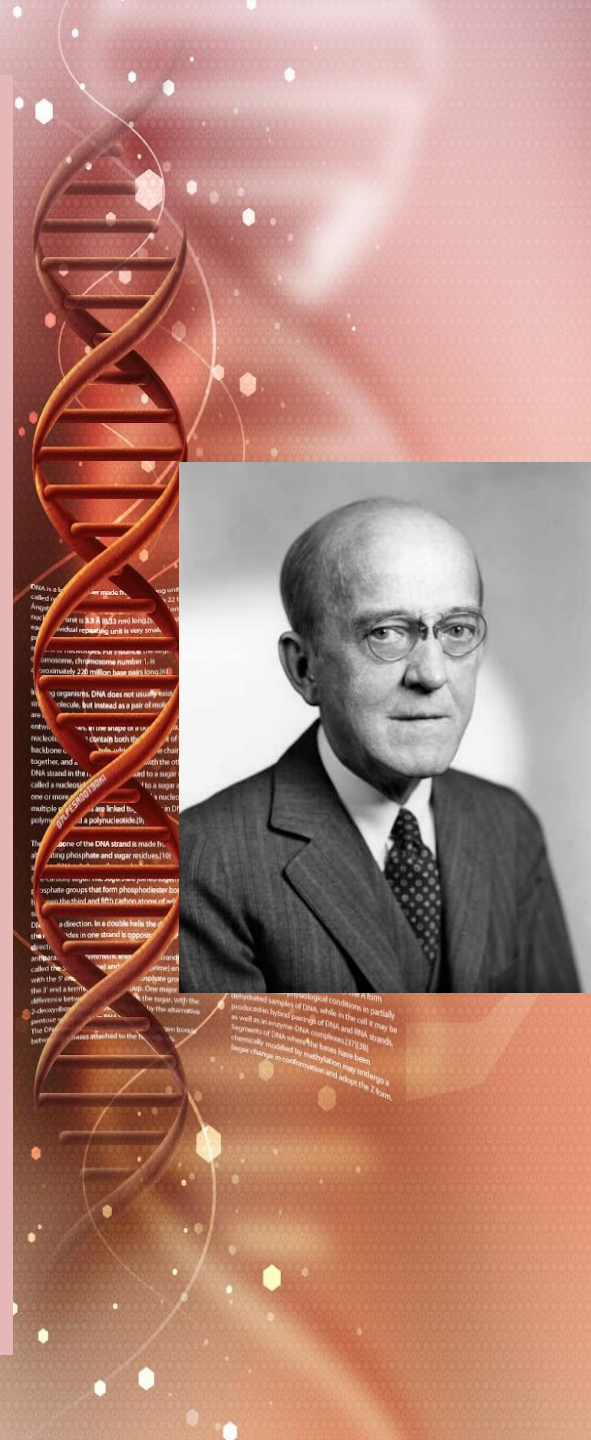


Было установлено, что:

- 1. Содержание ДНК** в любой клетке или организме **строго постоянно**;
- 2. Содержание ДНК в клетке увеличивается с возрастанием сложности клетки**, следовательно, с возрастанием генетической информации в клетке. Чем сложнее организм, тем больше ДНК в его клетках;
- 3. Гаплоидные половые клетки высших организмов** (содержащие одинарный набор хромосом) **содержат точно половину количества ДНК**, которое обнаружено в диплоидных клетках того же организма;
- 4. ДНК-содержащие вирусы бактерий (бактериофаги) и вирусы животных**, имеющие лишь несколько генов, **содержат очень мало ДНК**.

Это указывает на генетическую функцию ДНК:

ДНК хранит генетическую информацию.



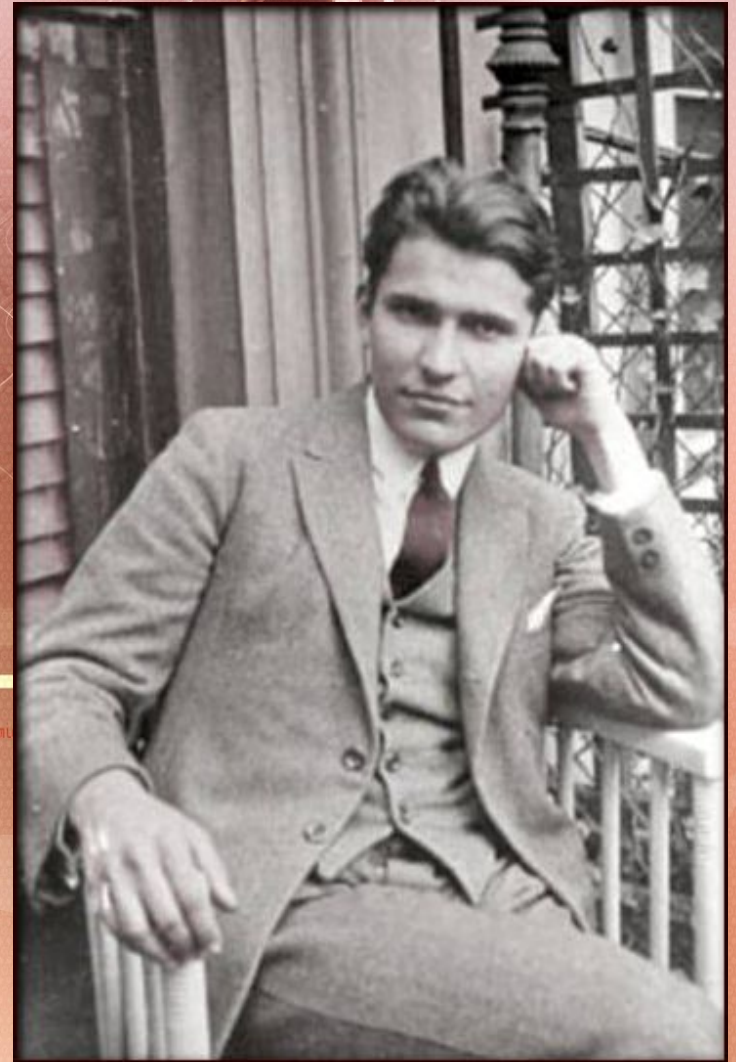
Правила Чаргаффа

1. Препараты ДНК, выделенные из разных тканей одного и того же организма, имеют одинаковый нуклеотидный состав.
2. Нуклеотидный состав ДНК у разных видов различен.
3. Число адениновых остатков в любой ДНК независимо от вида организма равно числу тиминовых остатков ($A=T$), а число гуаниновых остатков всегда равно числу цитозиновых остатков ($G=C$).

Следовательно:

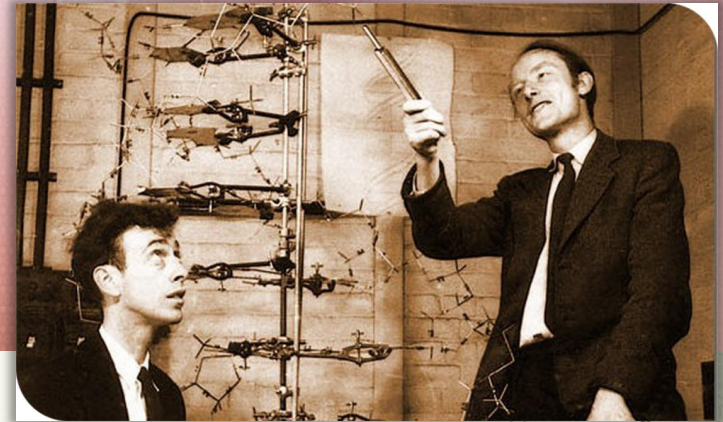
сумма пуриновых остатков равно сумме пиримидиновых, т.е. $A + G = T + C$

Было установлено, что ДНК близких видов имеют сходный нуклеотидный состав, а эволюционно отдаленные организмы заметно отличаются по нуклеотидному составу.



Вторичная структура ДНК

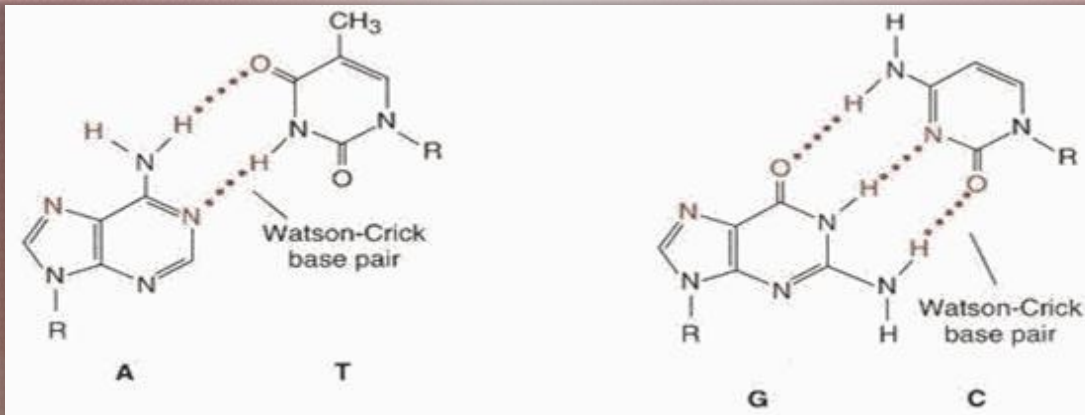
1953 год. Американский генетик Джеймс Уотсон и английский физик Френсис Крик предложили трехмерную модель двойной спирали ДНК.



С помощью данных рентгеноструктурного анализа установлено, что:

1. Молекула ДНК имеет постоянный диаметр 2 нм ($1 \text{ нм} = 10^{-9} \text{ м}$)
молекула пурина 1,2 нм
молекула пиримидина 0,8 нм
 $1,2 + 0,8 = 2 \text{ нм}$
Количество пуриновых оснований равно количеству пиримидиновых оснований.
2. Основания уложенных стопкой внутри двойной спирали ДНК и располагаются на расстояниях 0,34 нм друг от друга.
3. На каждый полный оборот двойной спирали приходится 10 пар оснований. Следовательно, молекула ДНК имеет периодичность в структуре равную 3,4 нм.





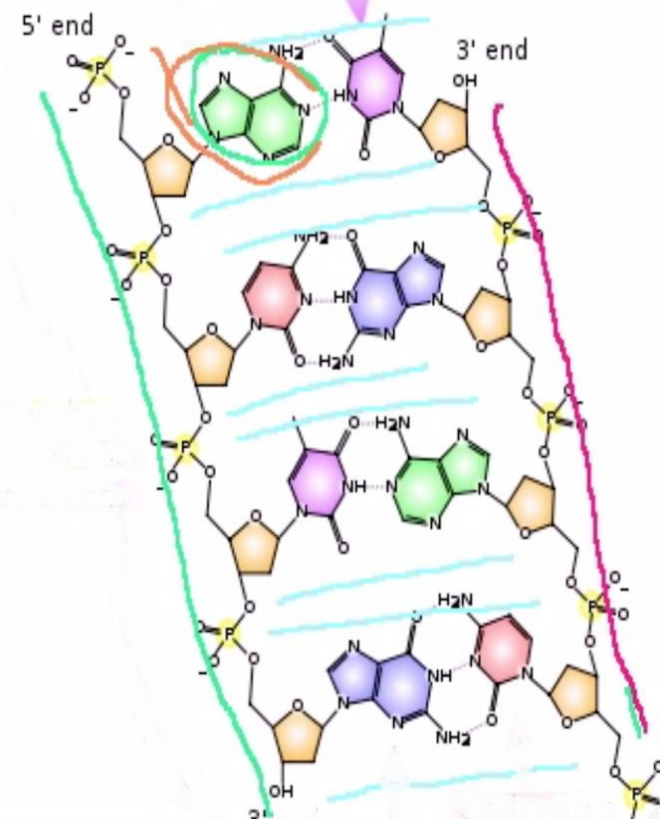
1. **Молекула ДНК** имеет постоянный **диаметр 2 нм** ($1 \text{ нм} = 10^{-9} \text{ м}$): молекула пурина 1,2 нм; молекула пиримидина 0,8 нм **$1,2 + 0,8 = 2 \text{ нм}$**
Количество пуриновых оснований равно количеству пиримидиновых оснований.

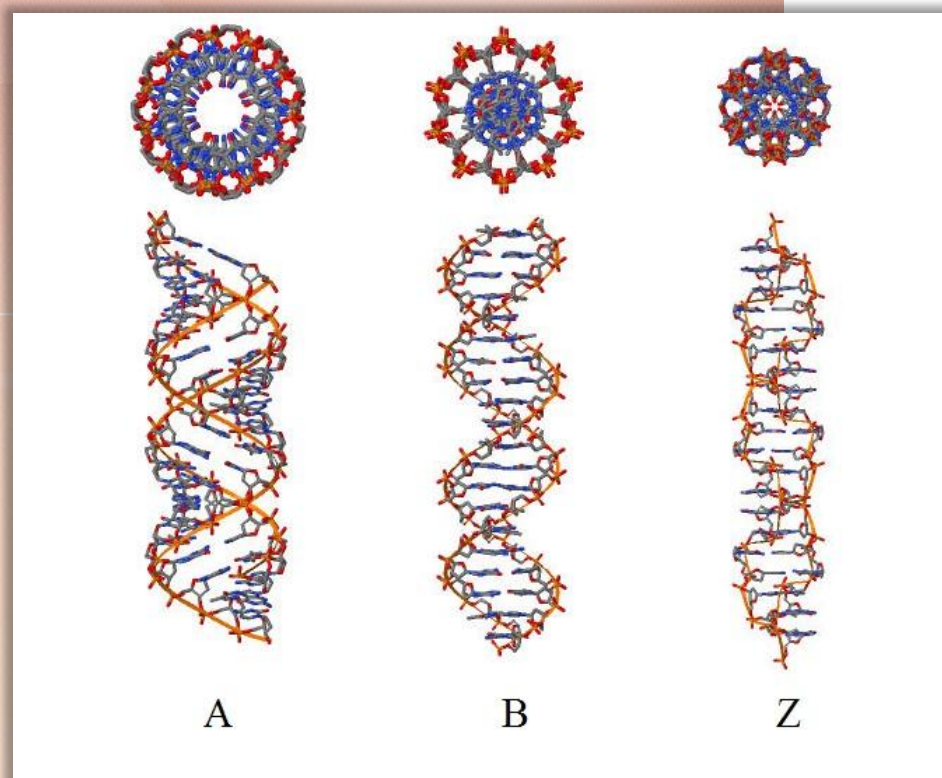
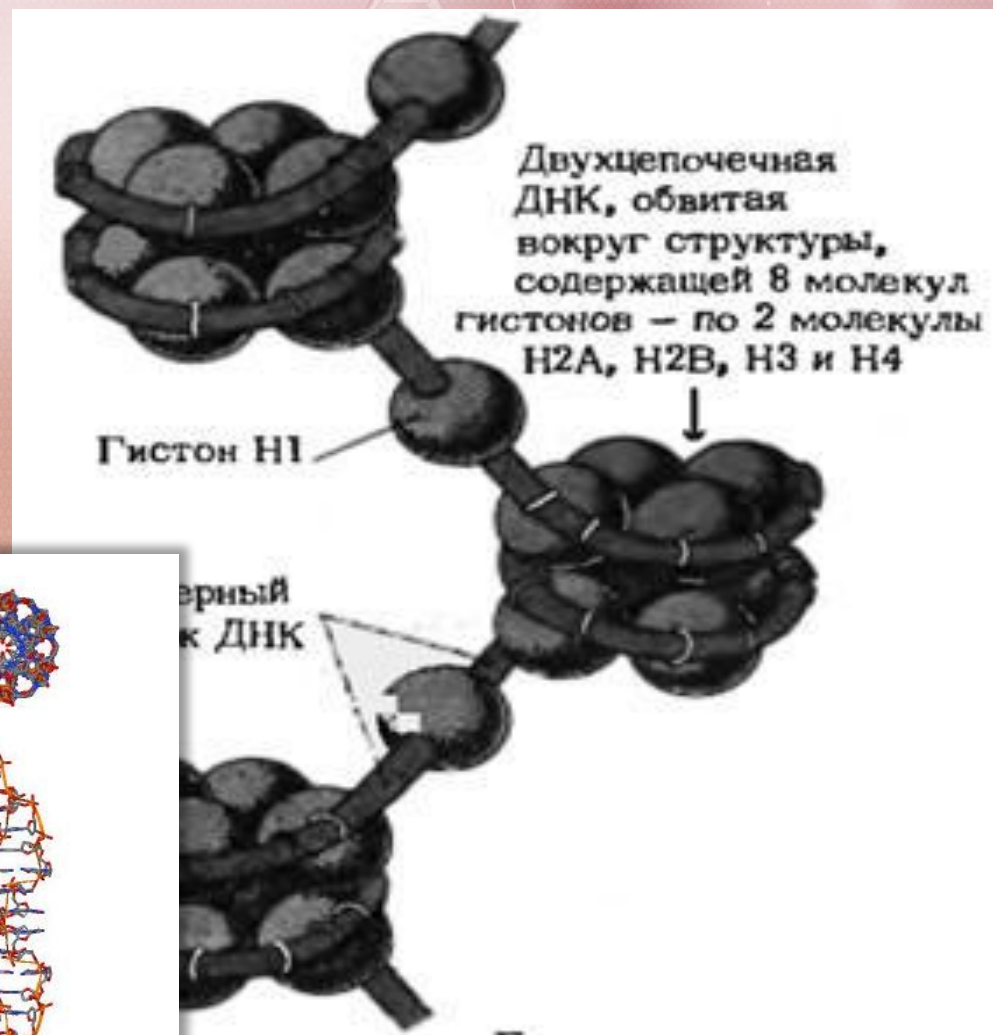
2. **Основания** уложенных стопкой внутри двойной **спирали ДНК** располагаются **на расстояниях 0,34 нм друг от друга**.

3. На каждый **полный оборот двойной спирали** приходится **10 пар оснований**. Следовательно, молекула ДНК имеет периодичность в структуре равную 3,4 нм.

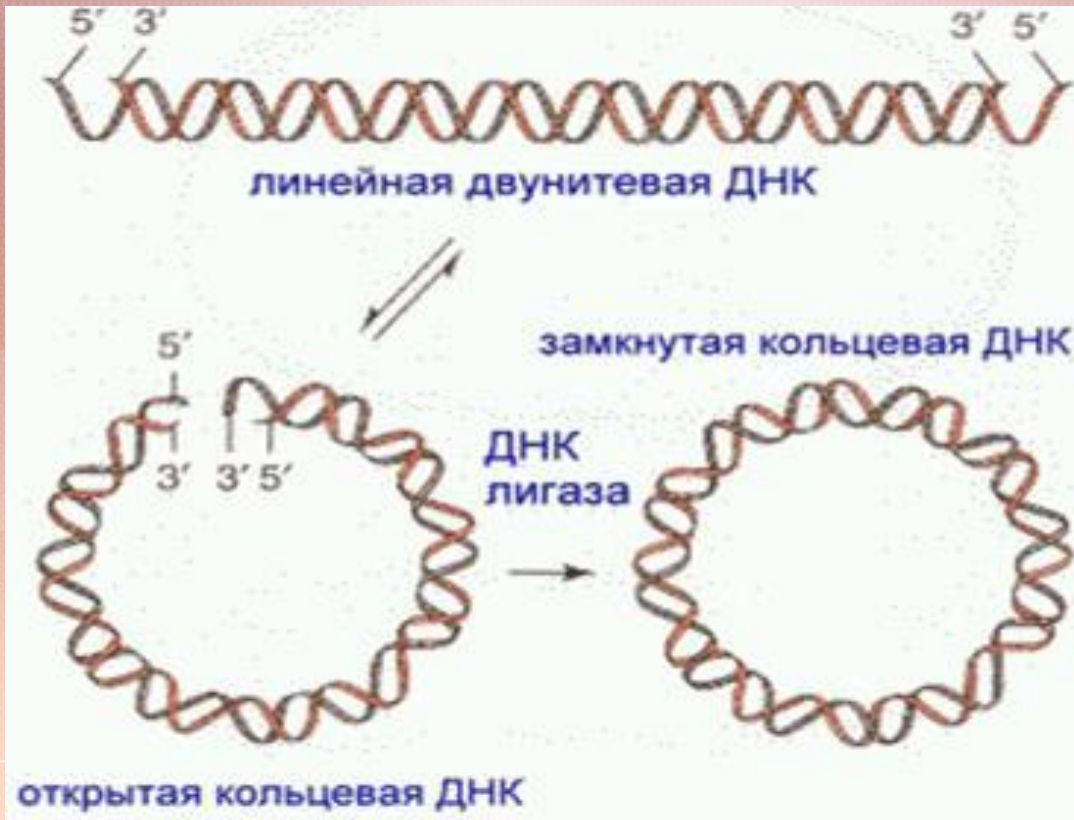
Стабилизация двойной спирали происходит:

1. за счет водородных связей между комплементарными основаниями $A = T, G \equiv C$.
2. за счет гидрофобных взаимодействий между основаниями, благодаря чему основания оказываются спрятанными внутрь двойной спирали и защищены от соприкосновения с водой.





Третичная структура ДНК



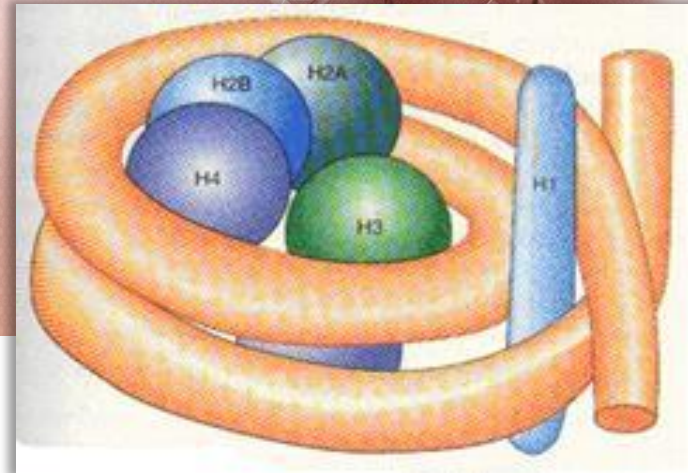
Размер типичной эукариотической клетки, например, клетки печени человека, составляет в поперечнике ~ 25 мкм. Ее ядро, размером ~ 5 мкм в диаметре, содержит 46 хромосом, суммарная длина ДНК которых равна 2 м. Эукариоты содержат значительно больше ДНК, чем прокариоты. Общая длина всей ДНК, выделенной из клеток организма взрослого человека, составляет $\sim 2 \times 10^{13}$ м или 2×10^{10} км, что превышает окружность земного шара (4×10^4 км) и расстояние от Земли до Солнца ($1,44 \times 10^8$ км).



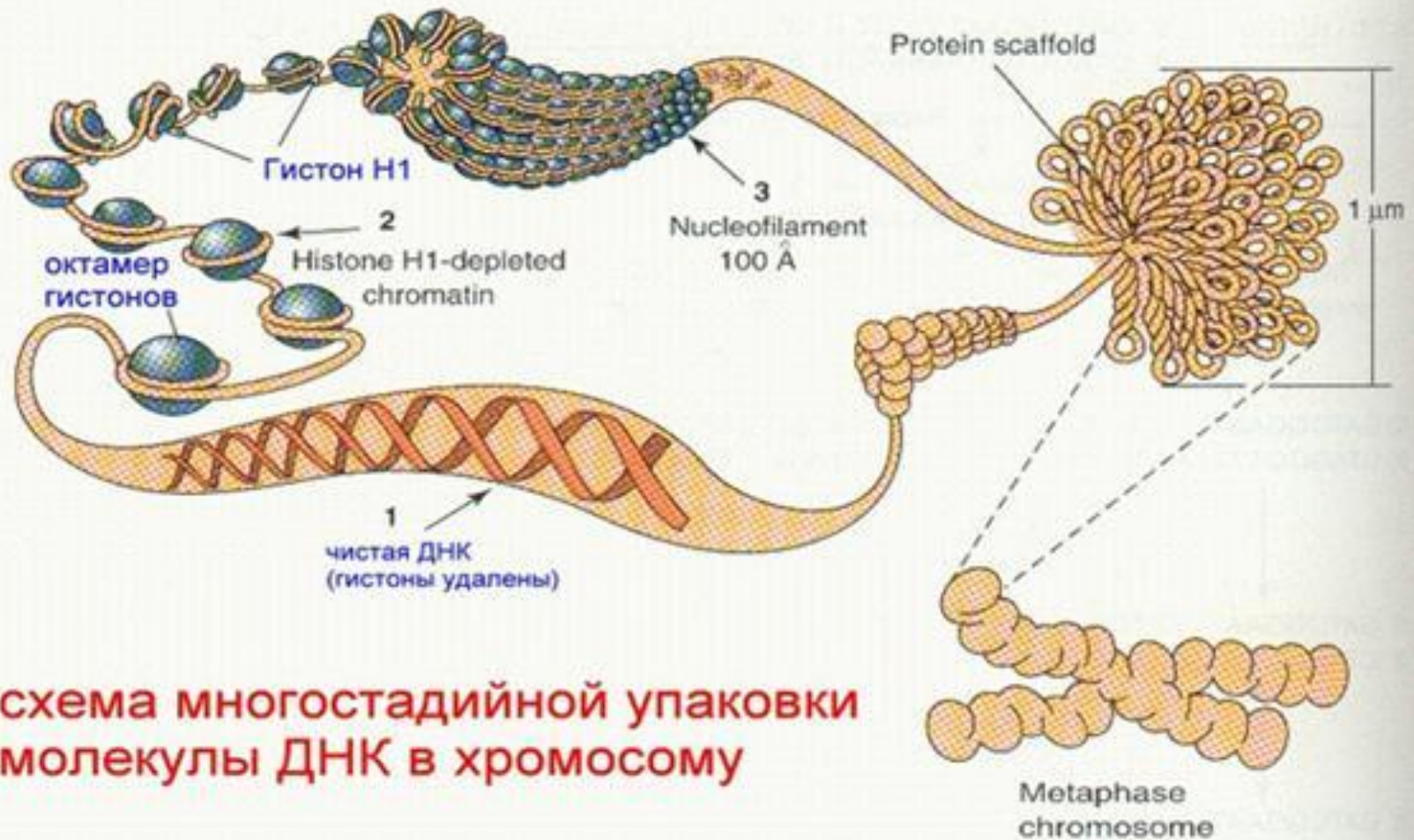
Срез клетки через
ядро

Нуклеосома

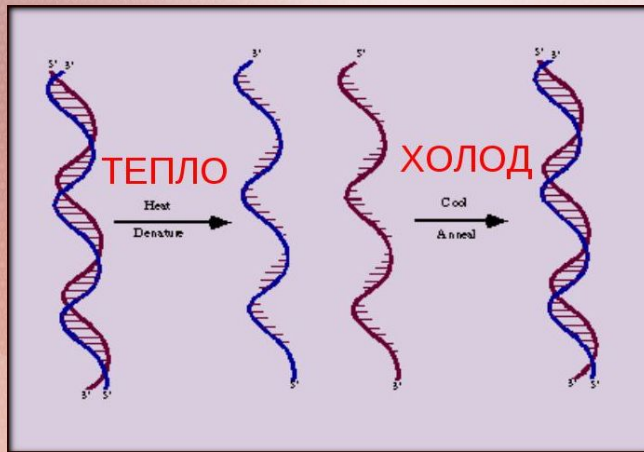
Нуклеосома состоит из белков-гистонов. Каждая нуклеосома содержит 8 молекул гистонов – по 2 молекулы H2A, H2B, H3, H4. Двухцепочечная ДНК обвивает нуклеосому дважды.



Упаковка ДНК в хромосоме



Физико-химические свойства ДНК



$t \geq 80^{\circ}\text{C}$ и выше

гиперхромным
эффектом

Структура
ДНК



Воздействие
ультрафиолетового
излучения

гипохромным

$t < 80^{\circ}\text{C}$



Функции ДНК

- закодирована генетическая информация
- обеспечение воспроизводства самой себя
- обеспечение синтеза белков
- РЕНАТУРАЦИЕЙ
-

Спасибо за внимание

