Genetics Review

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Spring/Summer, 2010

GeneticsReview

The Basis of Genetics

Genetics: the science of heredity, dealing with resemblances and differences of related organisms

What molecular biology implements our heredity?

How are the molecules passed from generation to generation?

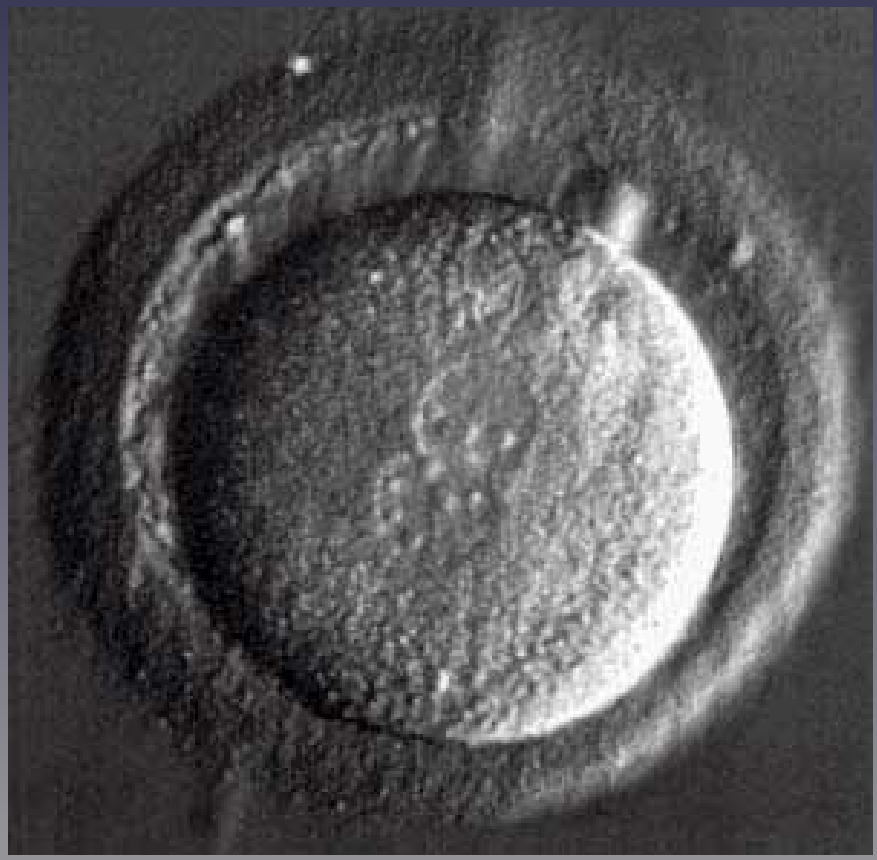
What can genetics tell us about evolution?

Genetics Review

The Basis of Genetics

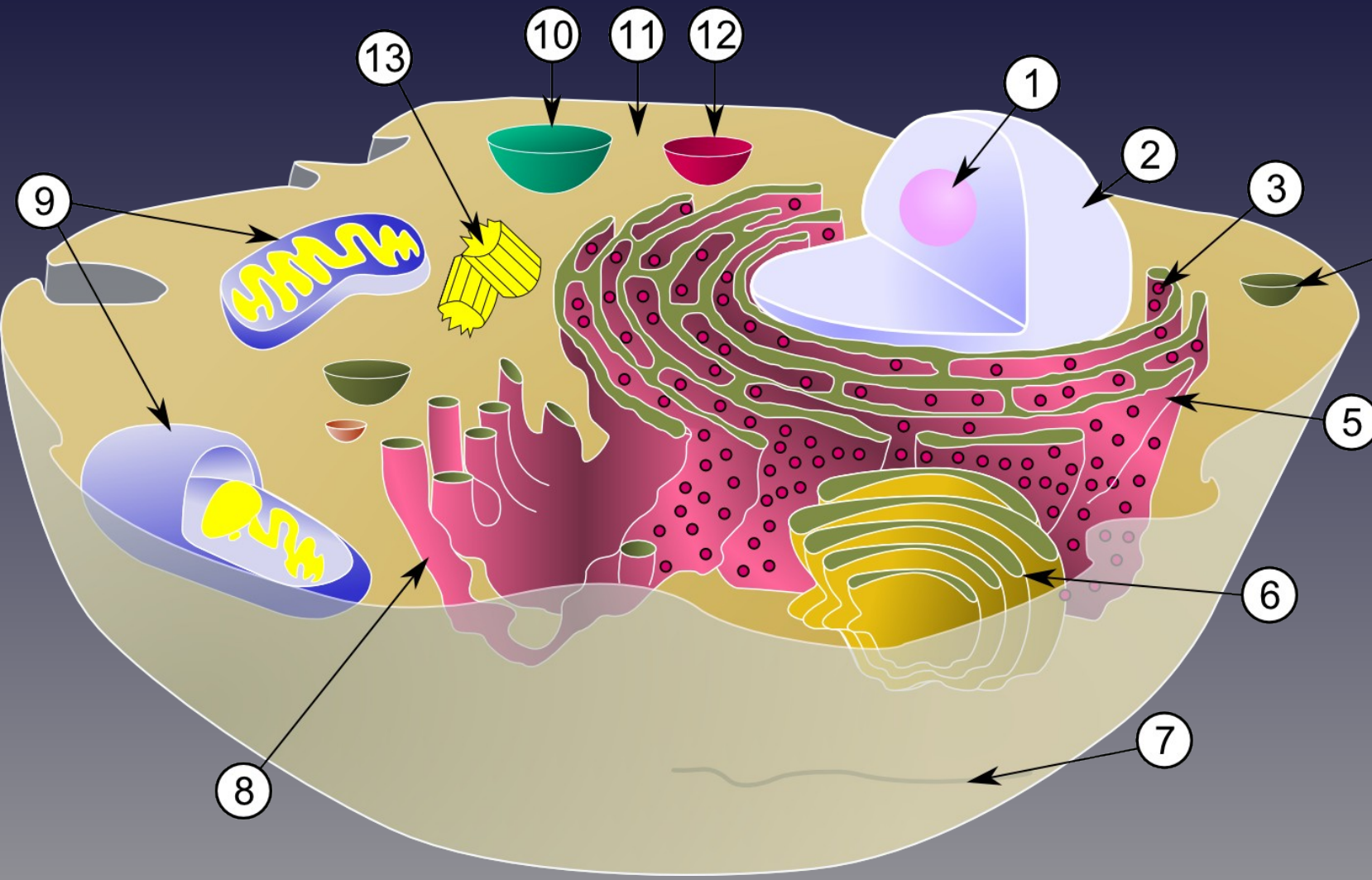
Why is a cow a cow?

Why does a single-cell cow embryo make a whole cow?



Genetics Review

The Basis of Genetics



1. Nucleolus
2. Nucleus
3. Ribosome
4. Vesicle
5. Rough endoplasmic reticulum
6. Golgi apparatus
7. Cytoskeleton
8. Smooth endoplasmic reticulum
9. Mitochondria
10. Vacuole
11. Cytosol
12. Lysosome
13. Centriole

Genetics Review

The Basis of Genetics

Why is a cow a cow?

If the nucleus (DNA)
of a fertilized cow's egg is
removed and replaced
by a banteng nucleus,
the single cell cow embryo
produces a banteng

Advanced Cell Technologies, Inc. 2003

Genetics Review
The Basis of Genetics

Why is a human a human?

Would a single cell cow embryo produce a human if the nucleus were replaced?

Genetics Review

Why the nucleus?

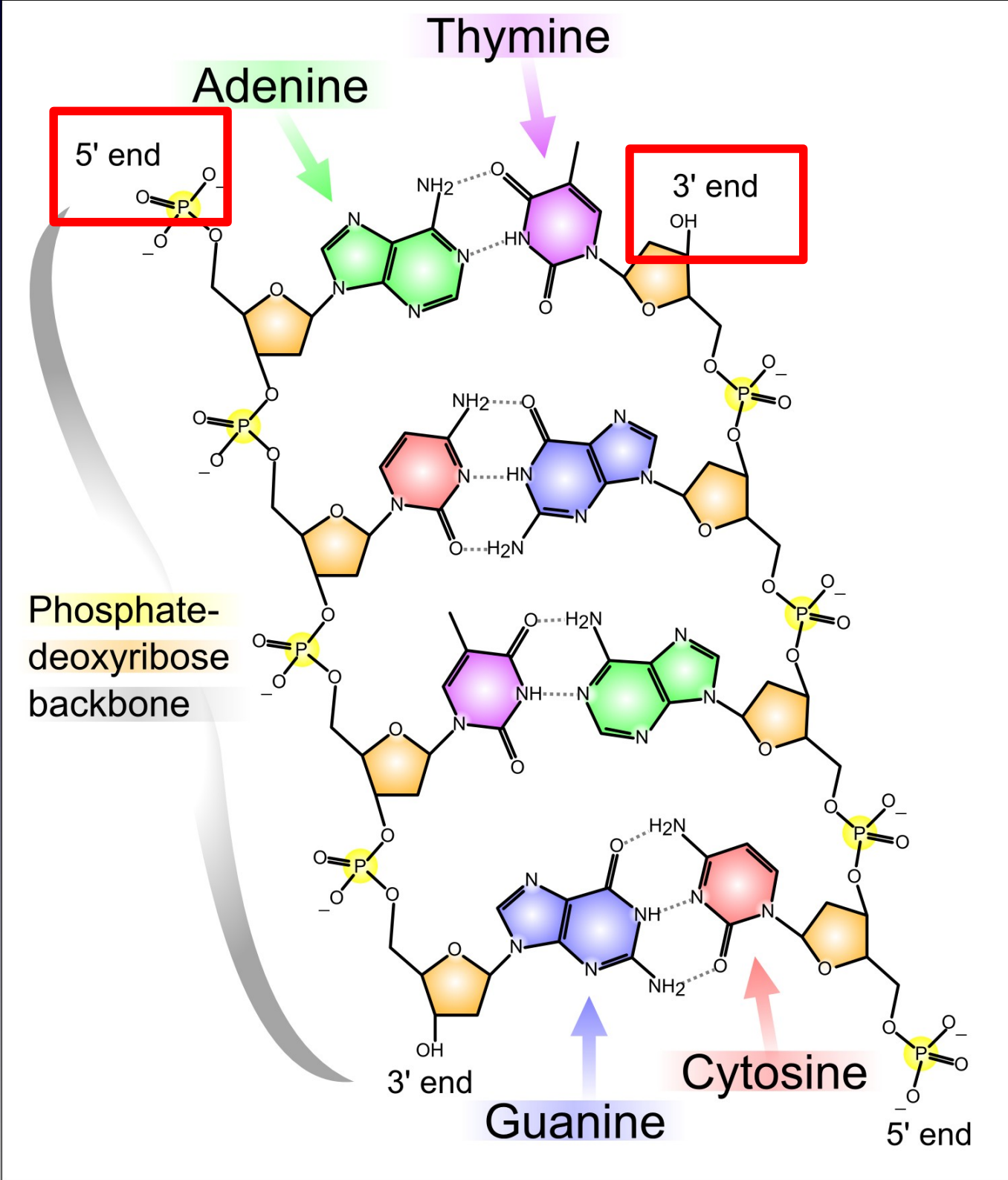
- The nucleus of a cell contains molecules of deoxyribonucleic acid (DNA)
- DNA is the stuff that carries all our inheritable information

Genetics Review

DNA

Deoxyribose Nucleic Acid

- Sugar-phosphate chain
- Four nucleotide (base) types: G, C, A, T
- Complementary strands
- Strong backbones, weak base pairing



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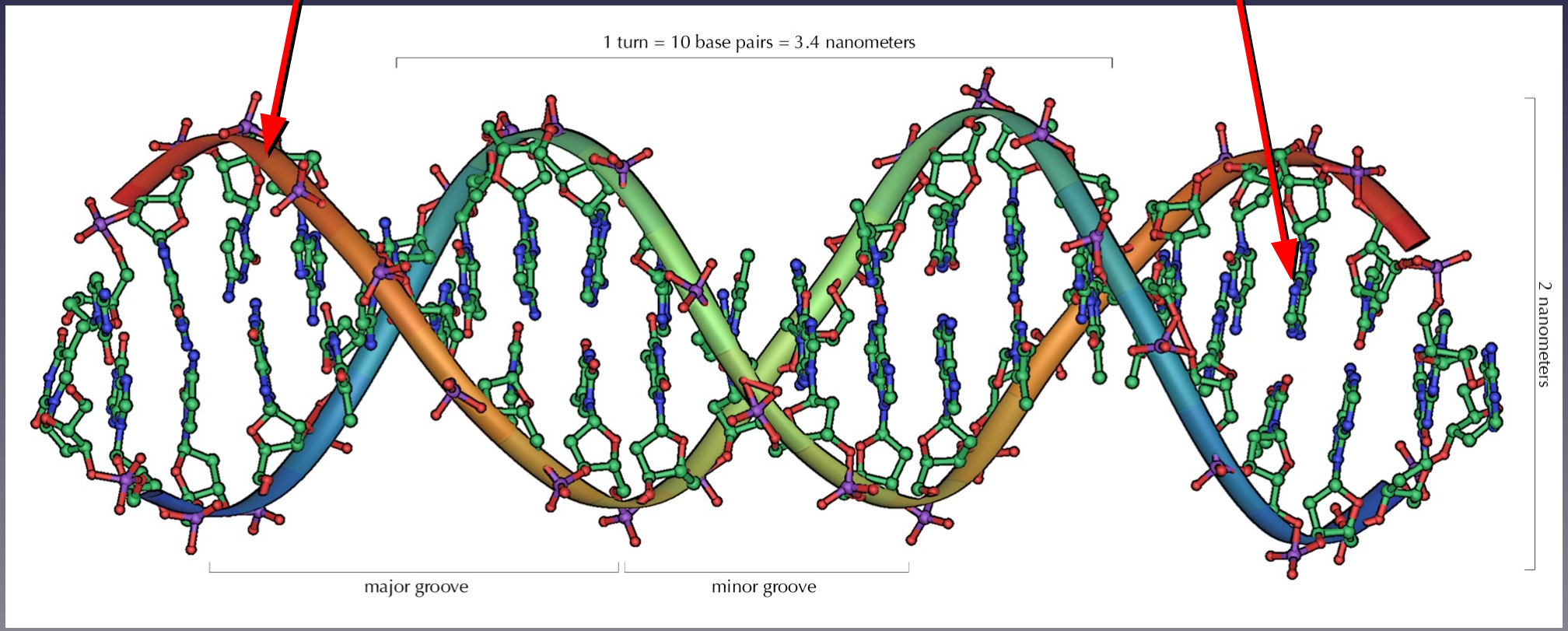
Backbone: Deoxyribose sugar plus phosphate

Nucleotides (bases)



Deoxyribonucleic Acid DNA

DNA animation

Genetics Review
The scaffolding of life

- DNA requires other molecules to make living organisms
- Protein
- Ribonucleic acid (RNA)
- Complex sugars
- Fats
- Others

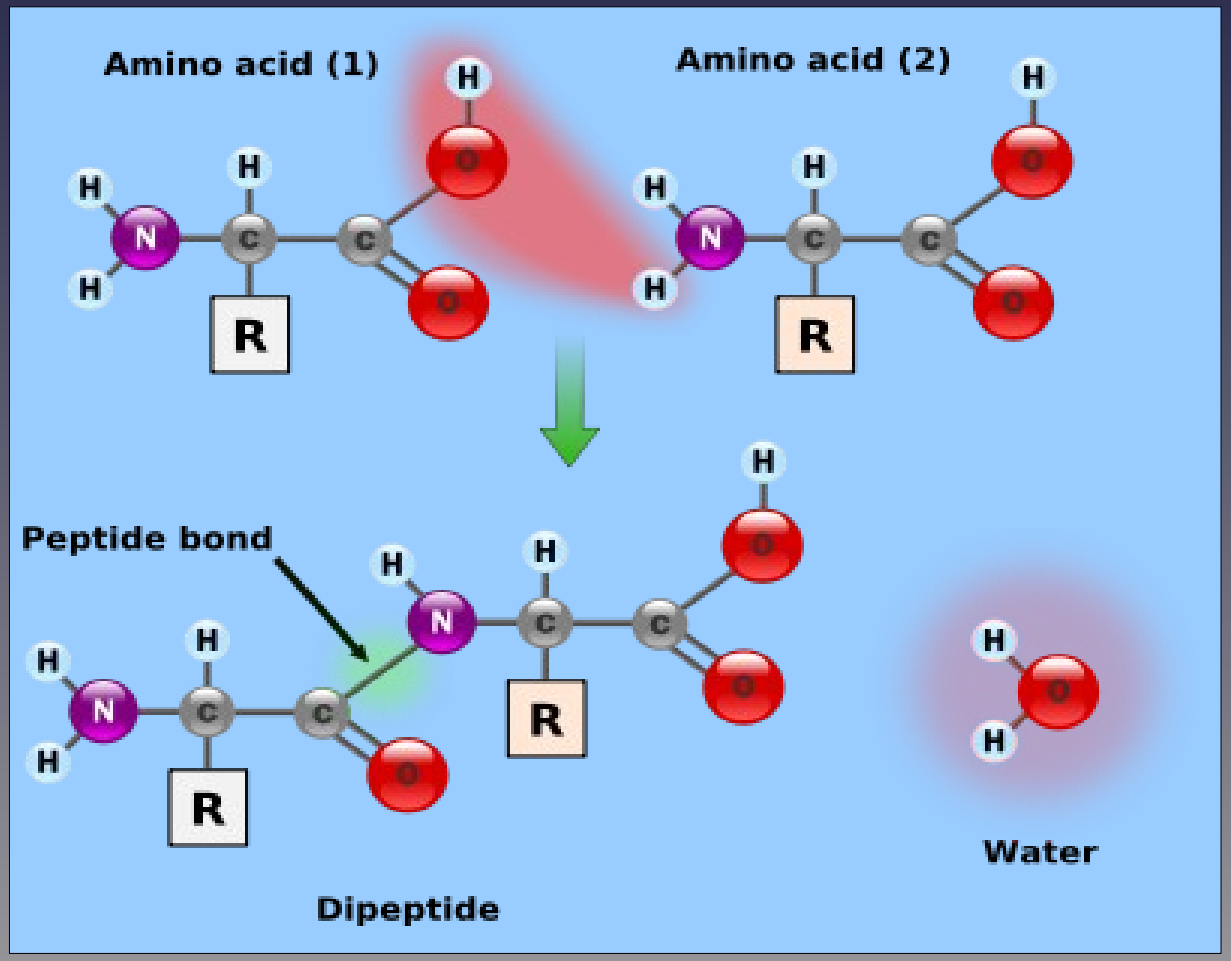
Genetics Review
Protein

Common Amino Acids

Proteins are large organic compounds made of *amino acids* (AAs) arranged in a linear chain (like DNA)

There are twenty different kinds of standard AAs, depending on the *residue*

A short chain of amino acids is called a *polypeptide*



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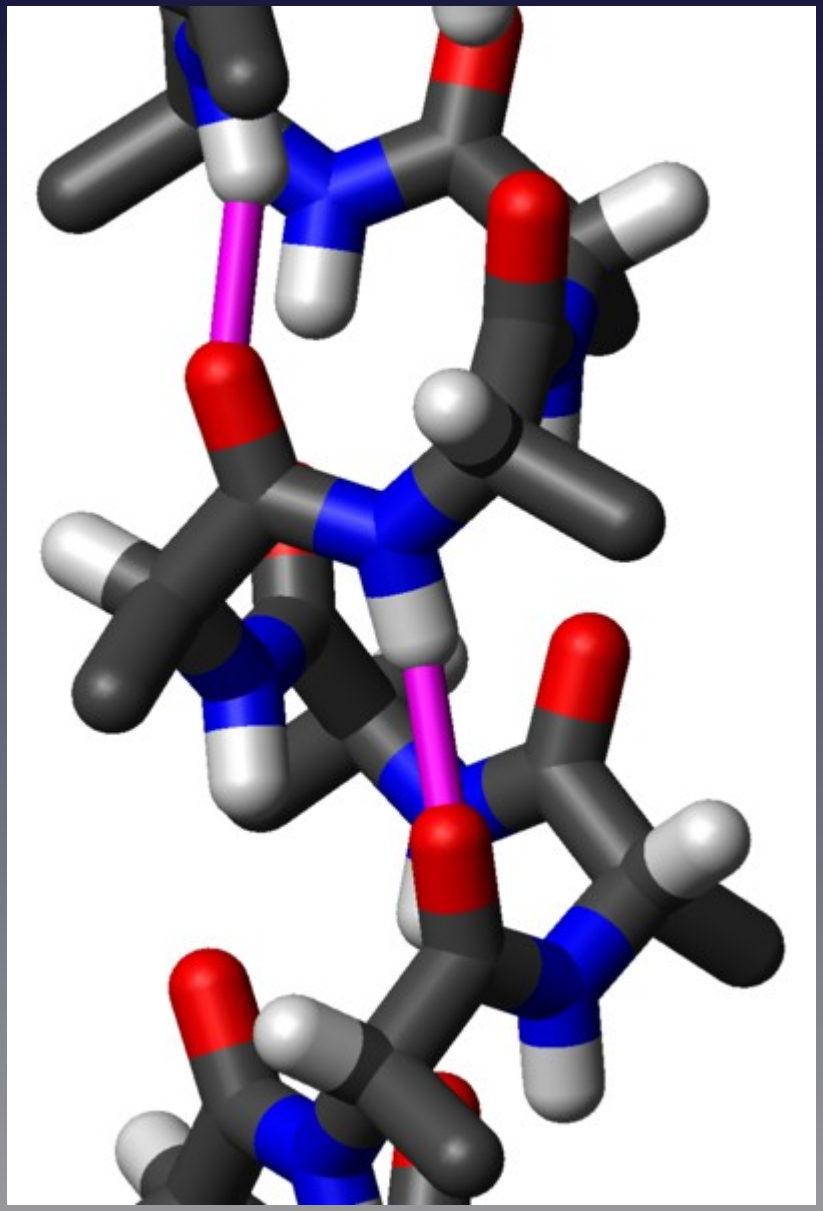
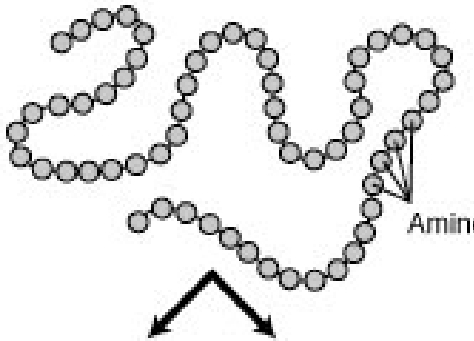
Protein

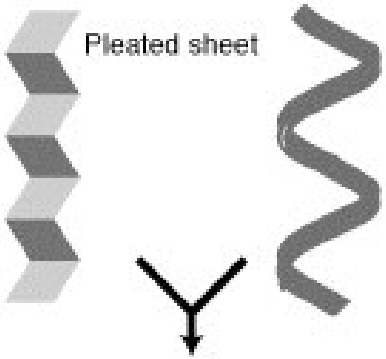


Polyalanine helix

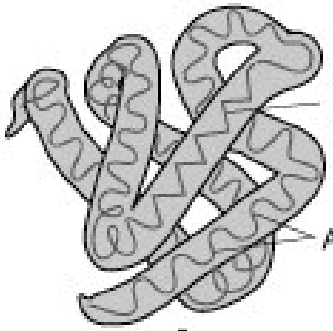


Primary protein structure
is sequence of a chain of amino acids

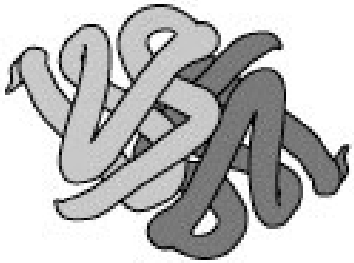
Amino Acids



Secondary protein structure
occurs when the sequence of amino acids are linked by hydrogen bonds



Tertiary protein structure
occurs when certain attractions are present between alpha helices and pleated sheets.



Quaternary protein structure
is a protein consisting of more than one amino acid chain.

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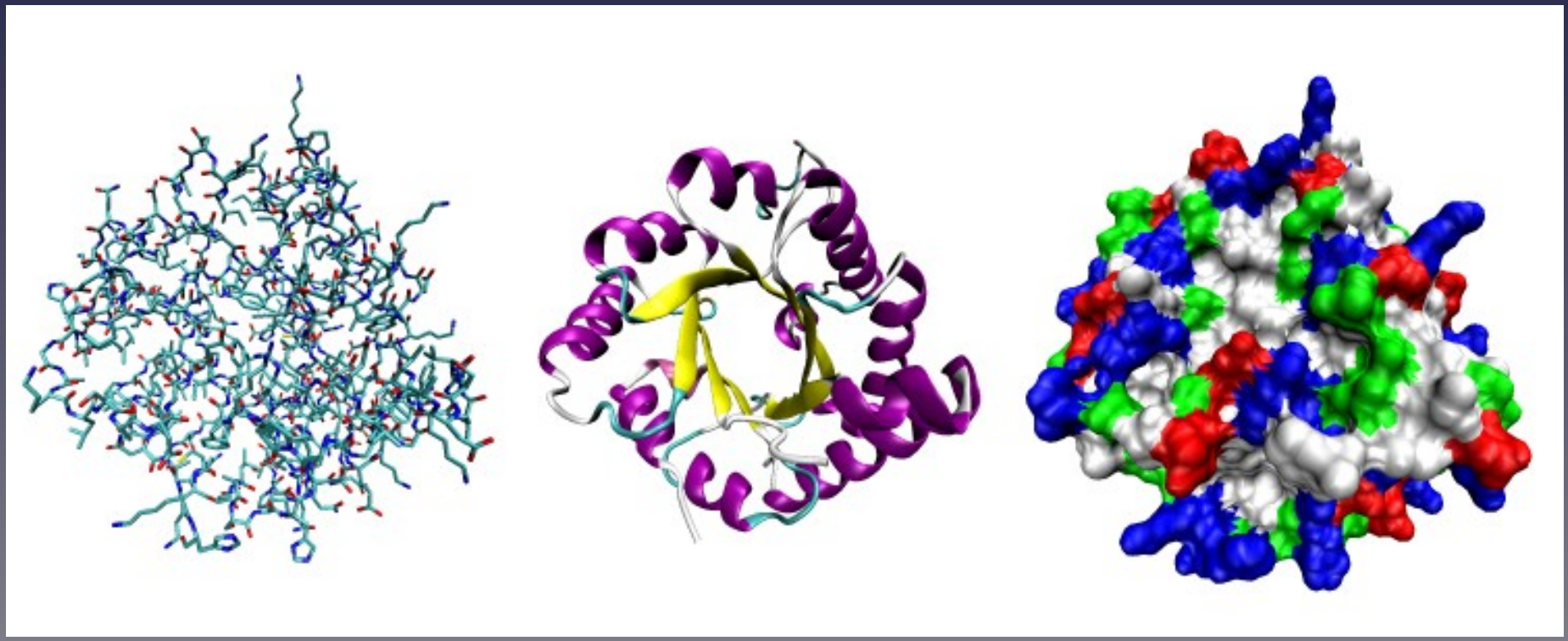
Growth and Cell Division: Protein

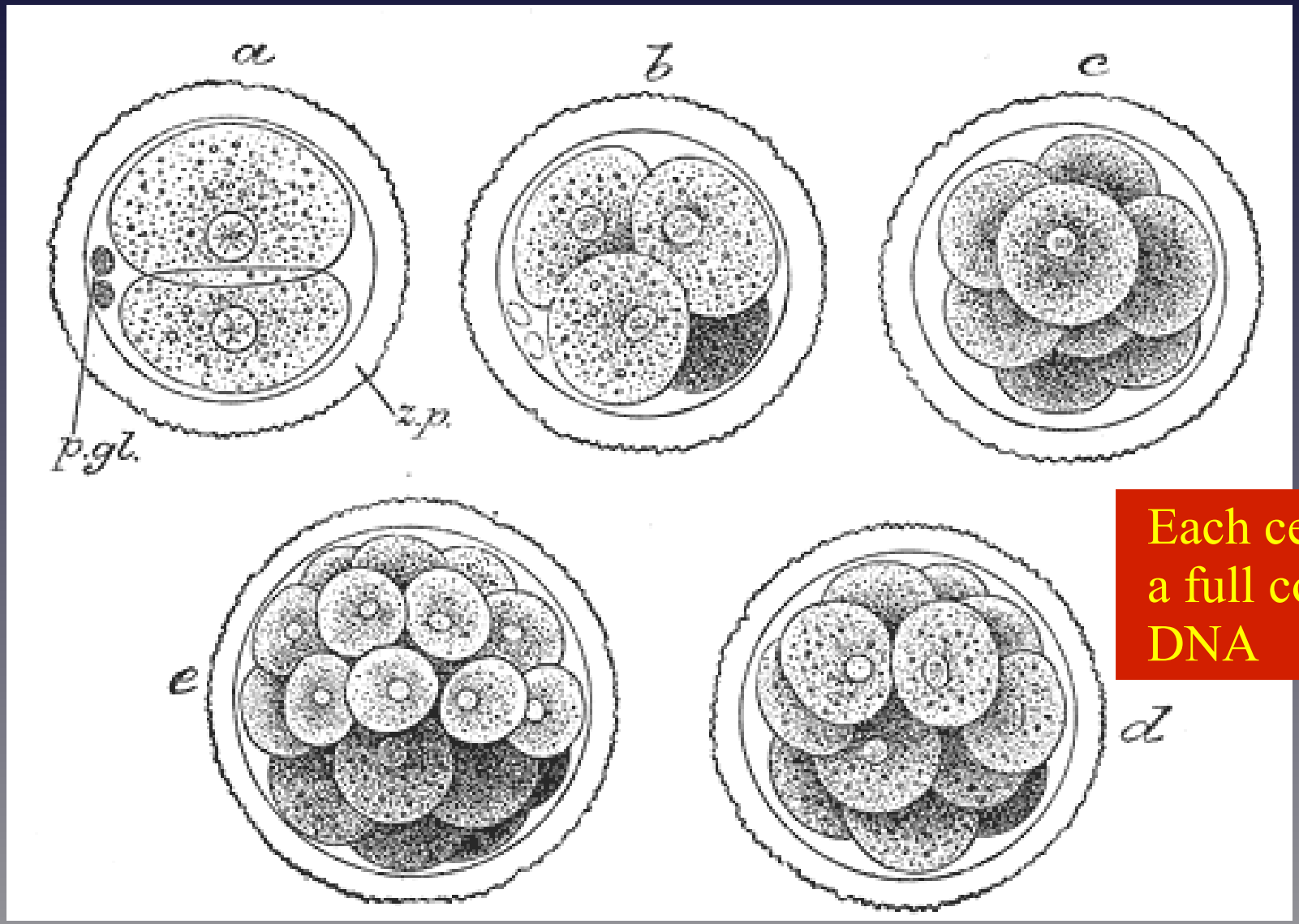


Protein Structure

Genetics Review
Enzymes

- Enzymes: Biomolecules that catalyze (dramatically increase the rates of) specific chemical reactions
- Billion years → Milliseconds
- Enzymes are very specific chemical factories
- Almost all enzymes are proteins
- A name ending in "ase" indicates an enzyme: polymerase, kinase, lactase, "myosin is a phosphohydrolase"

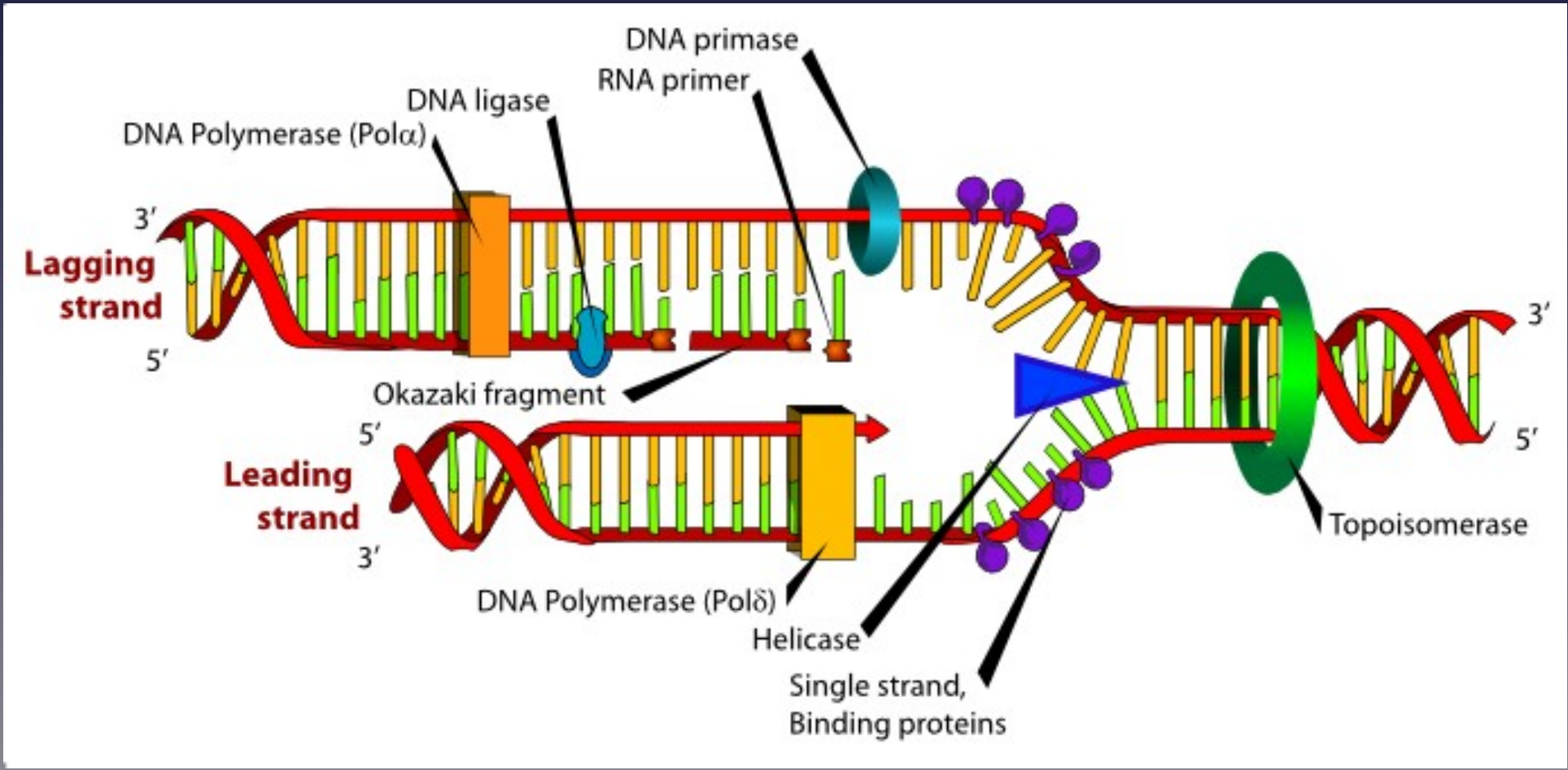
Genetics Review
Growth and Cell Division



Each cell contains a full copy of the DNA

From Gray's Anatomy, 1918

Genetics Review
DNA Replication



DNA Replication 1

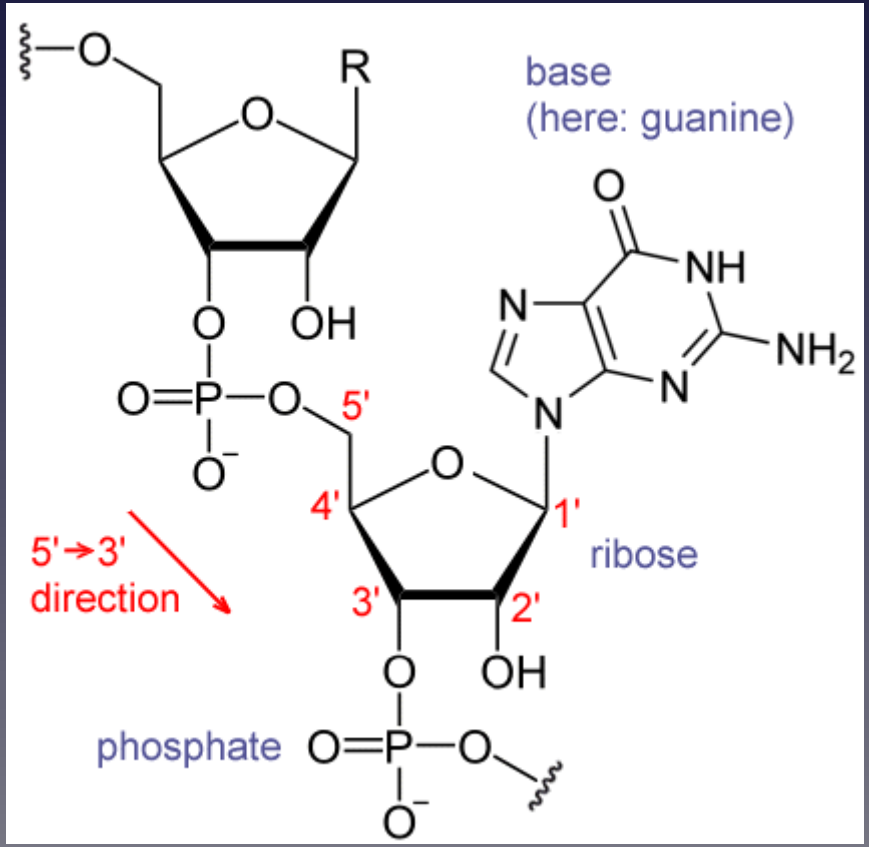
DNA Replication 2

Genetics Review
Making proteins

- In order for DNA to express its information, it has to direct the formation of all the rest of the molecules in the organism
- The DNA nucleotide sequence specifies the primary structure of every protein in the organism
- Each set of three nucleotides (letters) is a word meaning an amino acid
- Each portion of the DNA message that specifies one protein is called a *Gene*
- So, how do we get from DNA to protein?

Genetics Review
RNA

- The RNA chain is just like the DNA chain except for the sugar (added OH)
- Thymine is replaced by uracil
- Pairing occurs between GC, AU



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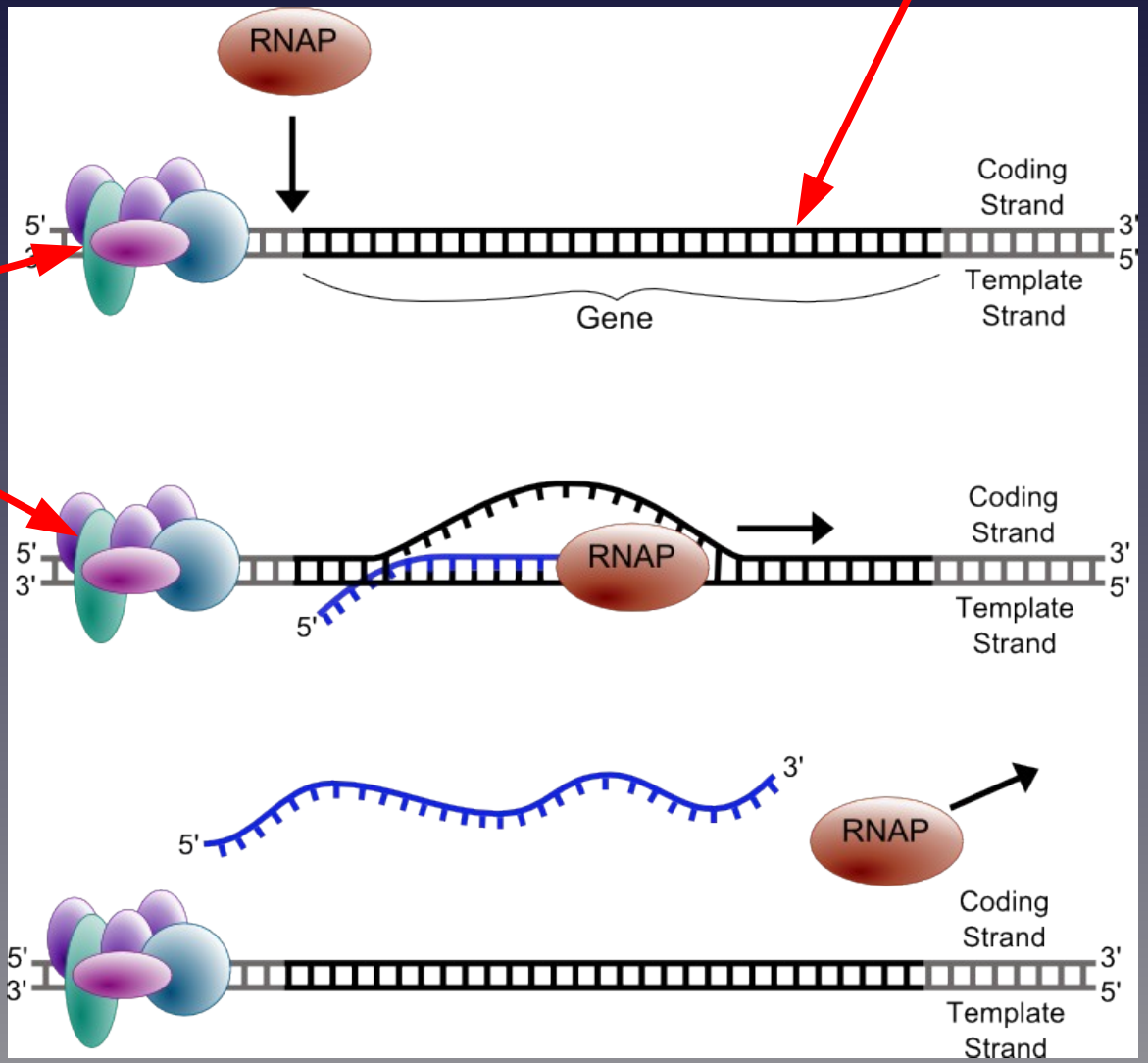
DNA → Proteins (Transcription)

Transcription Factors

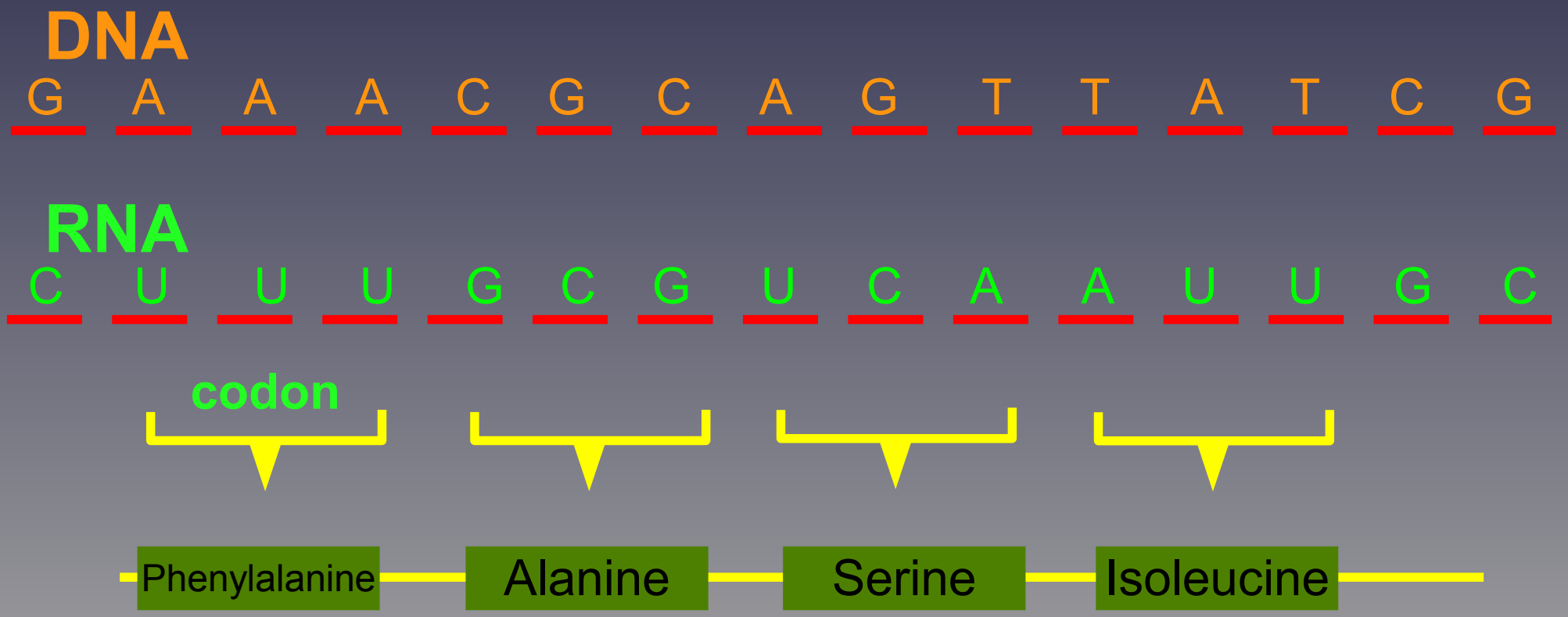
RNAP = RNA polymerase



Genetics Review

DNA → Proteins

A part of the DNA (a gene) is copied into messenger RNA
The messenger RNA is read by a ribosome and each three nucleotides (a codon) specifies an amino acid



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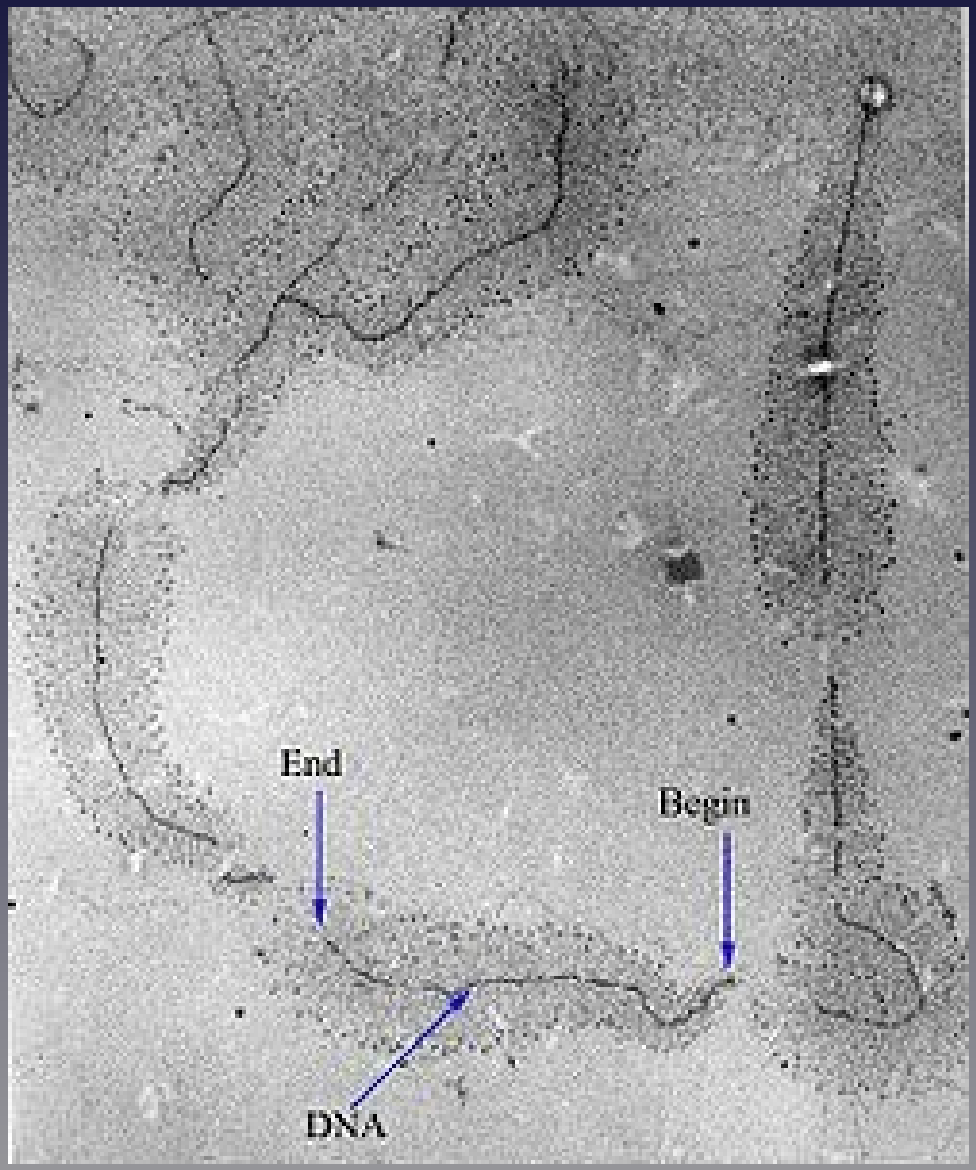
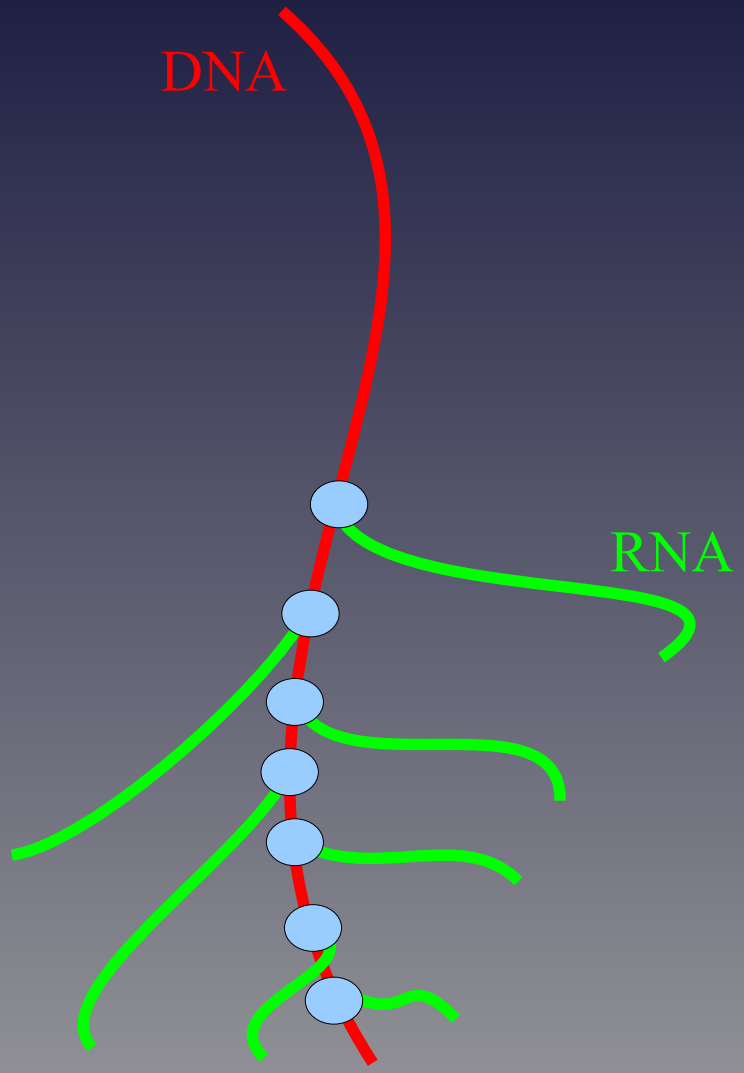
DNA → Proteins (RNA)





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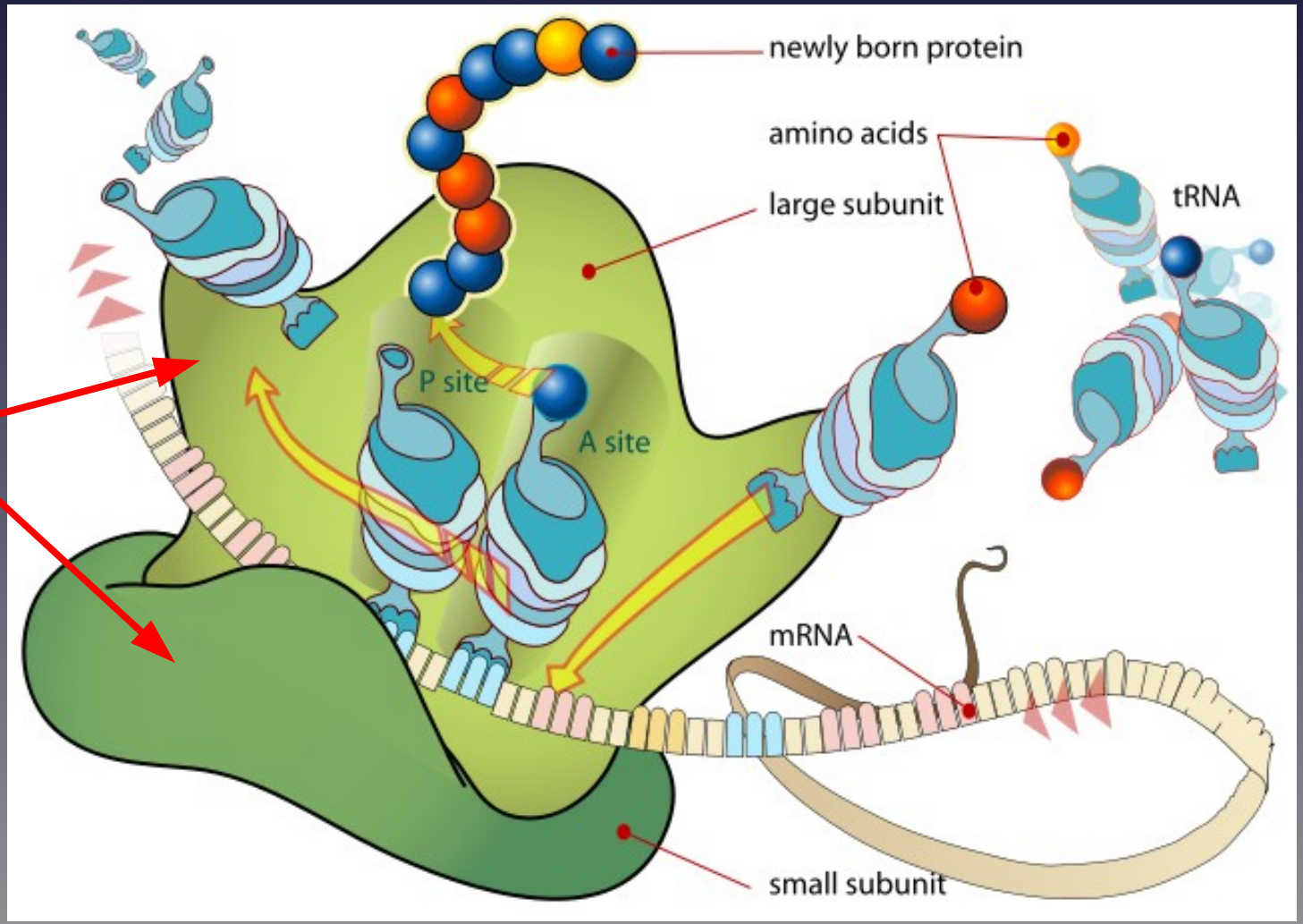
DNA → Proteins (Translation)

Ribosome
(two parts)



DNA to Protein#1

DNA to Protein#2

DNA to Protein#3

DNA to Protein#4

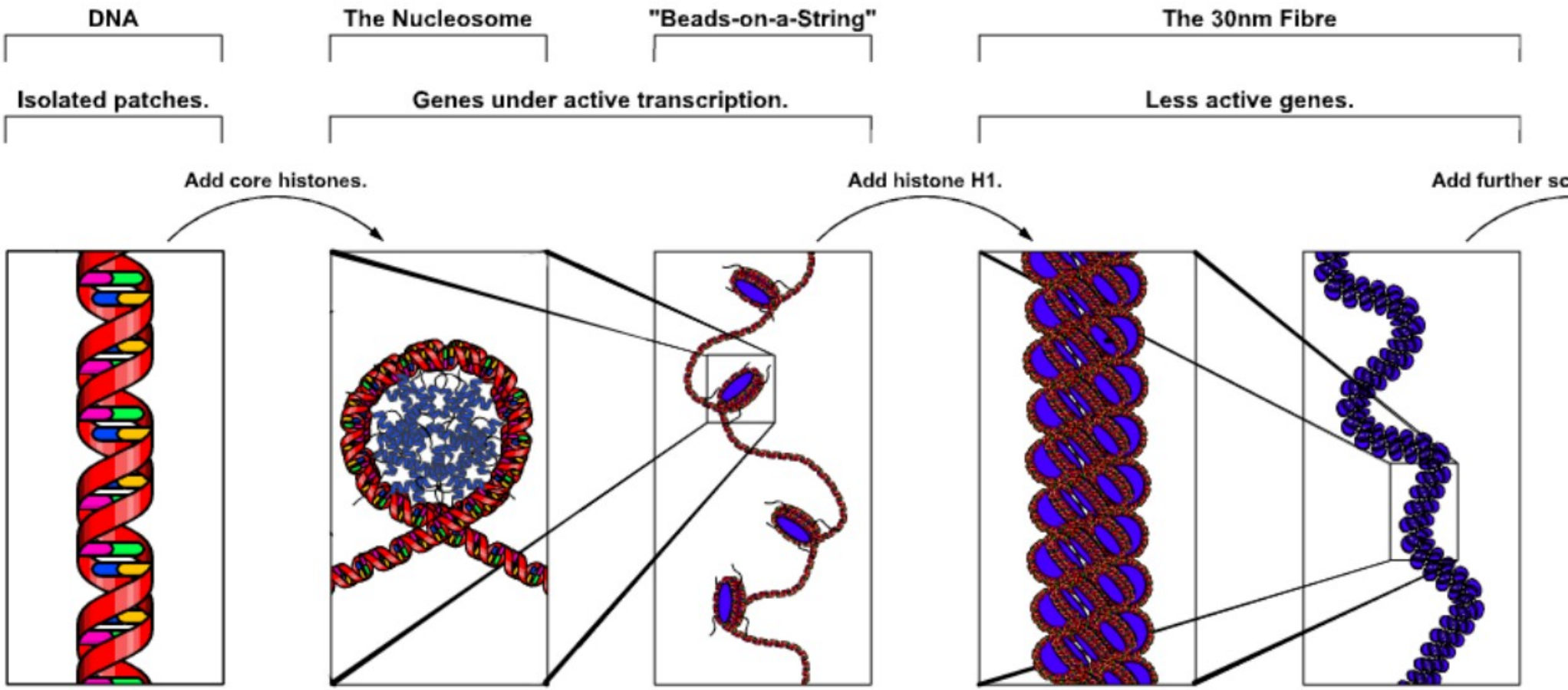
Genetics Review
Packaging DNA

- DNA is fragile
- DNA replication and translation is not needed continuously
- DNA must issue different instructions in different cells
- Therefore,

  DNA will function properly only if it is packaged to provide these functions

- The packaging material is a collection of proteins called *chromatin*

Genetics Review
Chromatin



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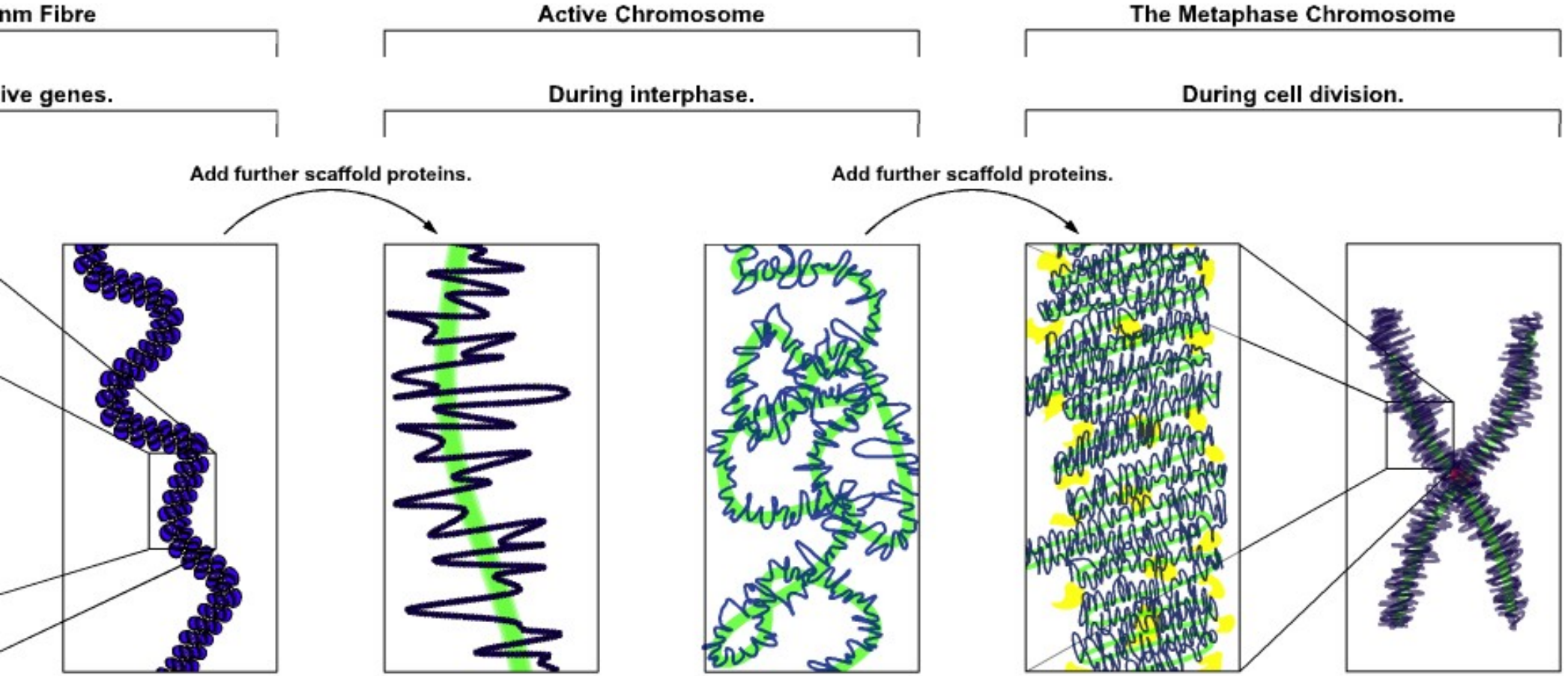
Chromatin



Genetics Review
Chromatin

Histone positions within the nucleosome using platinum labeling and the scanning transmission electron microscope:
C J Stoeckert, M Beer, J W Wiggins, J C Wierman,
Journal of Molecular Biology, Aug 1984 (Vol. 177, Issue 3, Pages 483-505)

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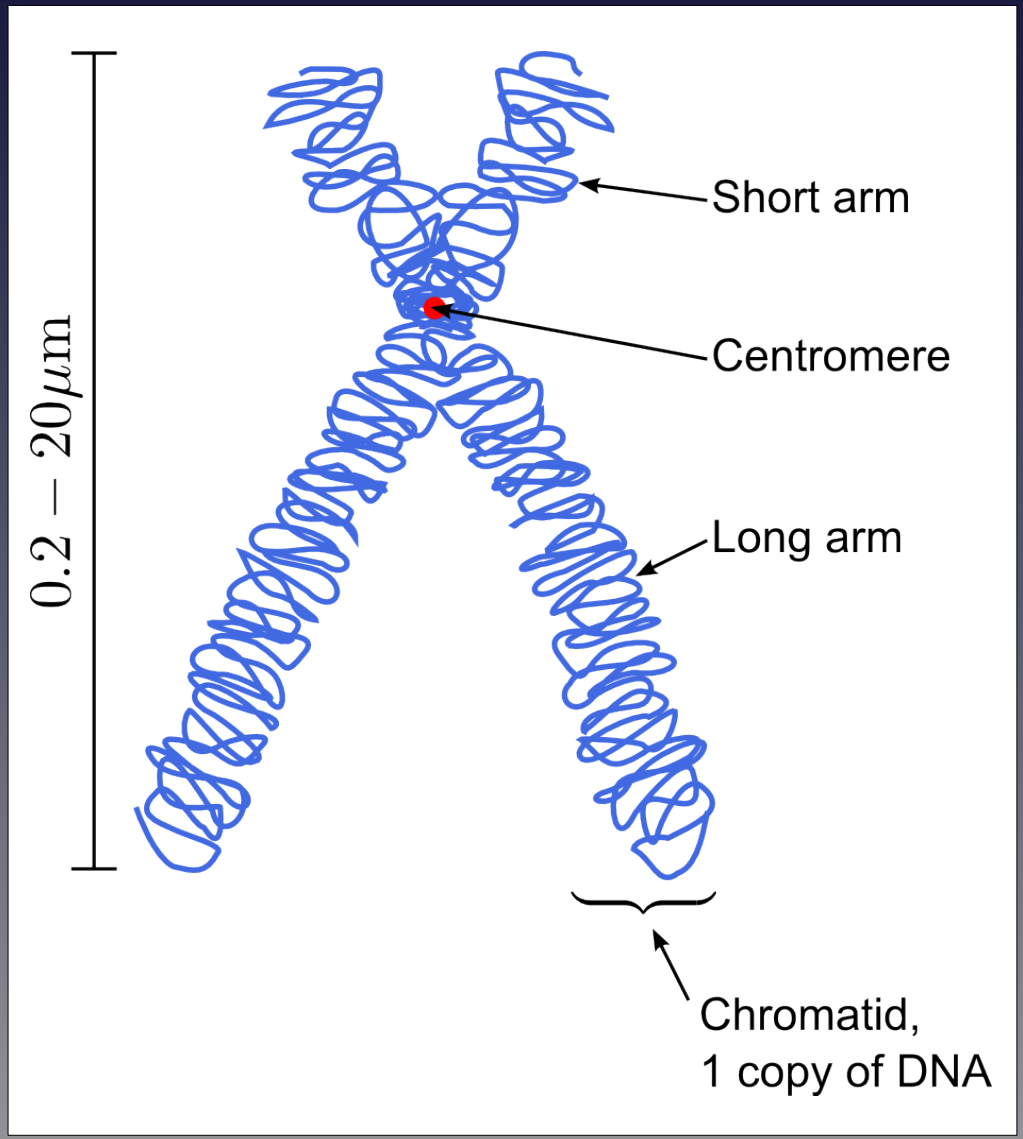
Chromosomes



Genetics Review

DNA Replication: Cell Division

Mitosis – Growth, creation of identical cells

Meiosis – Creation of eggs or sperm (gametes)

Cell Division

Genetics Review
DNA Replication: DNA Silencing

Each cell has two copies of each gene: one from each parent

One of the copies may be passive while the other is active

Both of the two copies can be active

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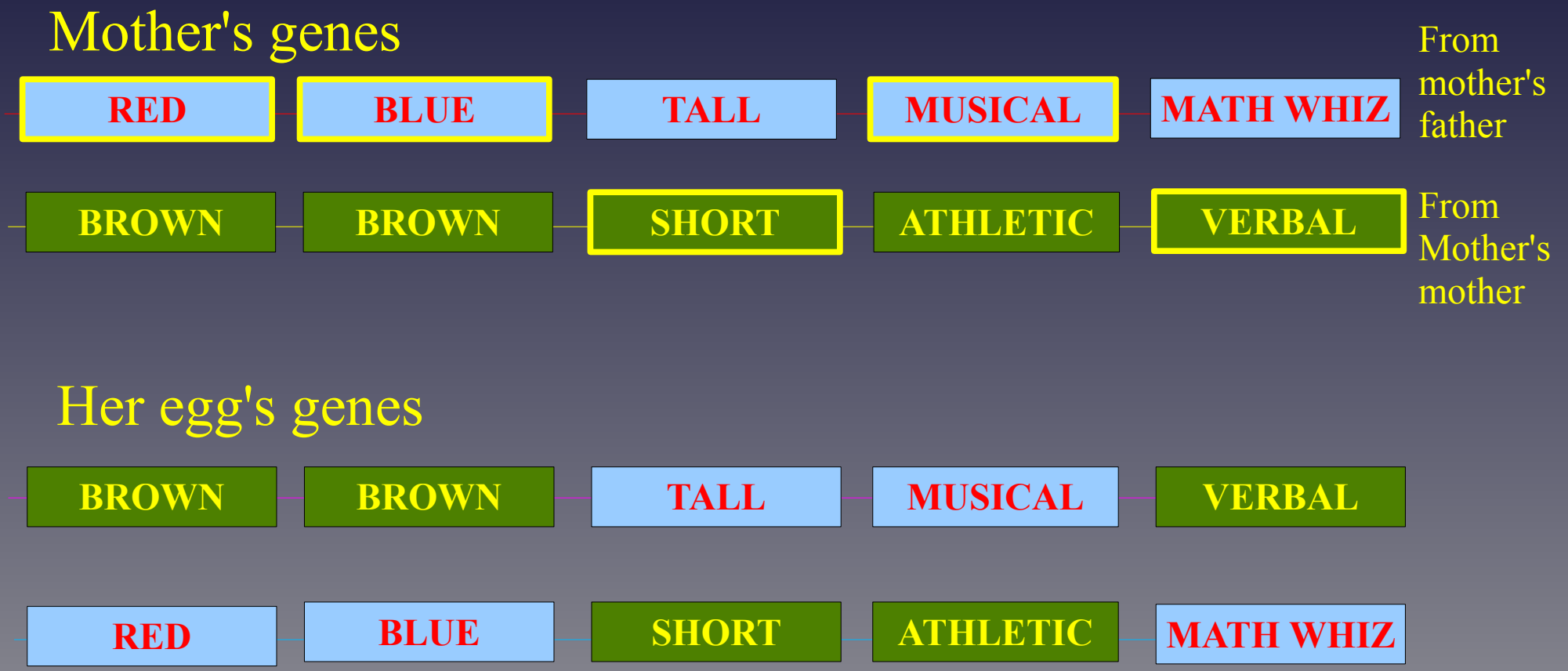
DNA Replication: Crossing Over



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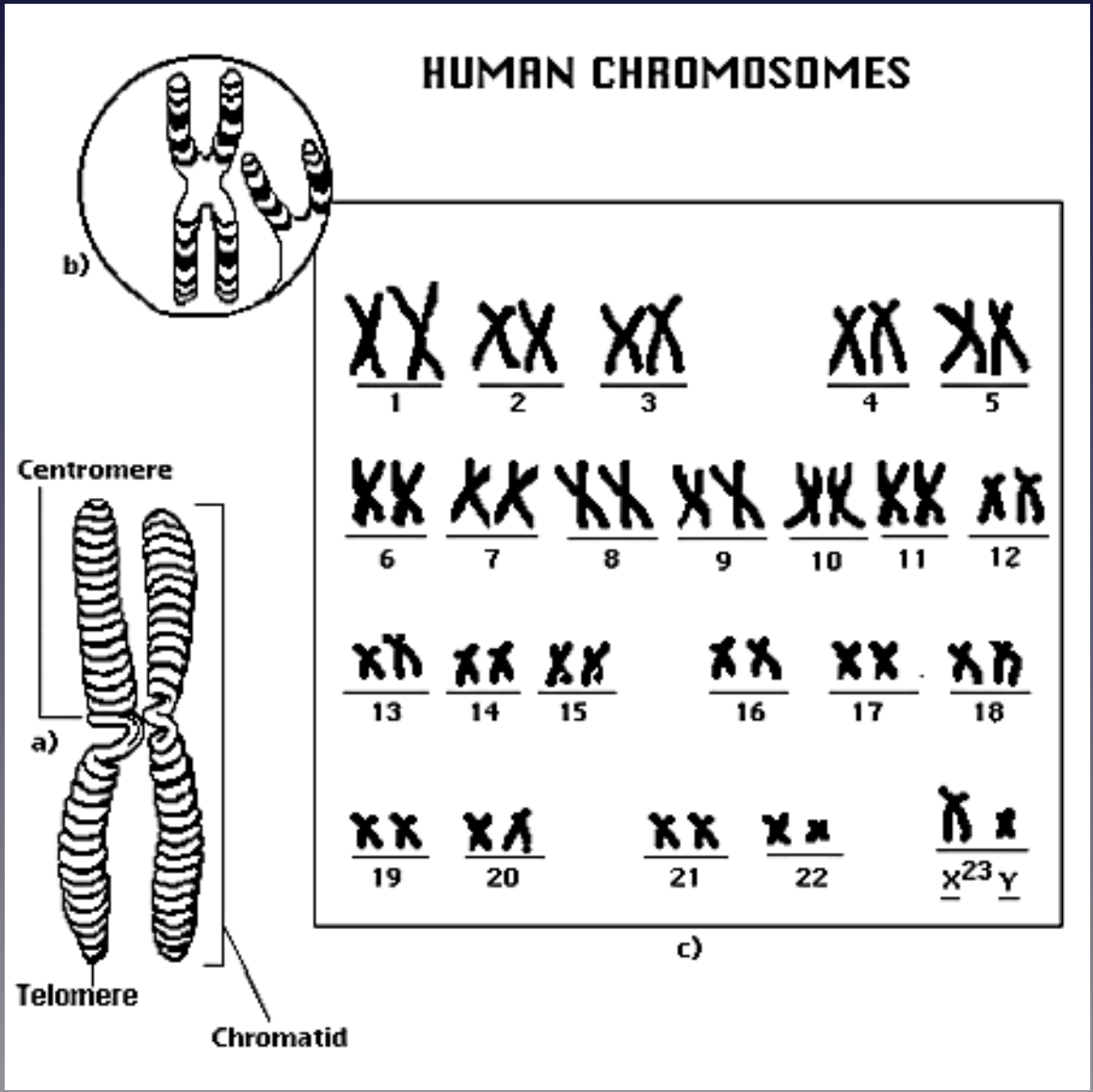
Chromosomes



Genetics Review
Mutations

Mutations
Changes to the nucleotide sequence of the genetic material of an organism

Point mutation
The replacement of a single base nucleotide with another nucleotide

Nucleotide deletion
Deletion of a single nucleotide. Leads to a *frameshift* and incorrect translation to protein.