**Lecture 1 structure and function**

•DNA and RNA are chain-lie molecules composed of subunits called nucleotides

•Nucleotides contain a base linked to the 1’-position of a sugar and a phosphate group

•Phosphate joins the sugars in a DNA or RNA chain through their 5’-and 3’-hydroxyl groups by phosphodiester bonds

•The DNA molecule is a double helix, with sugar-phosphate backbones on the outside and base pairs on the inside

•The bases pair in a specific way:–Adenine (A) with thymine (T)–Guanine (G) with cytosine (C)

REVIEW DNAS DNA……

1List the conclusions Griffith & Avery, Hershey & Chase drew from their experiments.

Griffith & Avery—DNA transformed pneumococcus(肺炎球菌) bacteria. Concluded that DNA, not protein, transforms bacteria.一种基因型细胞的DNA进入另一种基因型的细胞后，可引起稳定的遗传变异，DNA赋有特定的遗传特性。

Hershey and Chase—Bacteriophage（噬菌体） experiment. 噬菌体的DNA是决定遗传性的物质

2Describe the overall structure of the DNA molecule.

The DNA molecule is a double helix, with sugar-phosphate backbones on the outside and base pairs on the inside

3 What are the 4 kinds of bases?

Purine： Adenine Guanine

Pyrimidine： Cytosine Thymine

4 Summarize the relationship between genes & DNA.

DNA是由四种脱氧核糖核苷酸经磷酸二酯键连接而成的长链聚合物，是遗传信息的载体。

基因是遗传的物质基础，是DNA分子上具有遗传信息的特定核苷酸序列的总称，是具有遗传效应的DNA分子片段。

**Lecture 2 Chromosomes, chromatins and the nucleosome**

•DNA, Chromosome

DNA **DNA**, is a [nucleic acid](http://en.wikipedia.org/wiki/Nucleic_acid) that contains the [genetic](http://en.wikipedia.org/wiki/Genetics) instructions used in the development and functioning of all known living [organisms](http://en.wikipedia.org/wiki/Organism) (with the exception of [RNA viruses](http://en.wikipedia.org/wiki/RNA_virus)).

A **chromosome** is an organized structure of [DNA](http://en.wikipedia.org/wiki/DNA) and [protein](http://en.wikipedia.org/wiki/Protein) found in [cells](http://en.wikipedia.org/wiki/Cell_(biology)).

•Nucleosome, Chromatin,

**Nucleosomes** are the basic unit of [DNA](http://en.wikipedia.org/wiki/DNA) packaging in [eukaryotes](http://en.wikipedia.org/wiki/Eukaryotes), consisting of a segment of DNA wound around a [histone](http://en.wikipedia.org/wiki/Histone) [protein](http://en.wikipedia.org/wiki/Protein) core.[[1]](http://en.wikipedia.org/wiki/Nucleosome#cite_note-Campbell-0) This structure is often compared to thread wrapped around a spool

**Chromatin** is the combination of DNA and other proteins that make up the contents of the nucleus.

•Histone: H1, H2A, H2B, H3, H4

In [biology](http://en.wikipedia.org/wiki/Biology), **histones** are highly alkaline [proteins](http://en.wikipedia.org/wiki/Protein) found in [eukaryotic](http://en.wikipedia.org/wiki/Eukaryote) cell nuclei that package and order the [DNA](http://en.wikipedia.org/wiki/DNA) into structural units called [nucleosomes](http://en.wikipedia.org/wiki/Nucleosomes).

•Histone octamer, DNA packaging

A **histone octamer** is an [octamer](http://en.wikipedia.org/wiki/Octamer) of the [histones](http://en.wikipedia.org/wiki/Histone) found at the center of a [nucleosome core particle](http://en.wikipedia.org/wiki/Nucleosome_core_particle). It consists of 2 copies of each of the four core histone proteins ([H2A](http://en.wikipedia.org/wiki/Histone_H2A), [H2B](http://en.wikipedia.org/wiki/Histone_H2B), [H3](http://en.wikipedia.org/wiki/Histone_H3) and [H4](http://en.wikipedia.org/wiki/Histone_H4)). The octamer assembles when a tetramer, containing two copies of both H3 and H4, complexes with two H2A/H2B dimers. These histones of the histone octamer all contain [N-terminal tails](http://en.wikipedia.org/wiki/N-terminal_tail) that emanate from their central [histone folds](http://en.wikipedia.org/wiki/Histone_fold), and core domains with the C-terminals. The core domains are hydrophobic.

[Prokaryotes](http://en.wikipedia.org/wiki/Prokaryote) do not possess nuclei. Instead, their DNA is organized into a structure called the [nucleoid](http://en.wikipedia.org/wiki/Nucleoid).[[11]](http://en.wikipedia.org/wiki/Chromosome#cite_note-10) The nucleoid is a distinct structure and occupies a defined region of the bacterial cell. This structure is, however, dynamic and is maintained and remodeled by the actions of a range of histone-like proteins, which associate with the bacterial chromosome.[[12]](http://en.wikipedia.org/wiki/Chromosome#cite_note-11) In [archaea](http://en.wikipedia.org/wiki/Archaea), the DNA in chromosomes is even more organized, with the DNA packaged within structures similar to eukaryotic nucleosomes.

•DNA binding proteins, Histone modifications

Changes in chromatin structure are affected by chemical **modifications of histone** proteins such as methylation (DNA and proteins) and acetylation (proteins), and by non-histone, DNA-binding proteins.

•Centromere, telomere, replication origin

A **centromere** is a region of [DNA](http://en.wikipedia.org/wiki/DNA) typically found near the middle of a [chromosome](http://en.wikipedia.org/wiki/Chromosome) where two identical [sister chromatids](http://en.wikipedia.org/wiki/Sister_chromatids) come closest in contact.

A **telomere** is a region of repetitive [DNA](http://en.wikipedia.org/wiki/DNA) sequence at the end of a [chromosome](http://en.wikipedia.org/wiki/Chromosome), which protects the end of the chromosome from deterioration or from fusion with neighbouring chromosomes.

The origin of replication (also called the **replication origin**) is a particular sequence in a [genome](http://en.wikipedia.org/wiki/Genome) at which replication is initiated.

**Lecture 3 DNA Replication**

**Parent strand**

template

**Helicase(解旋酶), topoisomerase（拓扑异构酶）**

**Helicases** are a class of [enzymes](http://en.wikipedia.org/wiki/Enzyme) vital to all living [organisms](http://en.wikipedia.org/wiki/Organism). They are [motor](http://en.wikipedia.org/wiki/Molecular_motor) proteins that move directionally along a [nucleic acid](http://en.wikipedia.org/wiki/Nucleic_acid) [phosphodiester backbone](http://en.wikipedia.org/wiki/Phosphodiester_bond), separating two [annealed](http://en.wikipedia.org/wiki/Nucleic_acid_thermodynamics#Annealing) nucleic acid strands (i.e., [DNA](http://en.wikipedia.org/wiki/DNA), [RNA](http://en.wikipedia.org/wiki/RNA), or RNA-DNA hybrid) using energy derived from [ATP](http://en.wikipedia.org/wiki/Adenosine_triphosphate) [hydrolysis](http://en.wikipedia.org/wiki/Hydrolysis).

在DNA不连续复制过程中，结合于复制叉前面，催化DNA双链结构解链，并具有ATP酶活性的酶，两种活性相互偶联，通过水解ATP提供解链的能量。

**Topoisomerases** are enzymes that unwind and wind DNA, in order for DNA to control the synthesis of proteins, and to facilitate DNA replication.

DNA拓扑异构酶是存在于细胞核内的一类酶，他们能够催化DNA链的断裂和结合，从而控制DNA的拓扑状态。

**Replication fork**

The **replication fork** is a structure that forms within the nucleus during [DNA replication](http://en.wikipedia.org/wiki/DNA_replication). It is created by [helicases](http://en.wikipedia.org/wiki/Helicase), which break the [hydrogen bonds](http://en.wikipedia.org/wiki/Hydrogen_bond) holding the two [DNA](http://en.wikipedia.org/wiki/DNA) strands together. The resulting structure has two branching "prongs", each one made up of a single strand of DNA. These two strands serve as the template for the leading and lagging strands which will be created as[DNA polymerase](http://en.wikipedia.org/wiki/DNA_polymerase) matches complementary nucleotides to the templates. The templates may be properly referred to as the leading strand template and the lagging strand template.

**RNA Primase**

一种依赖于DNA的RNA聚合酶，其功能是在DNA复制过程中先合成一段RNA引物，在这引物上延伸新合成的DNA片段。不同于在DNA转录中起作用的RNA聚合酶。

**DNA polymerase**

A **DNA**[**polymerase**](http://en.wikipedia.org/wiki/Polymerase) is an [enzyme](http://en.wikipedia.org/wiki/Enzyme) that helps [catalyze](http://en.wikipedia.org/wiki/Catalyze) in the [polymerization](http://en.wikipedia.org/wiki/Polymerization) of [deoxyribonucleotides](http://en.wikipedia.org/wiki/Deoxyribonucleotide) into a [DNA](http://en.wikipedia.org/wiki/DNA) strand.

**Leading strand, lagging strand**

Leading strand:与复制叉移动的方向一致，通过连续的5ˊ-3ˊ聚合合成的新的DNA链。

lagging strand:与复制叉移动的方向相反，通过不连续的5ˊ-3ˊ聚合合成的新的DNA链。

**Okazaki fragment**

**Okazaki fragments** are short molecules of single-stranded [DNA](http://en.wikipedia.org/wiki/DNA) that are formed on the [lagging strand](http://en.wikipedia.org/wiki/Replication_fork) during [DNA replication](http://en.wikipedia.org/wiki/DNA_replication).

在DNA不连续复制过程中，沿着后随链的模板链合成的新DNA片段。这是以发现这种片段的日本科学家的名字命名的。

**Template**

a strand of [DNA](http://en.wikipedia.org/wiki/DNA) which sets the genetic sequence of new strand

or a strand of [RNA](http://en.wikipedia.org/wiki/RNA) which translates genes into protein

其结构作为另一个DNA合成的模型或依据的DNA分子。

**..priming synthesis**

**..primase enzyme**

**..synth. short (~30 bp) RNA primer**

**..primase+ DNA + proteins = primosome**

**..leading & lagging strand**

**..replication is 5' ..3'**

**..replication moves along template 3' ..5'**

**..DNA pol III most synthesis**

**..DNA pol I fills gaps on lagging strand**

**..DNA ligase seals gaps**

**..replication fork**

**..lagging strand**

**a) RNA primer growth**

**b) DNA elongation as Okazaki fragments**

**c) RNA primer removed by DNA pol I**

**d) DNA ligation**

**1. Why is replication necessary?**

So both new cells will have the correct DNA

**2. When does replication occur?**

During interphase(S phase).

**3. Describe how replication works.**

Enzymes unzip DNA and complementary nucleotides join each original strand.

**Lecture 4 Transcription (RNA systhesis)**

**Template**

a strand of [DNA](http://en.wikipedia.org/wiki/DNA) which sets the genetic sequence of new strands

**Primer**

a nucleic acid strand (or related molecule) that serves as a starting point for DNA replication

**dNTP, NTP**

[Nucleoside triphosphate](http://en.wikipedia.org/wiki/Nucleoside_triphosphate), an organic compound and building block of nucleic acids

**Template strand = antisense strand**

**Sense strand = nontemplatestrand**

**RNA** **processing and function**

* Capping of the 5’end of the RNA
  + Protection from degradation
  + Increased translational efficiency
  + Transport to cytoplasm
  + Splicing of first intron
* Splicing of the introns (most complicated)
  + 将不能翻译出氨基酸的内含子从mRNA前体上切除
* Poly adenylation(多聚腺苷化) of the 3’end
  + Increased mRNA stability
  + Increased translational efficiency
  + Splicing of last intron

**1. Why is transcription necessary?**

Transcription makes messenger RNA (mRNA) to carry the code for proteins out of the nucleus to the ribosomes in the cytoplasm.

**2. Describe transcription mechanism.**

RNA polymerase binds to DNA, separates the strands, then uses one strand as a template to assemble mRNA.

**3. What are the main differences between DNA and RNA.**

* DNA has deoxyribose, RNA has ribose;
* DNA has 2 strands, RNA has one strand;
* DNA has thymine, RNA has uracil.

**4.What is different between the DNA replication and RNA transcription ?**

* RNA is made of ribonucleotides
* RNA polymerase catalyzes the reaction
* The synthesized RNA does not remain base-paired to the template DNA strand
* Less accurate (error rate: 10-4)
* Transcription selectively copies only certain parts of the genome and makes one to several hundred, or even thousand, copies of any given section of the genome. (Replication?)

**Lecture5 DNA translation**

**1** **mRNA、tRNA、rRNA**

* rRNA ：the RNA structural component of the ribosome
* tRNA：assists in decoding the information contained within mRNA during translation by recruiting the correct amino acid to the growing peptide chain
* mRNA：the RNA that transfers genetic information stored in DNA into a form useable for protein synthesis

**2 ORF**

The protein coding region of each mRNA is composed of a continuous, non-overlapping string of codons called an opening reading frame (ORF) . An ORF should begins with a start codon and end with stop codon.

**3 polycistronic(多顺反子性的) mRNAs**

mRNA containing more than one ORF is called polycistronic mRNAs.

**4** **Kozak sequence**

The **Kozak consensus sequence**, **Kozak consensus** or **Kozak sequence**, is a sequence which occurs on [eukaryotic](http://en.wikipedia.org/wiki/Eukaryotic) [mRNA](http://en.wikipedia.org/wiki/MRNA) and has the [consensus](http://en.wikipedia.org/wiki/Consensus_sequence) (gcc)gccRccAUGG, where R is a [purine](http://en.wikipedia.org/wiki/Purine) ([adenine](http://en.wikipedia.org/wiki/Adenine) or [guanine](http://en.wikipedia.org/wiki/Guanine)) three bases upstream of the [start codon](http://en.wikipedia.org/wiki/Start_codon) (AUG), which is followed by another 'G'.

存在于真核生物mRNA的一段序列，其在翻译的起始中有重要作用。核糖体能够识别mRNA上的这段序列，并把它作为翻译起始位点。

**5 SD sequence**

在原核生物中, 核糖体中与mRNA结合位点位于16S rRNA 的3’端,mRNA中与核糖体16S rRNA结合的序列称为SD序列(SD sequence)

**6 ribosome/ribosome cycle**

* Ribosome:生物体的细胞器，是蛋白质合成的场所，通过mRNA与携带氨基酸的tRNA的相互作用合成蛋白质。由大小亚基组成。
* ribosome cycle :In cells, the small and large ribosome subunits associate with each other and the mRNA, translate it, and then dissociate after each round of translation. This sequence of association and dissociation is called the ribosome cycle.

**7 polysome**

an mRNA bearing multiple ribosomes

**8** **translation**

在多种因子辅助下，核糖体结合mRNA模板，通过tRNA识别该mRNA的三联体密码子和转移相应氨基酸，进而按照模板mRNA信息依次连续合成蛋白质肽链的过程。

Key points of the chapter

**1.The main challenge of translation and the solution**

The genetic information in mRNA cannot be recognized by amino acids. The genetic code has to be recognized by an adaptor molecular (translator), and this adaptor has to accurately recruit the corresponding amino acid.

**2.The structure and function of four components of the translation machinery.**

* mRNAs ：The protein-coding region of the mRNA consists of an ordered series of 3-nt-long units called codons that specify the order of amino acids.
* tRNAs： the translation of nucleotide sequence information into amino acids.
* aminoacyl-tRNA synthetases (氨酰-tRNA合成酶)：Each of the 20 amino acids is attached to the appropriate tRNA (s) by aminoacyl-tRNA synthetases.
* ribosomes The large subunit contains the peptidyl transferase center, which is responsible for the formation of peptide bonds.The small subunit interacting with mRNA contains the decoding center, in which charged tRNAs read or “decode”the codon units of the mRNA.

**3.Translation initiation, elongation and termination**

**4. How do prokaryotes and** **eukaryotes find the translation start sites?**

* Prokaryotes:通过SD序列。。。
  + Ribosome binding site (RBS) or SD-sequence in prokaryotic mRNA, complementary with the sequence at the 3’end of 16S (small subunit ) rRNA.
* Eukaryotes:
  + Eukaryotic mRNA uses a methylated cap to recruit the ribosome. Once bound, the ribosome scans the mRNA in a 5’-3’direction to find the AUG start codon.
  + Kozak sequence increases the translation efficiency.
  + Poly-A in the 3’end promotes the efficient recycling of ribosomesFig

**Lecture 6 The Genetic Code**

Import concept

**1.****Genetic codon**

核苷酸序列所携带的遗传信息。编码20种氨基酸和多肽链起始及终止的一套64个三联体密码子。

**2.Stop codon**

转录过程中能够终止RNA聚合酶转录的DNA序列。使RNA合成终止。

**3.codon-degeneracy**

Many amino acids are specified by more than one codon.when the first two nucleotides are identical, the third nucleotide can be either C or U without changing the code. A and G at the third position are interchangeable as well.

**4.Transition/Transversion**

Transition转换in the third position of a codon specifies a same amino acid.

Transversion颠换in this position changes the amino acid about half the time.

**5.****Wobble Rules**

The pairings permitted are those give ribose-ribose distances close to that of the standard A: U or G: C base pairs

一个tRNA通过与密码子第三个碱基非寻常配对(不是GC， AT)而识别不止一个密码子。

**6.Three Rules**

1 Codons are read in a 5’to 3’direction.

2 Codons are nonoverlapping and the message contains no gaps.

3 The message is translated in a fixed reading frame which is set by the initiation codon.

**7.Missense mutation, Nonsense or stop mutation, Frameshift mutation**

Missense mutation: An alternation that changes a codon specific for one amino acid to a codon specific for another amino acid.

Nonsense or stop mutation: An alternation causing a change to a chain-termination codon.

Frameshift mutation: Insertions or deletions of one or a small number of base pairs that alter the reading frame.

**8.****universality of the genetic code**

Key points of the chapter

**1.“The genetic code is degenerate”What does it mean? What’s the benefits? What’s about the anticodon recognition? How the code was discovered?**

1.The genetic code evolved in such a way as to minimize the deleterious effects of mutations.

2.Code degeneracy may serve as a safety mechanism to minimize errors in the reading of codons.

**2.What are the three rules governing the genetic code? What are the mutations altering genetic code?**

1 Codons are read in a 5’to 3’direction.

2 Codons are nonoverlapping and the message contains no gaps.

3 The message is translated in a fixed reading frame which is set by the initiation codon.

1 Missense mutation: An alternation that changes a codon specific for one amino acid to a codon specific for another amino acid.

2 Nonsense or stop mutation: An alternation causing a change to a chain-termination codon.

3 Frameshift mutation: Insertions or deletions of one or a small number of base pairs that alter the reading frame.

**3.What are the benefits of the code universality? What’s about the mitochondrial codes and tRNAs?**

Allow us to directly compare the protein coding sequences among all organisms.

Make it possible to express cloned copies of genes encoding useful protein in different host organism.

Only 22 tRNAs are present in mammalian mitochondria. The U in the 5’wobble position of a tRNA is capable of recognizing all four bases in the 3’of the codon.

**Lecture 7 Gene Regulation in Prokaryotes**

Key points of this chapter

**1.Operon(操纵子)**

是基因表达的协调单位，由启动子、操纵基因及其所控制的一组功能上相关的结构基因所组成。操纵基因受调节基因产物的控制。

Operon: : a unit of prokaryotic gene expression and regulation which typically includes:1. Structural genes for enzymes in a specific biosynthetic pathway whose expression is coordinately controlled. 2. Control elements, such as operator sequence.3. Regulator gene(s) whose products recognize the control elements.

**2.Operator**

与一个或者一组结构基因相邻近，并且能够与一些特异的阻遏蛋白相互作用，从而控制邻近的结构基因表达的基因。

**3.Polycistronic message**

mRNA containing more than one ORF is called polycistronic mRNAs.

**4.Cis-acting elements**

指与结构基因串联的特定DNA序列(不编码蛋白质)，对基因转录的精确起始和转录效率起重要作用。

**5.****Activator/represor**

activator：

represor：与基因的调控序列结合的调控蛋白质。与调控序列结合，对基因的表达起阻遏(抑制)作用。

**6.Housekeeping genes**

expressed constitutively, essential for basic processes involving in cell replication and growth.

**7.Regulatory gene/structural gene**

A **structural gene** is a [gene](http://en.wikipedia.org/wiki/Gene) that codes for any RNA or protein product other than a regulatory factor (i.e. [regulatory protein](http://en.wikipedia.org/wiki/Regulatory_protein)). It may code for a [structural protein](http://en.wikipedia.org/wiki/Protein#Structural_proteins), an [enzyme](http://en.wikipedia.org/wiki/Enzyme), or an RNA molecule not involved in regulation. Structural genes represent an enormous variety of protein structures and functions, including structural proteins, enzymes with catalytic activities and so on.

**8.Regulation of transcription initiation in bacteria: the lac operon model**

**Lecture 8 Gene Regulation in Eukaryotes**

Explain these conceptions：

**1.Promoter**

a promoter is a regulatory region of DNA generally located (towards the 5’region of the antisense strand) of a gene that generally promotes transcription of the gene.

**2.Regulatory sequence**

A **regulatory sequence** (also called a *regulatory region* or a *regulatory area*) is a segment of [DNA](http://en.wikipedia.org/wiki/DNA) where [regulatory proteins](http://en.wikipedia.org/wiki/DNA_binding_protein) such as [transcription factors](http://en.wikipedia.org/wiki/Transcription_factor) bind preferentially. These regulatory proteins bind to short stretches of DNA called regulatory regions, which are appropriately positioned in the genome, usually a short distance 'upstream' of the gene being regulated. By doing so, these regulatory proteins can recruit another protein complex, called the [RNA polymerase](http://en.wikipedia.org/wiki/RNA_polymerase). In this way, they [control](http://en.wikipedia.org/wiki/Regulation_of_gene_expression) [gene expression](http://en.wikipedia.org/wiki/Gene_expression) and thus [protein biosynthesis](http://en.wikipedia.org/wiki/Protein_biosynthesis).

**3.Cis acting element**

指与结构基因串联的特定DNA序列(不编码蛋白质)，对基因转录的精确起始和转录效率起重要作用。

**4.Trans acting element**

指由位于不同染色体上或同一染色体上相距较远的基因编码的蛋白质因子，可以通过与顺式作用成分和RNA聚合酶的相互作用来调节基因的转录活性。

能直接或间接地识别或结合在各类顺式作用元件核心序列上，参与调控靶基因转录效率的蛋白质。

**5.Enhancer**

指能使与它连锁的基因转录频率明显增加的DNA序列。

**6.Silencer**

某些基因含有负性调节元件——沉默子，当其结合特异蛋白因子时，对基因转录起阻遏作用。

**Expound the general mechanism of control of gene expression of Eukaryotes**

**Lecture 9 Gene and Genomics**

**Important concepts**

**Gene/****Genome**

A gene is a segment of DNA on a chromosome that codes for a specific protein and thus determines a trait.

the Genome is the entirety of an organism's hereditary information.

**Genomics**

Genomics is the molecular characterization of whole genomes.

**Short-gun sequencing**

A strategy for large-scale sequencing

**DNA sequencing principle**

**Structural genomics**

Characterizes the physical nature of whole genomes.

**Functional genomics**

Attempts to understand the broadsweep of genome function atdifferent developmental stages andunder different environmentalconditions.

**Comparative genomics**

Meaning information gained inone organism can haveapplications in other evendistantly related organisms.

**Gene** **density**

the average number of genes per Mb of genomic DNA

**Tell the difference of the following concepts, chromosome, chromatin,**

**DNA, gene, RNA,**

**Lecture 10 Techniques of Molecular Biology**

**1** **Restriction endonucleases**

the nucleases that cleave DNA at particular sites by the recognition of specific sequences

**2 Southern/Northern/Western Blotting, those techniques for what’s purpose ?**

* Western Blotting: is an analytical technique used to detect specific proteins in a given sample of tissue homogenate or extract.
* A Southern blot is a method routinely used in molecular biology for detection of a specific DNA sequence in DNA samples.
* The northern blot is a technique used in molecular biology research to study gene expression by detection of RNA (or isolated mRNA) in a sample

**3** **PCR and its working principle ? Its application ?**

The polymerase chain reaction(PCR) is to used to amplify a sequence of DNA using a pair of primers each complementary to one end of the the DNA target sequence.

**4** **DNA** **sequencing**