BACK TO SCHOOL: **MOLECULAR BIOLOGY**

Evolution and the Natural World

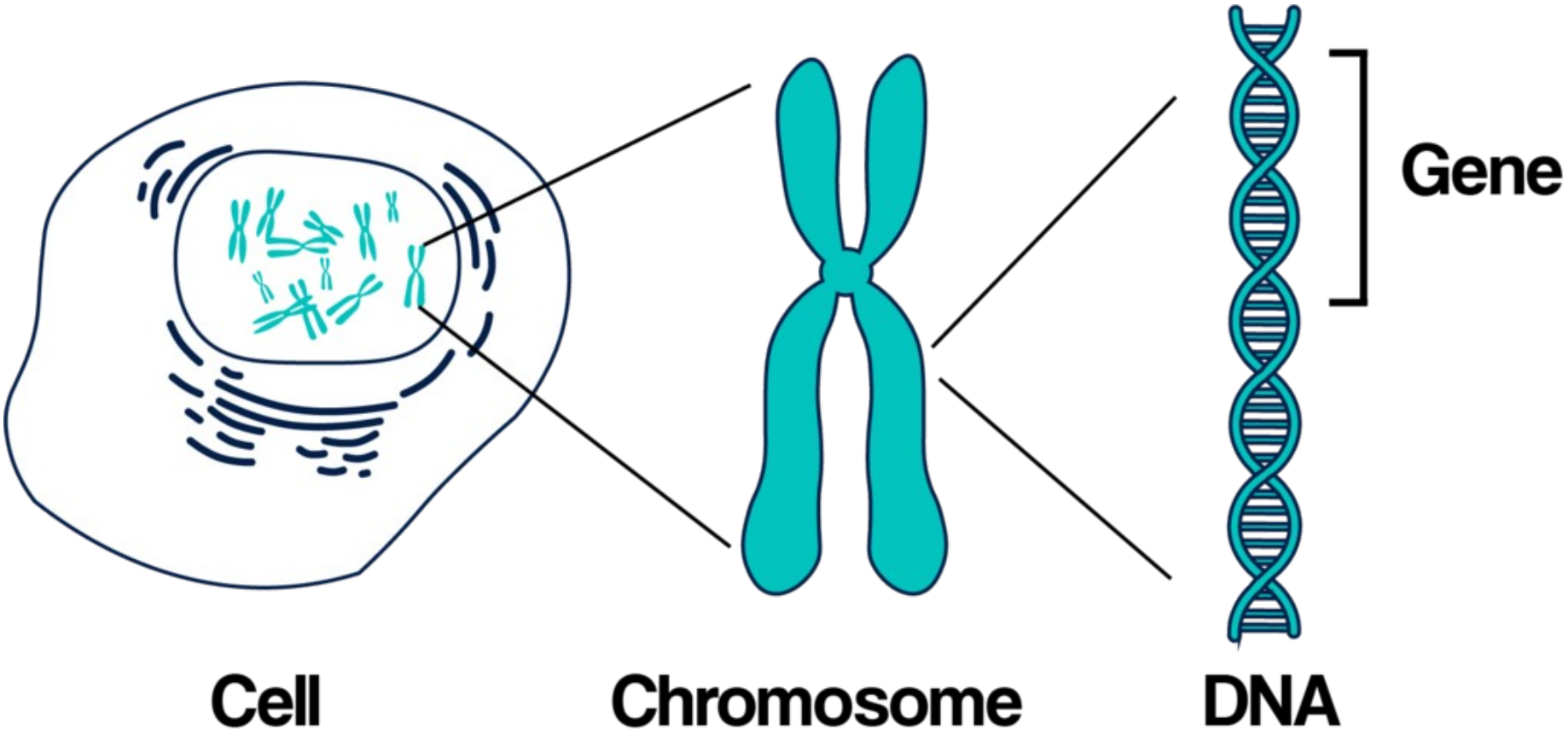
Lecture 2

21/09/2021

Vasili Pankratov

QUICK RECAP

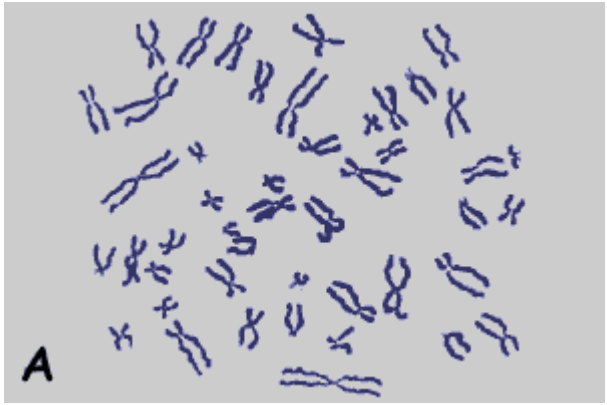
What are genes?


Gene
Cell
Chromosome
DNA

Can one see chromosomes and DNA?

Can one see chromosomes and DNA?

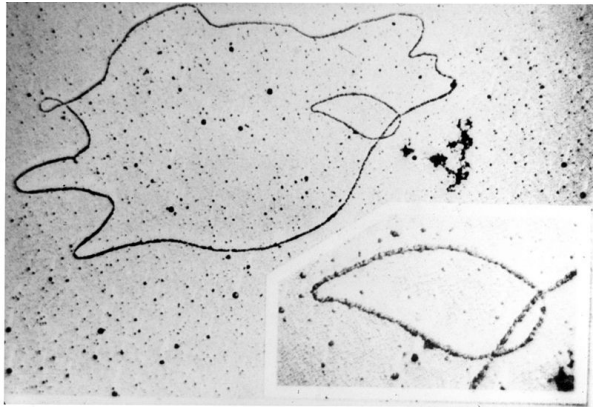
Light microscopy



Electoron microscopy

https://docwithpen.org/2015/07/28/science-marvels-1/

Electoron microscopy



Wikimedia:
DNA Under electron microscope Image 3576B-PH.jpg

Can one see nucleotides and genes?

Can one see nucleotides and genes?

- To know the nucleotide sequence of a DNA we run some chemical reaction to discriminate between nucleotides – this is **DNA sequencing**

- Genes are inforamtion units:

  fhfdhsgenesdshareyknlikervbkcwordsqadsfintersppersedpermwithiuertrandomerfgsequencesfhgpoofletterskiyvwwithxcnvpnofspacesgherthndsfhsdqr

Can one see nucleotides and genes?

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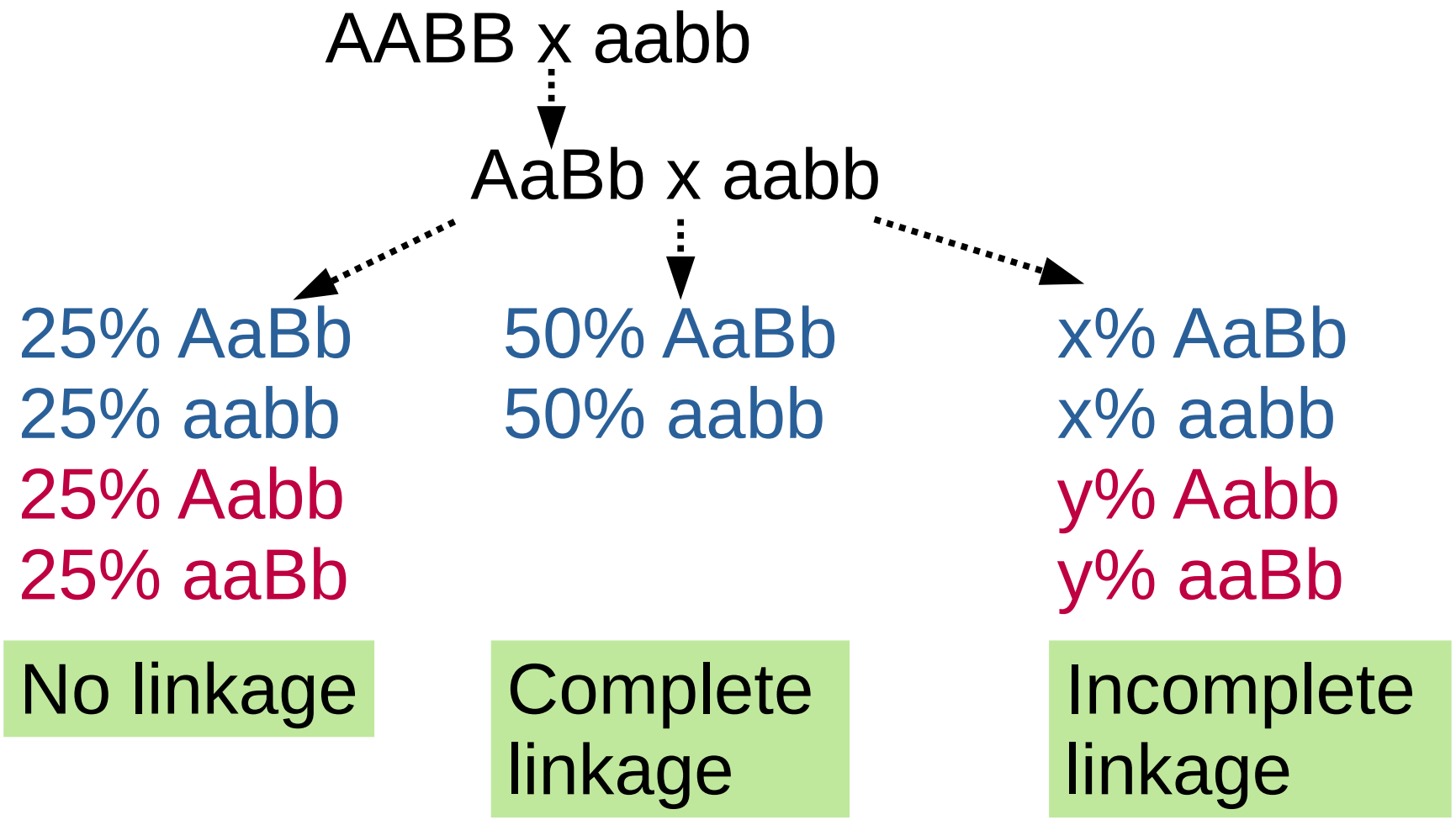
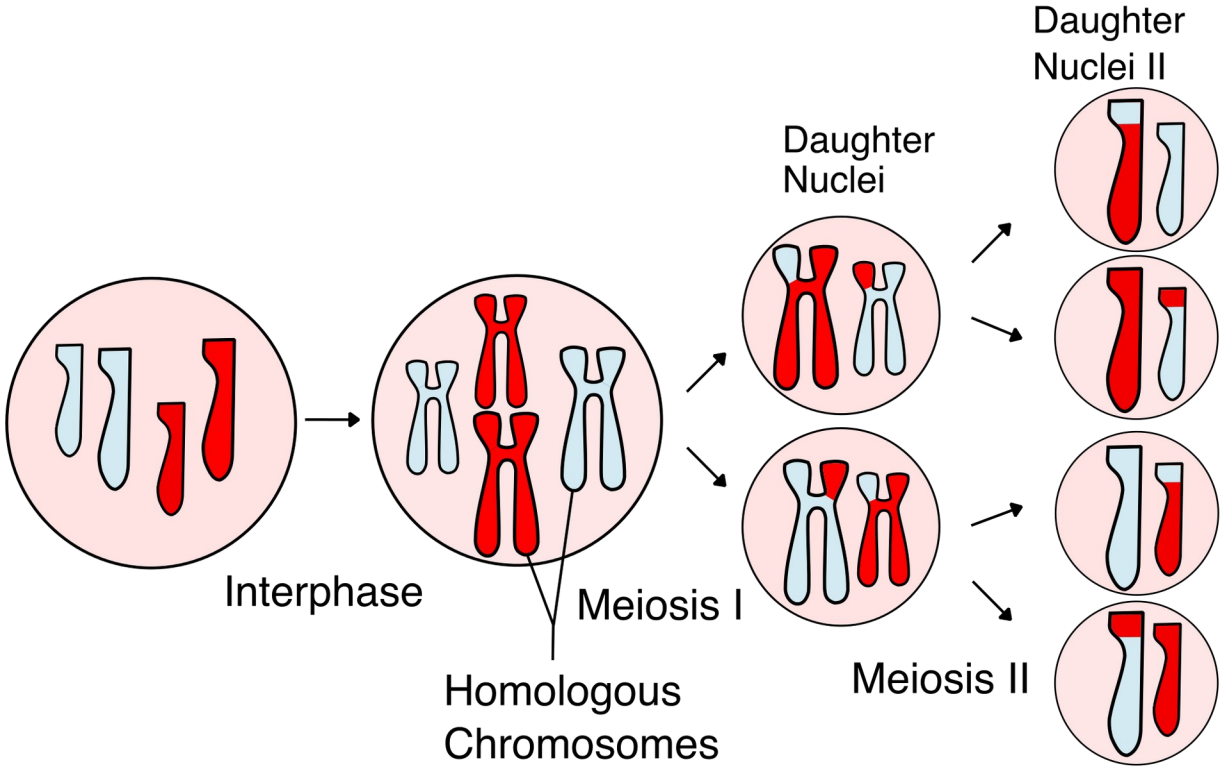
  fhfdhsgenesdshareyknlik
  ervbkcwordsqadsfintersp
  ersedpermwithiuertrando
  merfgsequencesfhgpoofl
  etterskiyvwwithxcnvpnof
  spacesgherthndsfhsdqr


AABB x aabb
AaBb x aabb
25% AaBb
25% aabb
25% Aabb
25% aaBb
50% AaBb
50% aabb
x% AaBb
x% aabb
y% Aabb
y% aaBb
No linkage
Complete linkage
Incomplete linkage

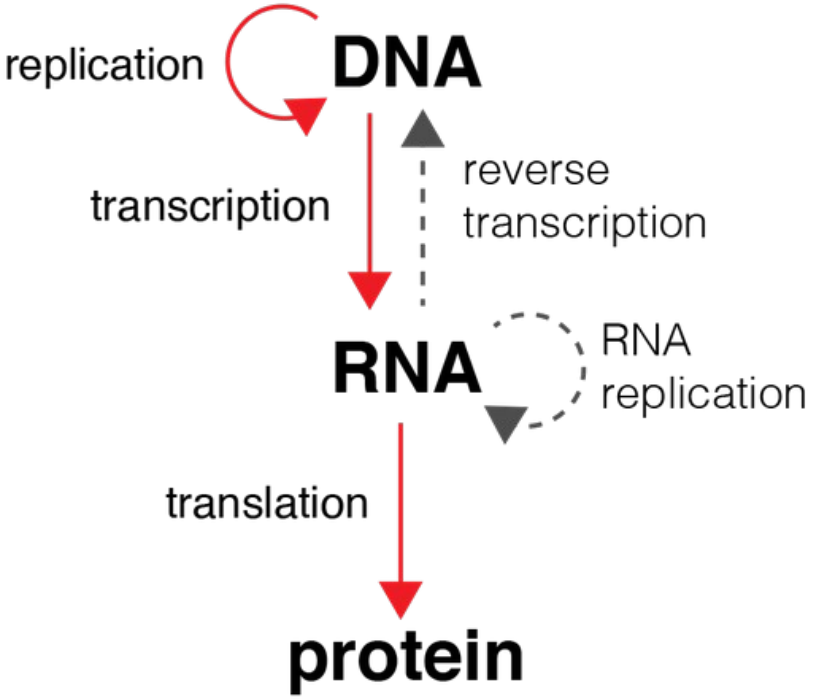
Recombination (crossing over)



MOLECULAR BIOLOGY (MB)

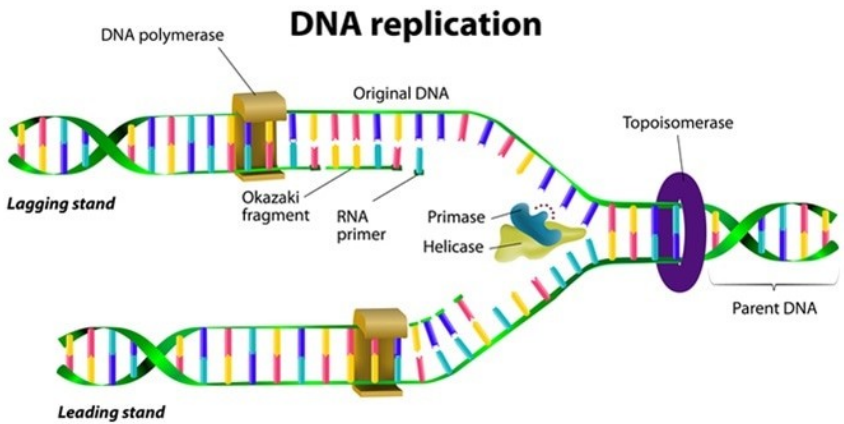
Molecular mechanisms of inheritance

The central dogma of MB



- **Replication** – DNA copying, ensures that daughter cells (including gametes) get the same DNA
- **Transcription + translation** – gene expression. These are the two steps needed to synthesize a protein ecoded by a gene.

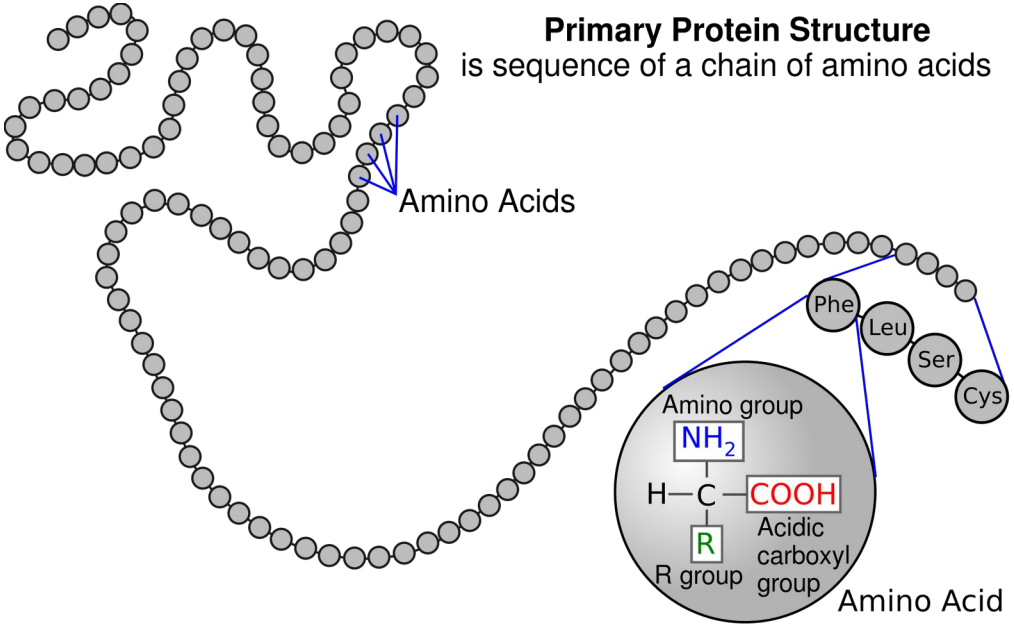
DNA replication – the basis of inheritance



https://www.news-medical.net/life-sciences/Mechanism-of-DNA-Synthesis.aspx

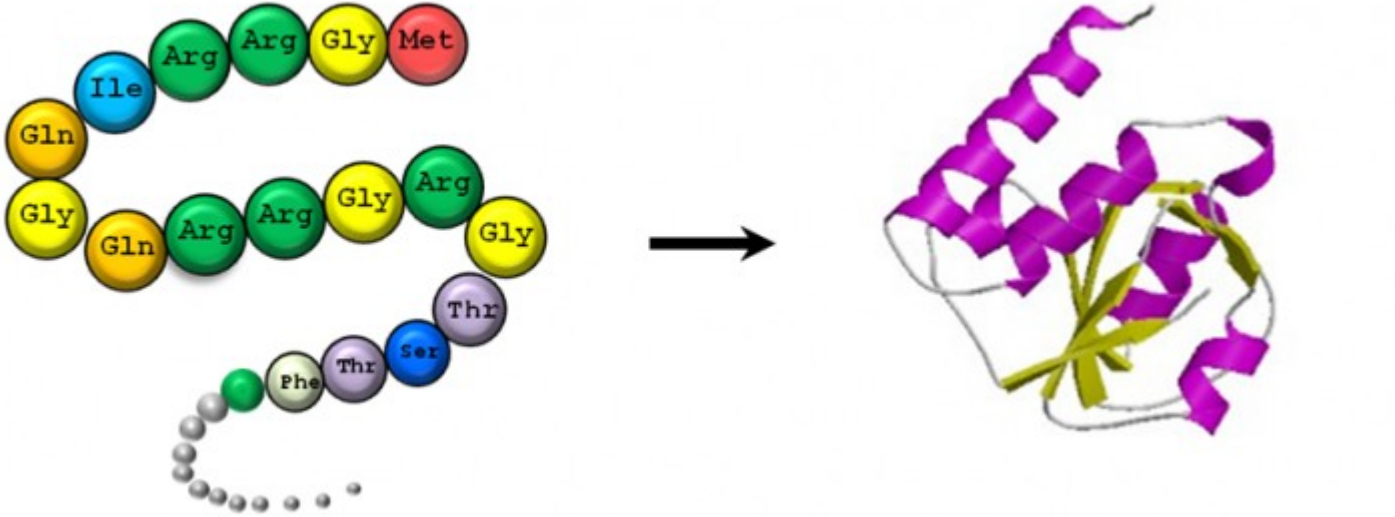
- Happens via a semi-**conservative** mechanism
- The main enzyme is DNA-**polymerase**
- Is very precises but not perfect – **mutations** may happen

Genes code for **proteins**



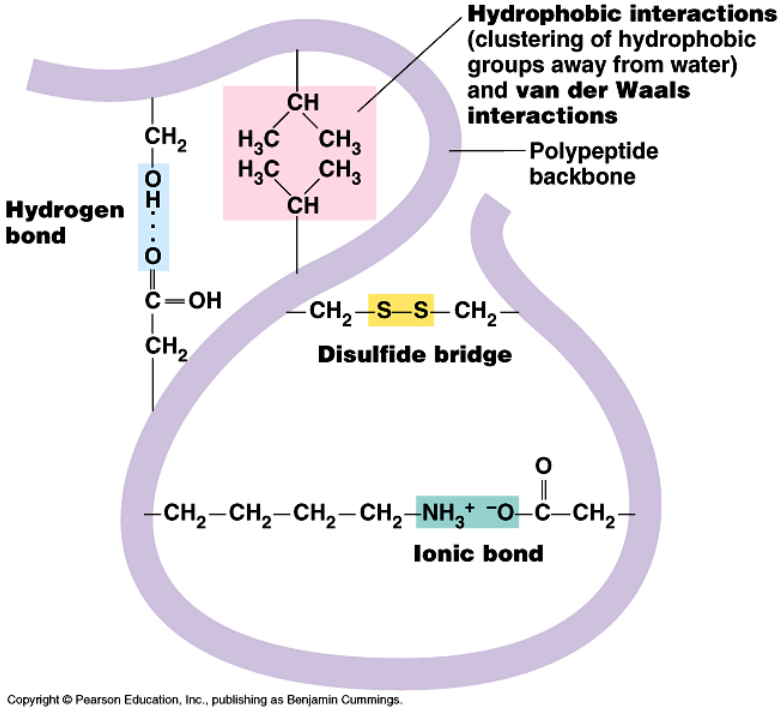
- Proteins are polymers of amino acids
- Proteins do most of the work in the body, most importantly, **enzymes** are proteins

Why can proteins do different stuff?



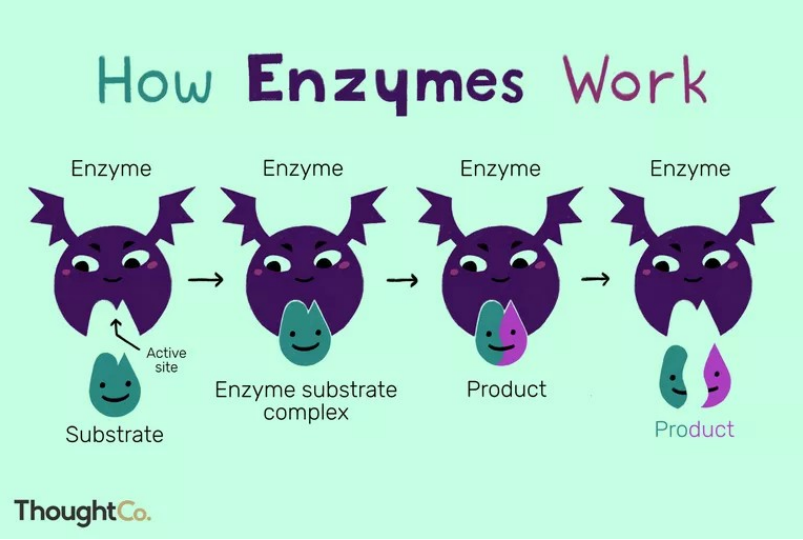
- Each protein has a specific **3D structure**, defined by its' AA sequence, which determines protein's properties

Protein 3D structure



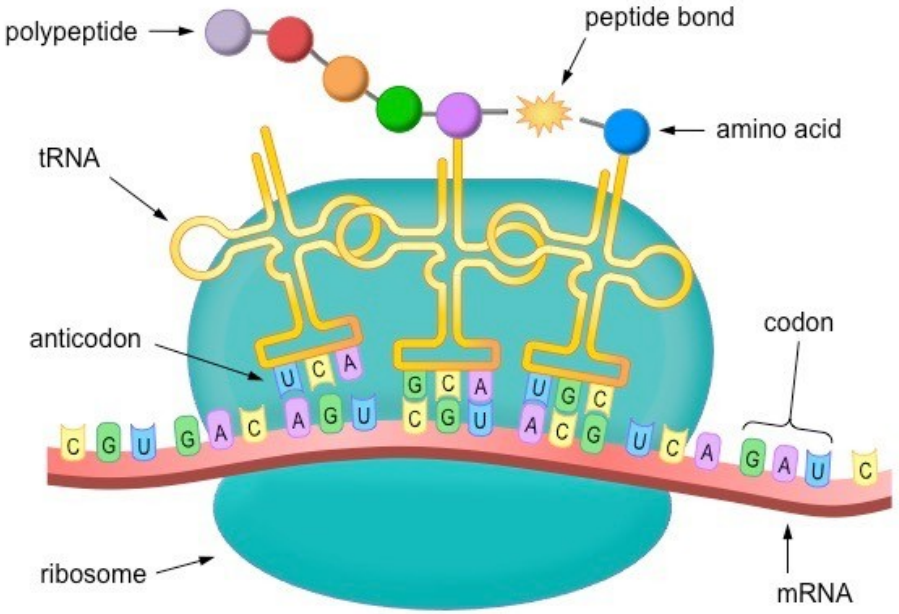
- **Proteins' 3D structure** is the key to their functions
- The 3D structure depend on the amino acid sequence
- But it also depends on conditions like pH and temperature and it may change as a result of chemical modifications

Enzymes



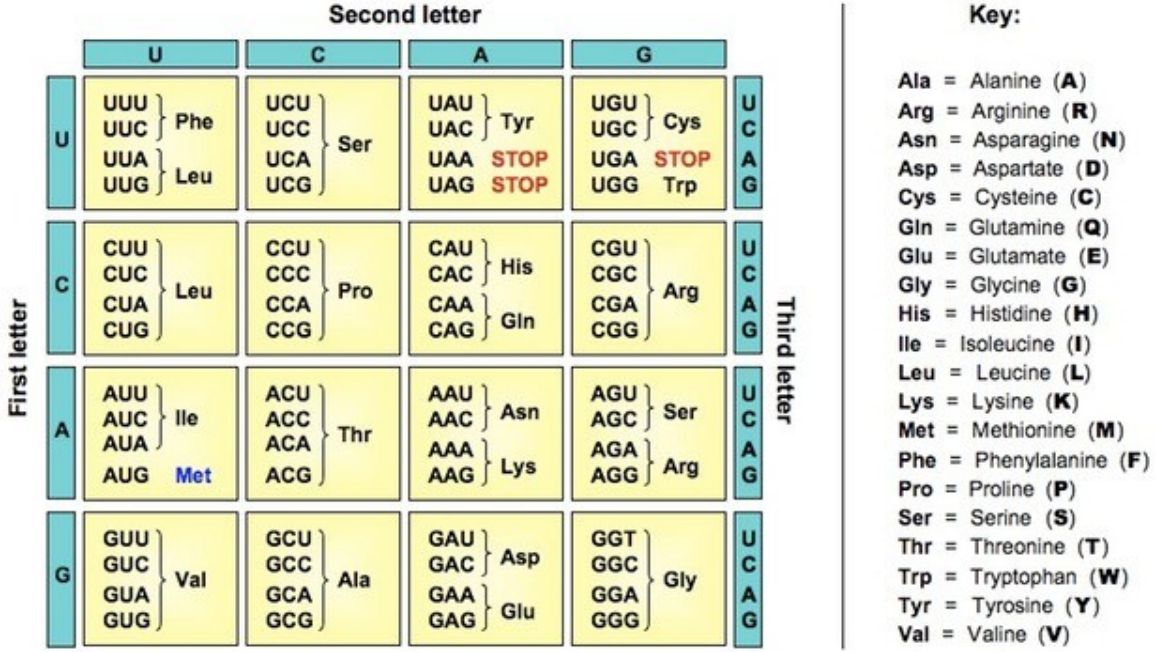
- Every type of compound (sugars, lipids, nucleotides etc.) are synthesized with the help of enzymes (each reaction needs its enzyme)
- The chemical composition of a cell depends on the enzymes it contains

Protein synthesis (Translation)



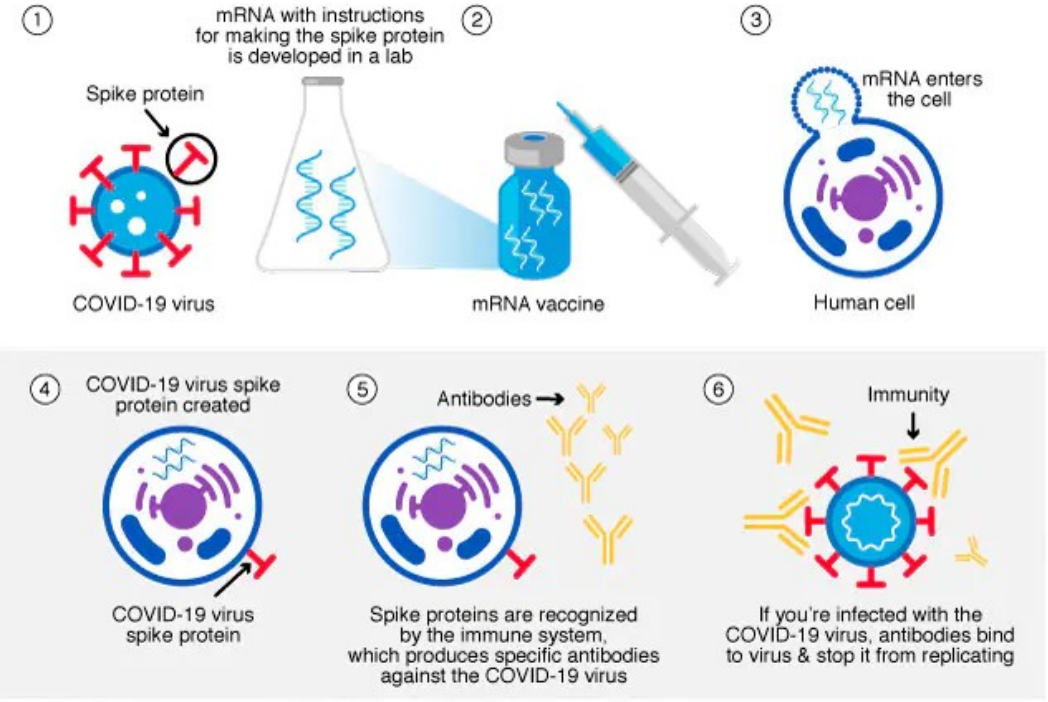
- **Ribosome** – the place and the enzyme
- **Messenger RNA** – the source of info about the amino acid sequence
- **Codon** – information unit
- **Transport RNA** – adapter between mRNA and each amino acid

mRNA to protein decoding

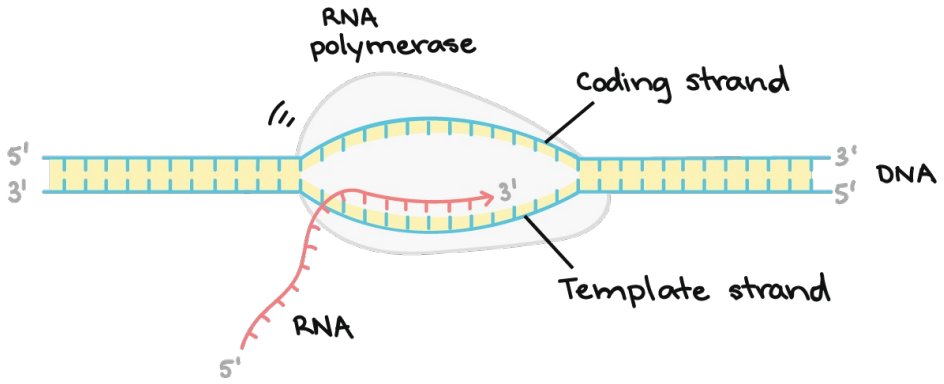


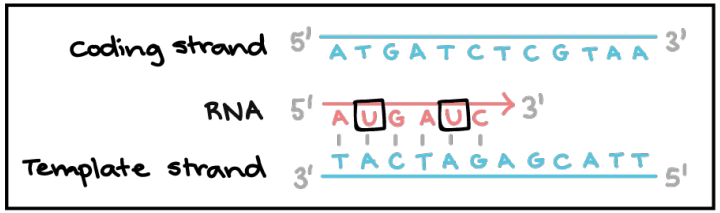
- **Genetic code** is a “dictionary” to translate RNA nucleotide sequence into protein amino acid sequence
- It is **redundand** and (almost) **universal**

MRNA vaccines



RNA synthesis (Transcription)

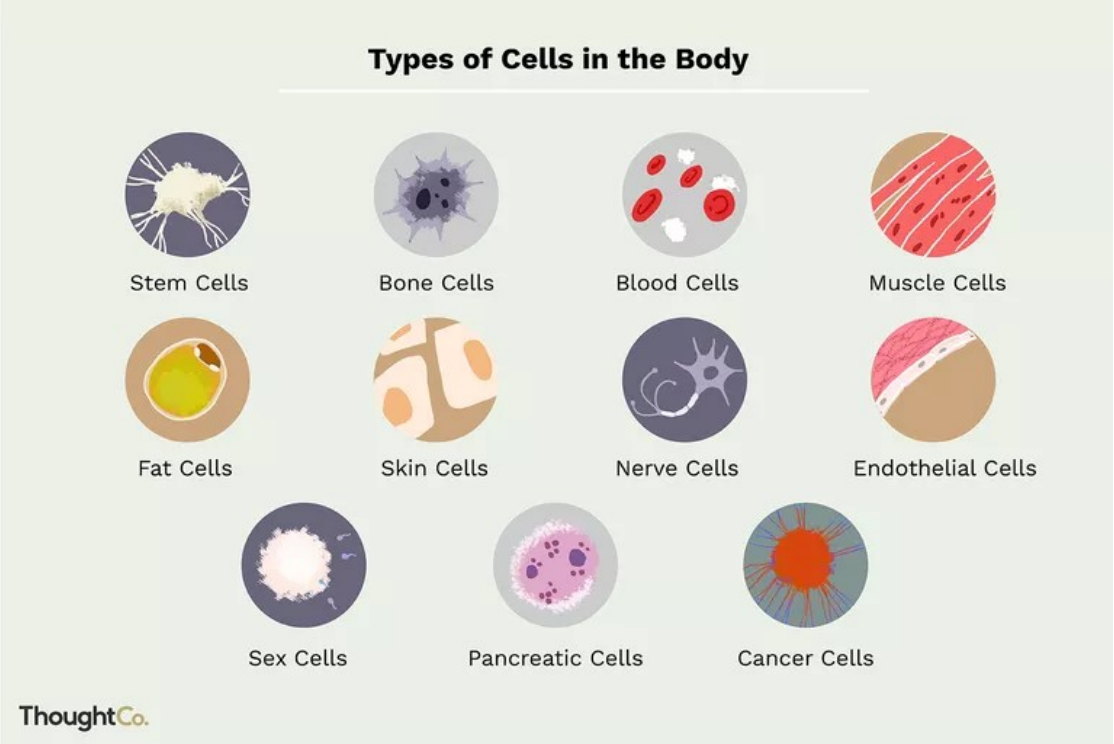




- **RNA polymerase** – the enzyme
- **Complementarity** – the rule for going from DNA to RNA
- DNA **template strand** – the source of info about the nucleotide sequence

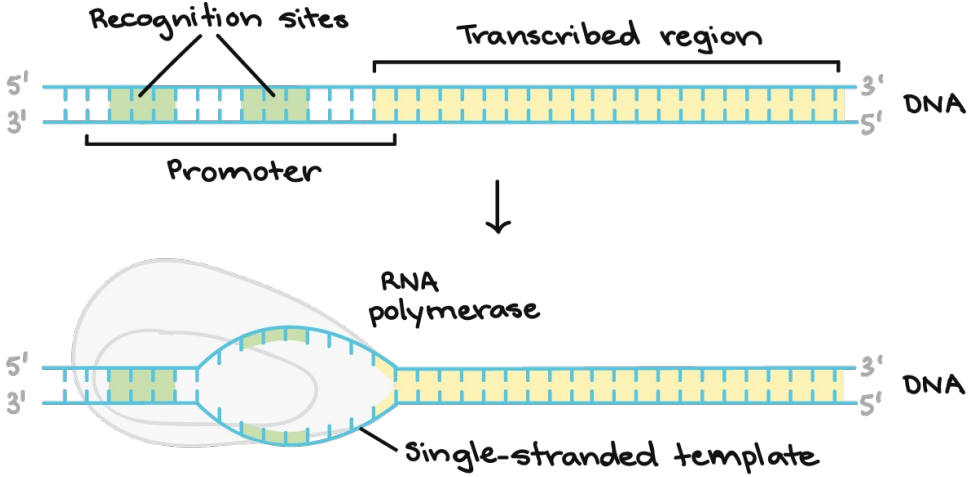
https://www.khanacademy.org/science/biology/gene-expression-central-dogma/transcription-of-dna-into-rna/a/stages-of-transcription

Controlling gene expression



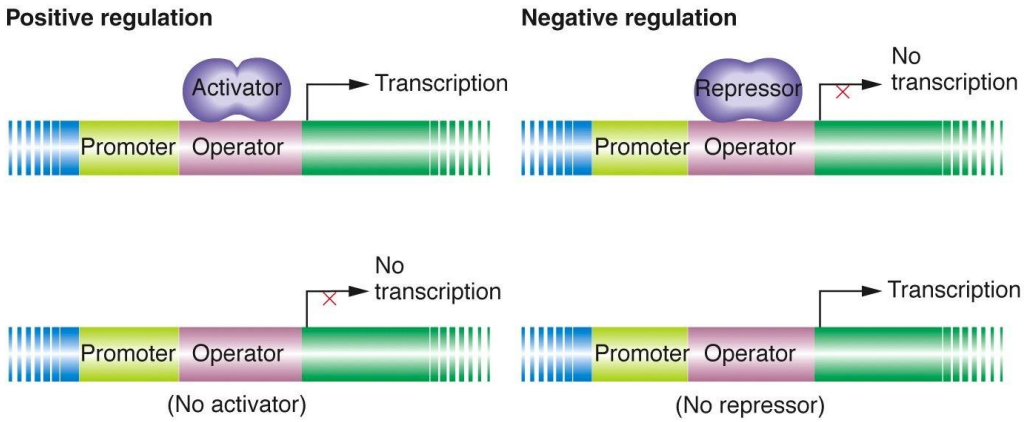
Gene expression differs between cell types, stages of the cell cycle, organismal life stage and depending on various conditions

Controlling transcription



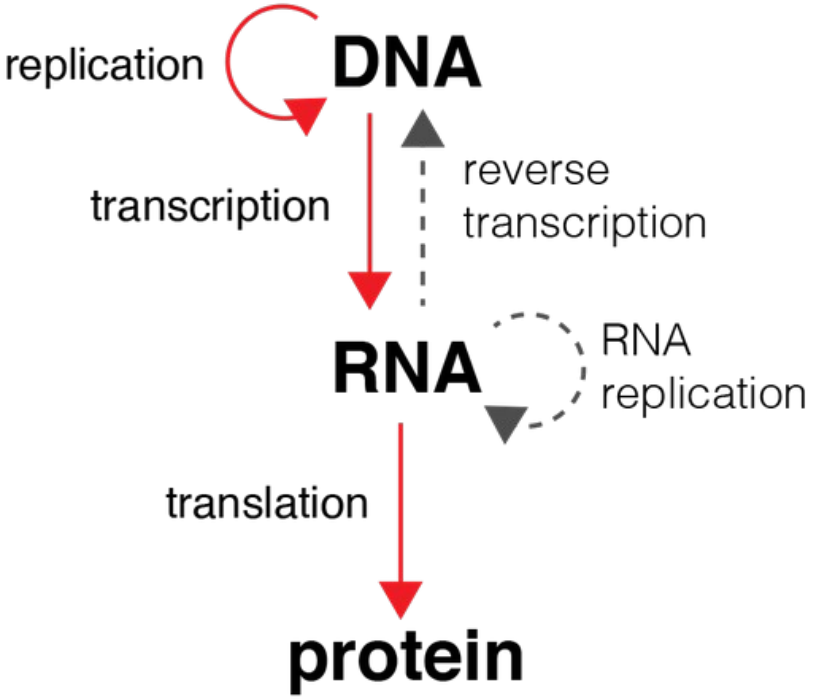
- **Promoter** is a DNA sequence where RNA polymerase binds – it «marks» the start of the gene
- **Promoters** control transcription initiation

Controlling transcription



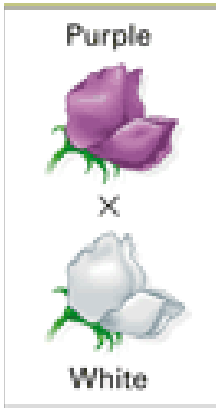
- **Regulatory proteins (RPs)** that bind to promoters can either activate or repress transcription of a given gene
- Transcription is mostly regulated by synthesizing / destroying / modifying RPs

Summary: the central dogma



- **Genes** are chromosomal regions that **code** for **proteins** (“one gene – one protein”)
- Some DNA sequences provide instructions on when, where and how much of a protein to produce – **regulatory sequences (like promoters)**

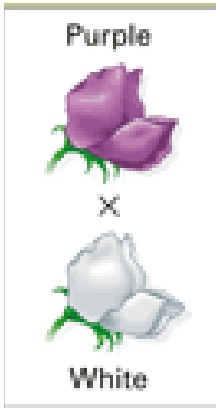
Genes to phenotype: simple case

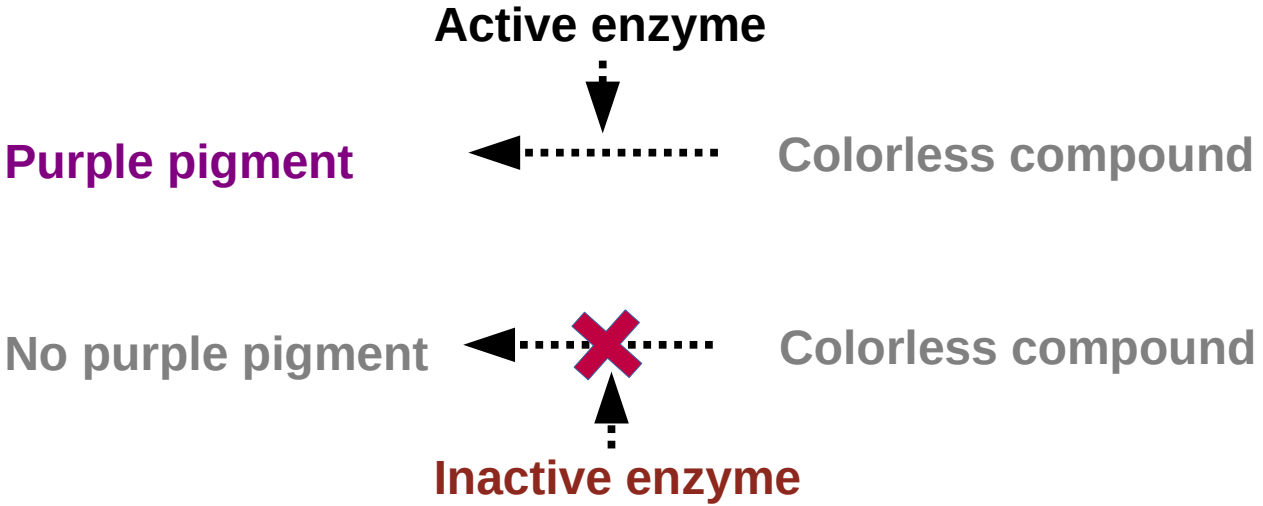


Purple pigment

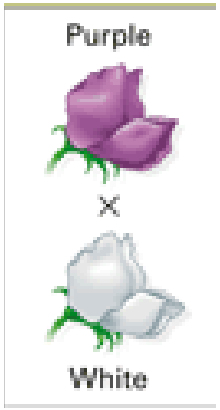
No purple pigment

Genes to phenotype: simple case





Genes to phenotype: simple case



Active enzyme ⟵ Normal allele (A)

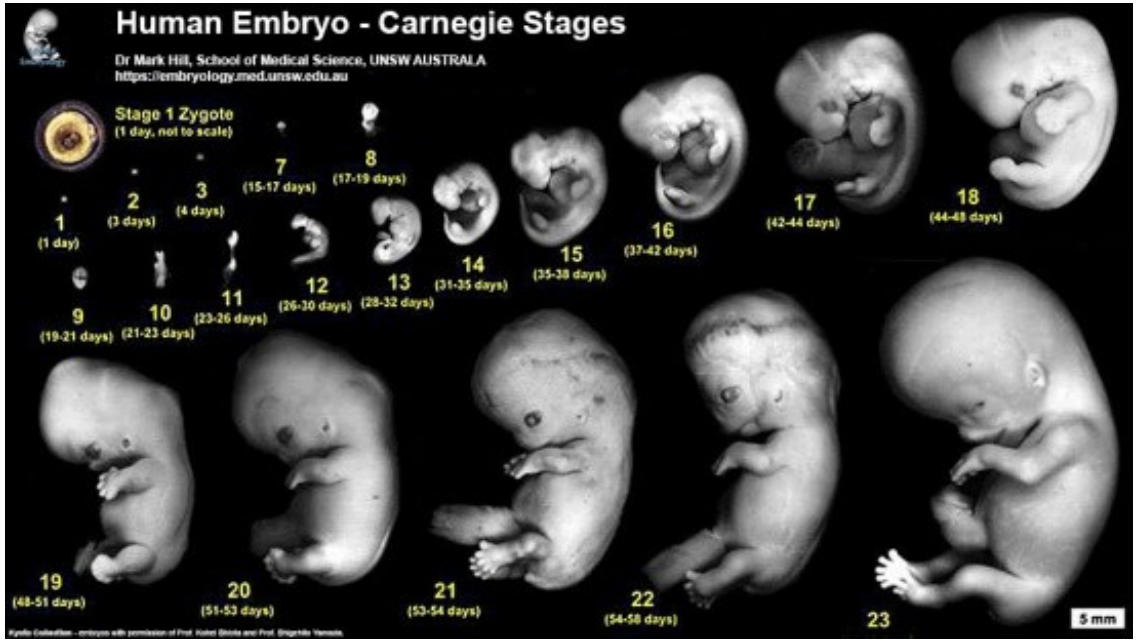
Purple pigment ⟵ Colorless compound

No purple pigment ⟵ Colorless compound

Inactive enzyme ⟵ Nonfunctional allele (a)

Mutation in the protein-coding part: incorrect AA sequence
Mutation in the promoter – no transcription happening

Genotype to phenotype



https://embryology.med.unsw.edu.au/embryology/index.php/Embryonic_Development

- **Development** is the link between genotype and phenotype
- RPs control the **time, place and levels** of other proteins' expression
- This controls the cellular and organismal processes incl. development

Summary

- Proteins do most of the work in the cell/organism including being enzymes
- The function of a protein depends on its amino acid sequence
- This sequence is defined by the nucleotide sequence of a gene and is decoded during transcription and translation
- The genetic code is a rule how to convert nucleotide sequence into amino acid sequence

Summary

- Interaction between regulatory sequences and regulatory proteins controls most of the processes in the cells and organisms by controlling the concentration of other proteins through time and space