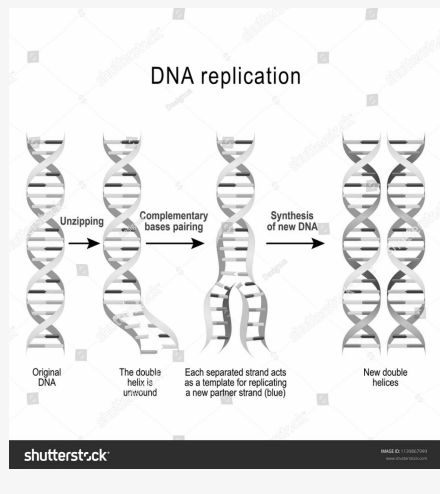


DNA vs. RNA

| | |
|-----------------|-----------------|
| DNA: | RNA: |
| double stranded | single stranded |
| deoxyribose | ribose |
| A-T | A-U |
| G-C | G-C |

DNA Replication Steps Image



DNA Comparison (cont)

no histones DNA wrapped around histones (proteins)
 supercoiled forms chromatin
 DNA

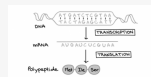
RNA Processing

Eukaryotic modifications to primary transcript (pre mRNA)
 ~ before it leaves the nucleus
 ~ bond alterations to the ends
 ~ removal in intervening sequences

Role of Introns

regulate gene activity
 single gene may be able to synthesize more than one protein

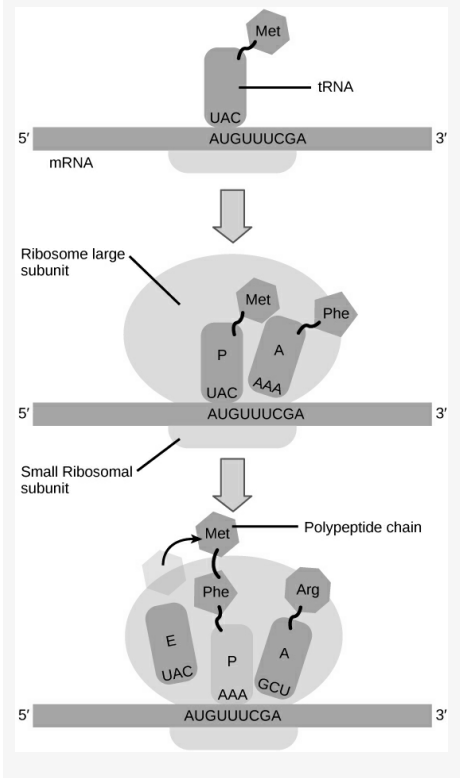
Transcription and Translation Image



Translation

RNA -> protein
 information in RNA is passed to proteins
 1) codon recognition
 2) peptide bond formation
 3) translocation

Translation Image



DNA Comparison

| | |
|------------------|----------------------------------|
| Prokaryotic DNA: | Eukaryotic DNA: |
| double stranded | double stranded |
| circular | linear |
| one chromosome | usually more than one chromosome |
| in cytoplasm | in nucleus |

Regulation of Gene Expression

what makes cells different:
 ~ cells have different shapes and proteins
 ~ cells use the DNA in the nucleus differently
 ~ some gene are turned on/off
 differentiation:
 ~ when a cell changes from one form to another
 ~ cells become specialized in structure and function
 differential gene expression:

Regulation of Gene Expression (cont)

~ the expression of different genes by cells with the same genome

DNA Packing

chromatin: a complex of DNA and protein

histones: proteins associated with DNA packing

DNA methylation

"off switch"

tightly wrapped around histones

genes can not be transcribed

methyl groups are added to the DNA

gene expression is reduced

less transcription

barr bodies: one X chromosome condenses because of DNA methylation

Histone Acetylation

"on switch"

loosely wrapped around histones

genes can be transcribed

acetyl groups are added to amino acids of histone proteins

Gene Regulation

DNA is made up of DNA

DNA is used to give instructions for the production of proteins in the process of protein synthesis

Gene Regulation (cont)

gene regulation determines which genes are turned on/off

proteins can increase or decrease transcription

Types of Mutations

point mutations:

~ caused by just one nucleotide base pair substitution of a gene

~ ex:

~~ missense mutation

~~~ still codes, but not properly (sickle cell anemia)

~~ nonsense mutation

~~~ alterations codes for a stop codon

~~ silent mutation

~~~ a change in DNA but not a change in the amino acid sequence

frameshift mutations:

~ caused by insertions and deletions of base pairs

~ alters the three letter reading frame

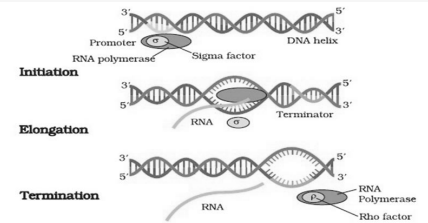
## Parts of a Nucleotide

phosphate group

sugar

nitrogenous base

## Transcription Image



## DNA Replication

in S phase of Mitosis

making DNA from DNA

nucleotides can only be added to the 3' end of a nucleotide

5' to 3' direction

enzymes mediate the process of DNA replication

- 1) helicase unwinds DNA at origin of replication and creates replication forks
- 2) topoisomerase prevents overwinding and single-strand binding proteins support the replication bubble
- 3) primase adds RNA primer
- 4) DNA polymerase III adds nucleotides in 5' to 3' direction on leading strand
- 5) lagging strand grows in 3' to 5' direction away from the replication fork by the addition of okazaki fragments
- 6) DNA ligase seals together okazaki fragments (short segments of DNA that grow 5' to 3' that are added onto the lagging strand)
- 7) DNA polymerase replaces RNA primers with DNA

### Prokaryotic vs. Eukaryotic Transcription

| Prokaryotic:                         | Eukaryotic:                                    |
|--------------------------------------|------------------------------------------------|
| takes place in cytoplasm             | takes place in nucleus                         |
| several gene transcribed at one time | single gene transcribed at one time            |
| no modifications before translation  | primary transcript modified before translation |

### Main Types of RNA

#### mRNA:

- ~ "messenger"
- ~ carries genetic code to the ribosome
- ~ codon

#### tRNA:

- ~ "transfer"
- ~ transfers amino acids to the ribosome
- ~ anticodon

#### rRNA:

- ~ "ribosomal"
- ~ makes up ribosomes
- ~ ribosomes build proteins

### Ribosomes

- made in nucleotide
- P site: holds the polypeptide
- A site: holds amino acids
- E site: exit site

### Ribosomes (cont)

some are free and some are fixed

### Leading Strand

- need RNA primer from DNA primase
- RNA primer allows DNA polymerase to add nucleotides at the 3' end
- can not add nucleotides at 5' end

### Operon

operon: way of regulating genes and is usually made up of a few genes that involve enzymes

RNA polymerase: builder enzyme, needed in order to start transcription, needs a promoter to bind to DNA

operator: a part of the DNA where a repressor can bind, if repressor is bound to operator it blocks RNA polymerase which means mRNA can not be made so neither can proteins

lac operon: operator and promoter region of DNA and three genes that code for enzymes that help in breaking down lactose

~ there is a gene that codes for the repressor production and this gene has its own promoter

~ if lactose is not present, then the repressor binds to the operator and blocks RNA polymerase which means mRNA and proteins can not be produced

### Operon (cont)

~ if lactose is present, the lactose (sugar) binds to the repressor (repressor can not bind to operator) and RNA polymerase finds its promoter, binds, and transcribes to make mRNA from the genes on operon, the mRNA will be used to make enzymes to break down the lactose sugar

~ no lactose: "off"

trp operon:

~ evolved in bacteria to deal with absence of tryptophan

~ tryptophan is an amino acid which moves proteins

~ designed to make tryptophan if it is not present

~ if bacteria does not have tryptophan, there is a number of genes that are required to make it

~ tryptophan fits inside the repressor and the repressor will change its shape to fit in the receptor

~ if a lot of tryptophan is present, then we do not want to make more so the repressor is going to set operator in "off"

### Chromosomal Mutations

involves a change in the structure or number of chromosomes

deletion: loss of all or part of a chromosome

duplication: reverses the direction of parts of a chromosome



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## Chromosomal Mutations (cont)

inversion: reverses the direction of parts of a chromosome

translocation: part of one chromosome break off and attaches to another chromosome

## Differentiation

when a cell changes from one type to another

all specialized cells come from stem cells (unspecialized)

DNA contains genes and genes contain proteins that change the way cells look and act

every somatic cell in your body contain the same DNA

using genes -> expressing -> turned "on"

the specialized cells can not specialize again and can not go backwards to the stem cells

cells decide what they will be based on internal or external environmental cues

internal: transcription factors will activate certain genes and turn them on (factors are bunched up because of when the zygote will divide)

external: (induction) (like peer pressure) a group of cells can induce another group to differentiate by using signals (like diffusion, direct contace, gap junctions)

goal: to change gene expression (turn on/off genes)

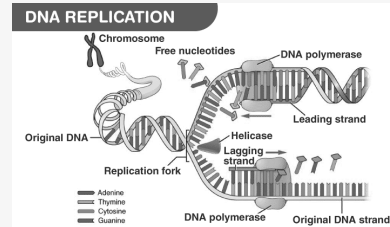
## Structure of DNA

double helix

~ "backbone": sugar + phosphate

~ "rungs": nitrogenous bases

## DNA Replication Image



## DNA Replication Key Factors

Eukaryotic: replication before mitosis or meiosis (interphase)

helicase: unzipping enzyme

~ breaks the hydrogen bonds holding bases together

DNA polymerase: builder

~ replicates DNA molecules to build new strand of DNA

primase: initializer

~ makes the primer so that DNA polymerase can figure out where to go to start to work

ligase: gluer (binder)

~ helps glue/bind DNA fragments together

## DNA Replication Process (2nd example)

starts at the origin (identified by DNA sequence)

1) helicase unwinds DNA

~ single stranded binding protein bind to DNA strands to prevent the strands from going back together

~ topoisomerase keeps DNA from supercoiling

2) primase makes RNA primers on both strands

3) DNA polymerase builds new strand in 5' to 3' direction

~ this means it moves along old template strand in 3' to 5' direction

~ adds new bases to 3' end on new strand

4) ligase takes care of gaps between Okazaki fragments

at the end of replication there is two identical DNA molecules

~ semi-conservative: each copy contain a new and original strand

## Transcription

DNA -> RNA

1) Initiation

~ promoter sites: region of the DNA where the RNA polymerase binds

~~ 100 nucleotides long

~~ transcription factors: binding protein

~~ TATA box: promoter sequence

2) Elongation

## Transcription (cont)

- ~ RNA polymerase in action
- ~~ separates and untwists helix
- ~~ links nucleotides in a 5' to 3' direction
- 3) Termination
- ~ termination sequence: AAUAAA

## Transcript Modifications

- 5' cap: GTP is added
- two functions:
  - 1) protects transcript from hydrolytic enzymes
  - 2) tags the end as "leader segment" for the ribosome
- s' end: last to be translated
- poly(A)tail: 30 to 200 nucleotides added to end
- ~ inhibits degradation
- ~ facilitates ribosomal attachment
- ~ attached to stop codon
- RNA splicing
  - ~ removal of introns (noncoding sequences) (intervening sequences)
  - ~ pasting of exons (coded sequences) (exit the nucleus)
- small nuclear ribonucleoproteins found in nucleus (snRNP; snurps): complexes of small RNA units and proteins found in nucleus
- spliceosome: complex of snurps involved in the locating and cutting out of introns

## Codons

- codons:
- ~ mRNA triplet that codes for an amino acid
- ~ start codon: AUG
- ~ stop codon: UAA, UAG, UGA
- reading frame:
  - ~ start to stop sequence of nitrogen bases
- anticodons:
  - ~ complement of the codon found on tRNA

## Prokaryotic vs. Eukaryotic Translation

| Prokaryotic:                                                 | Eukaryotic:                            |
|--------------------------------------------------------------|----------------------------------------|
| takes place in cytoplasm                                     | takes place in cytoplasm               |
| ribosomes begin translating while mRNA is still transcribing | transcription and translation separate |

## Redundancy and Ambiguity of the Code

- redundancy: more than one codon for an amino acid
- ambiguity: codon do not code for more than one amino acid

## Evolution of the Codes

- early evolution since shared among living species
- genes can be transferred within species and among others as well

## Lagging Strand

- primer is several nucleotides
- DNA primase goes along the lagging strand and adds RNA primer
- once you have primer, polymerase can add on DNA at 3' end (5' to 3')
- end up with Okazaki fragments
- slower process
- DNA ligase puts all fragments together as one strand
- ~ RNA is replaced with DNA

## Mutations Image

