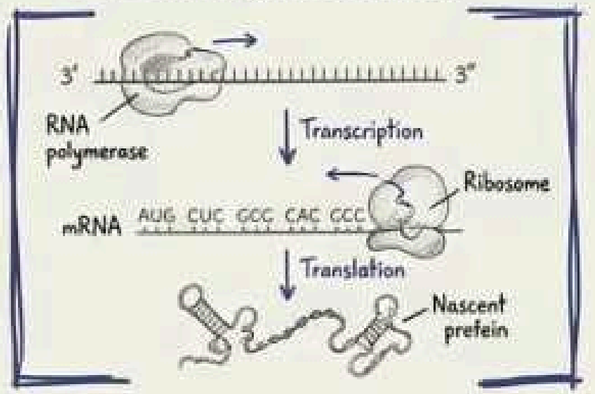
¶ 3.1

1. Information Flow

How does a gene become a working molecule?



2. The Code

What is the genetic code, and how is it read?

Codon Table

Methionine

	AUG	AUC	UCC	AGG	
U	UUC	Meth	UUG	Phenyl-alanine	U
C	UUC		UUC		C
T	AUG		UUG	Toye	G
U	CUU	Thu	CAG	Glycine	U
C	CUC		CAC		C
T	UUG		CAG		G
U	AUU	Tex	AAG	Slycien	U
A	AUC		AAC		A
T	AUG		AAG	Anating	G
U	GGU	Ale	GAG	Glycine	U
C	GUC		GAC		C
G	GGG		GAG		G

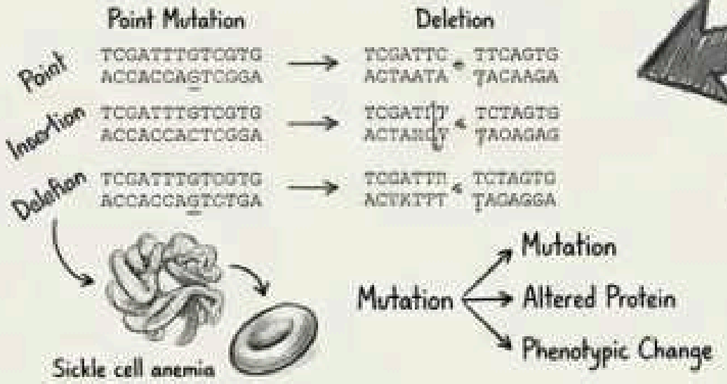
Redundancy

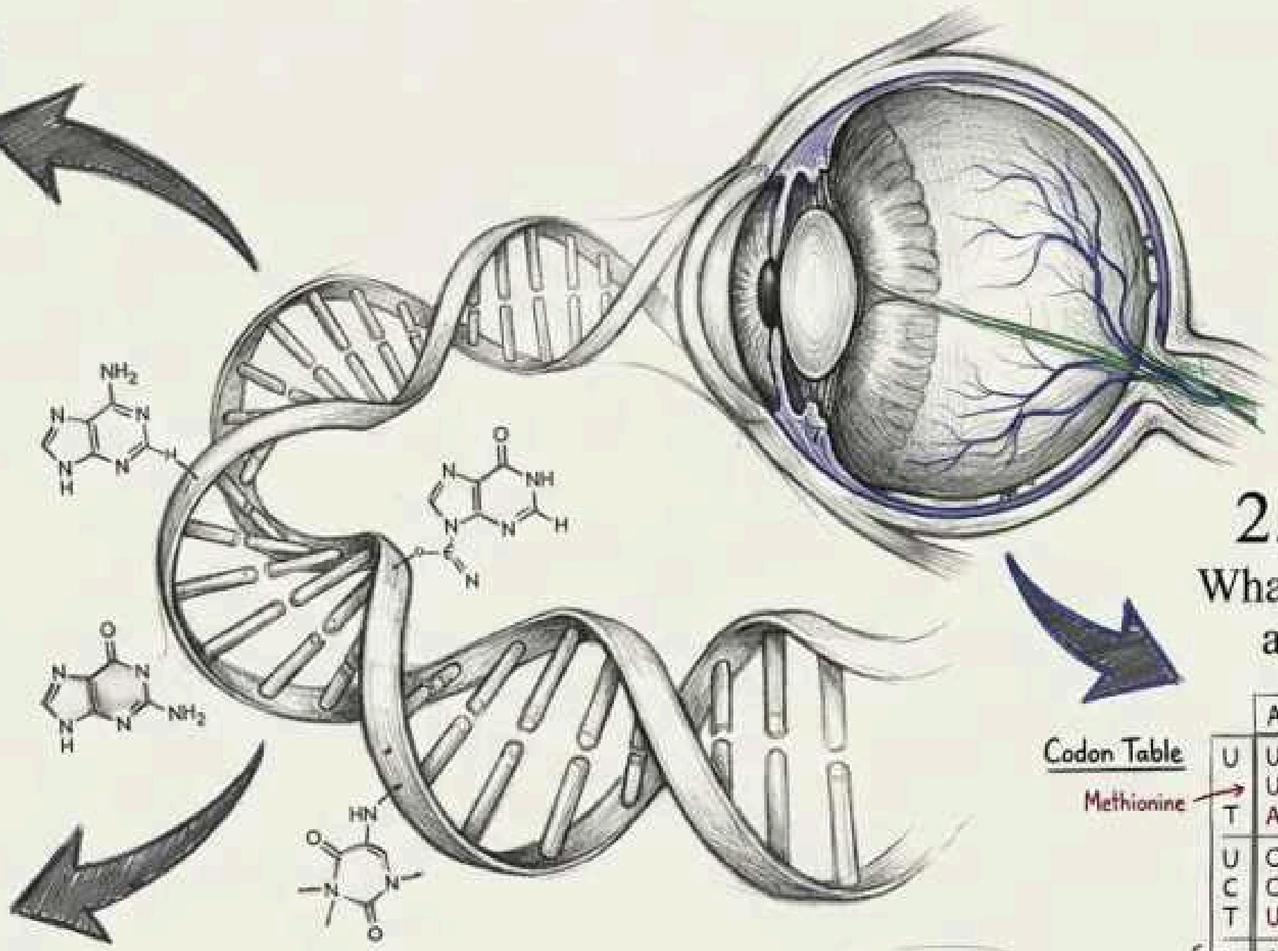
Codon Table

Redundancy

3. Variation

What happens when the code changes or is read differently?

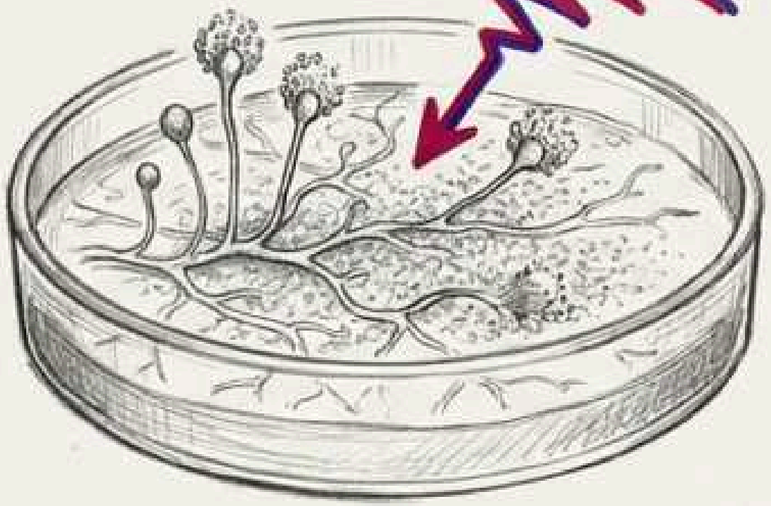




A *gene* turns into a *trait* through an *information pipeline.*

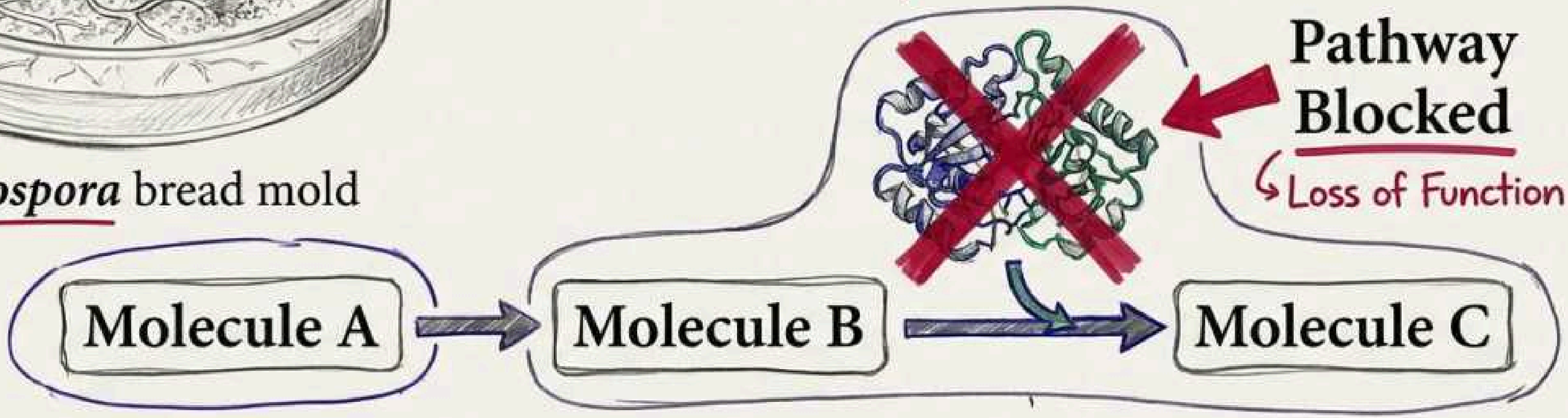
¶ 3.2

X-rays



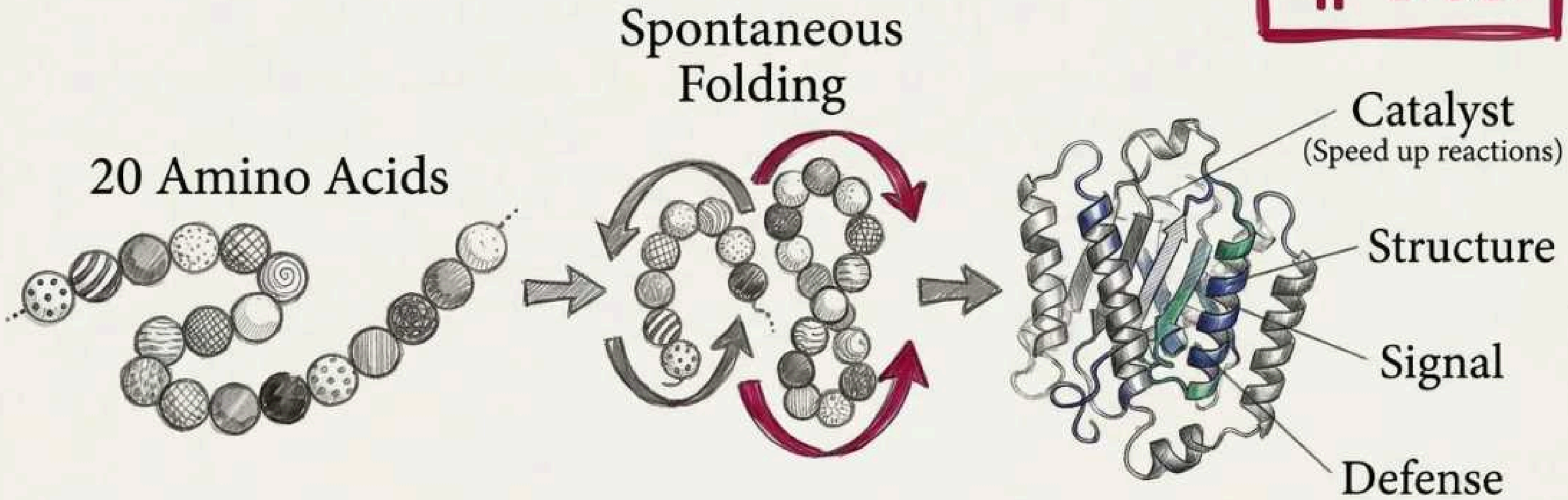
Neurospora bread mold





1 Gene = 1 Enzyme (→ Protein)

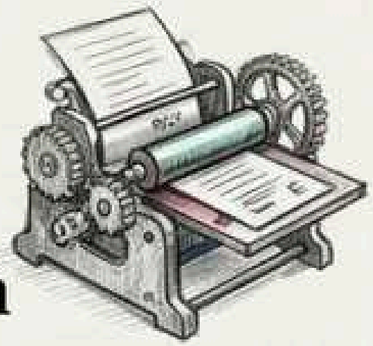
¶ 3.3



Sequence → Fold → Function

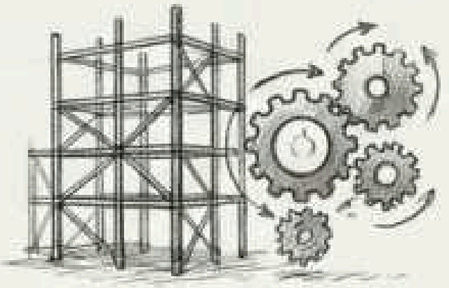
A gene is a recipe for an order.

¶ 3.4



Transcription

Translation



DNA → RNA → Protein

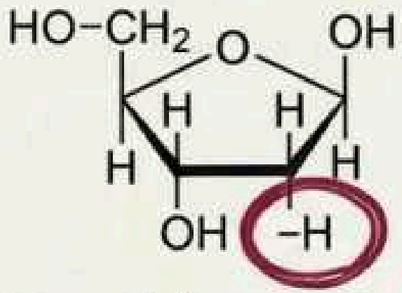
Reverse Transcriptase

Special Case: Retroviruses

¶ 3.5

DNA

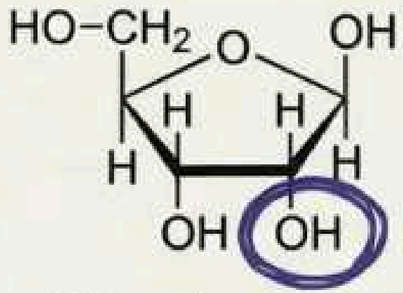




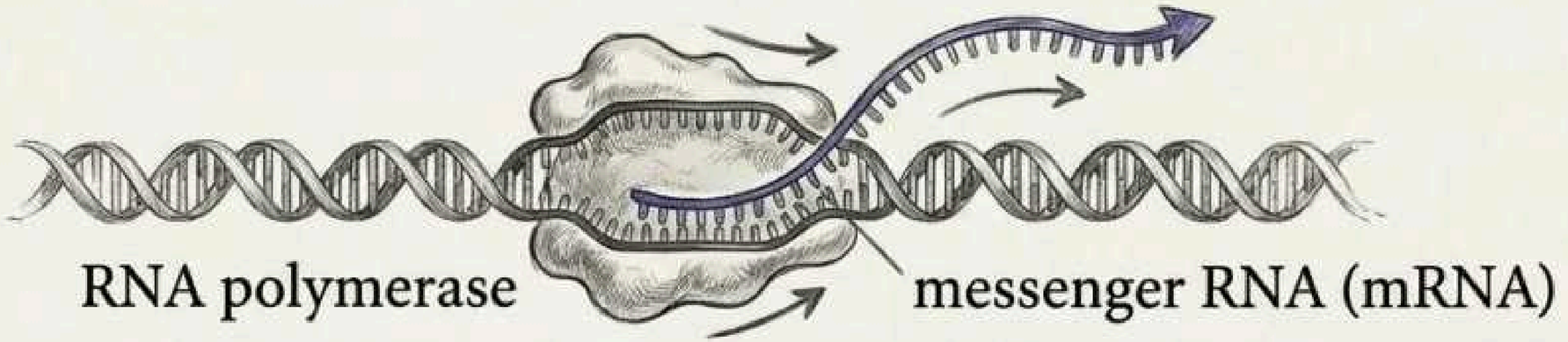
- Double strand
- Uses Thymine (T)

RNA



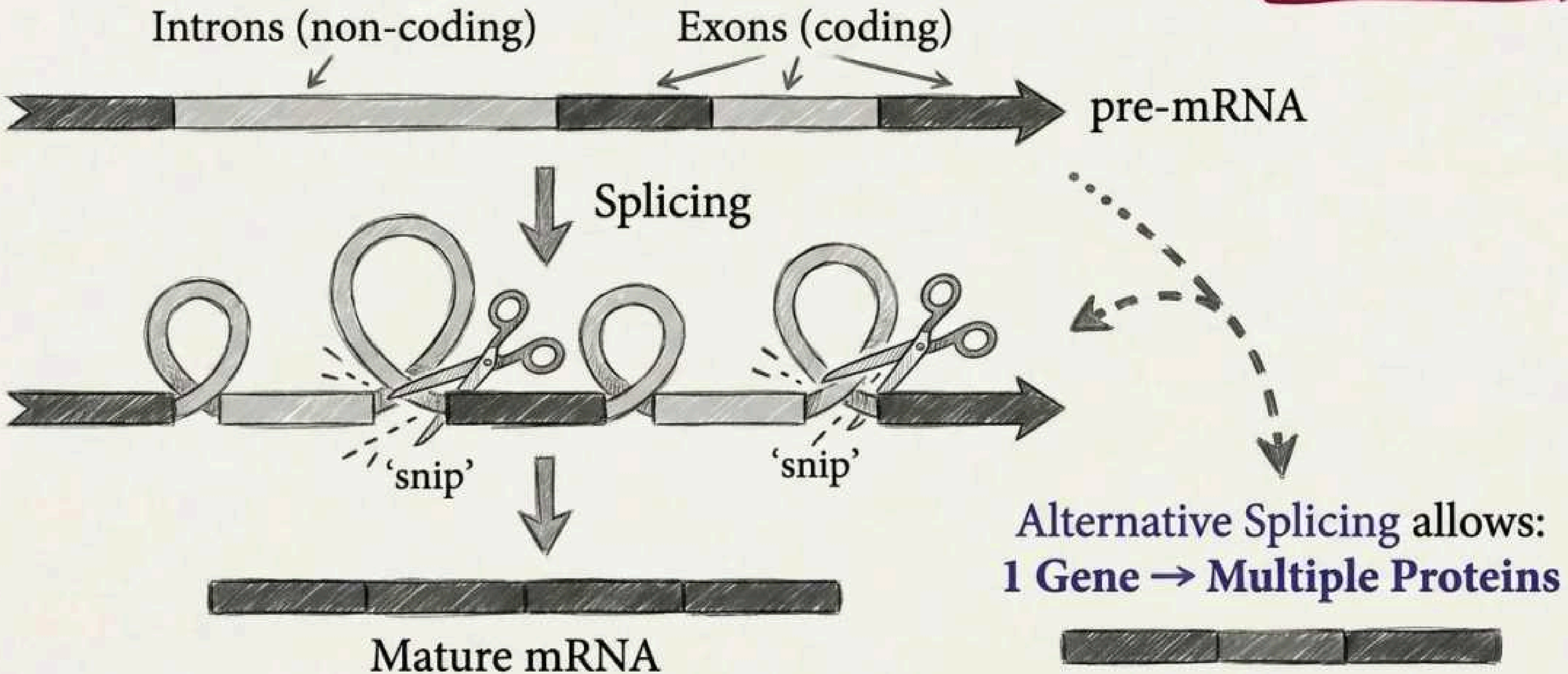


- Single strand
- Uses Uracil (U)



RNA MODIFICATION

¶ 3.6



¶ 3.7

Given: 4 Bases to specify 20 Amino Acids.

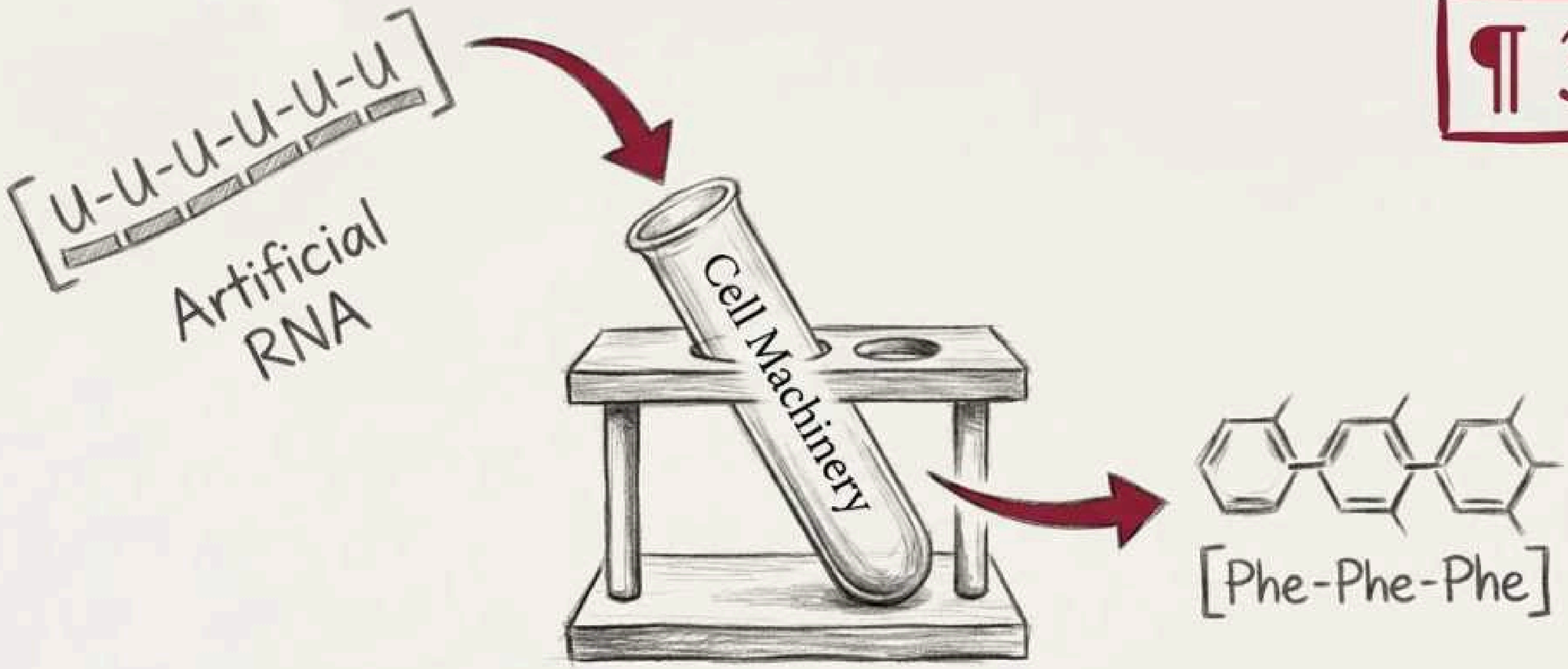
Singlets: $4^1 = 4$ combinations (Too few)

Doublets: $4^2 = 16$ combinations (Too few)

Triplets: $4^3 = 64$ combinations (Enough!)

Therefore: The code **MUST** be read in triplets, known as Codons.
Each codon names one amino acid.

¶ 3.8



1961 Nirenberg & Matthaei Experiment

Conclusion: Codon UUU = Phenylalanine
By 1966, all codons were cracked.

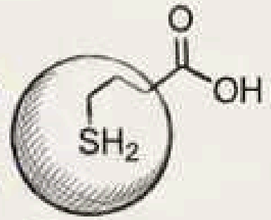
¶ 3.9

The Genetic Dictionary

UUU	UUU	CUU	CUG	UUU	CUG	UGA	UUG
UUC	CUC	CUA	CUC	UAC	CGC	UGA	CUC
UUA	CUG	CUA	CUG	UAA	CCG	UGA	UUG
UUG	CUG	CUA	CUG	CAA	CGC	CGA	CUG
AUU	AUC	ACA	ATG	AAU	ATC	AAG	AUG
AUA	AUC	ACA	ATG	AAA	AGC	AAG	AUG
UUU	UUC	CAG	GTG	GAU	GGC	GAG	AUG
UUG	UUG	CAG	GTG	GAG	GGC	GAG	GGG

61 Codons specify Amino Acids.

UCU
UCC
UCA



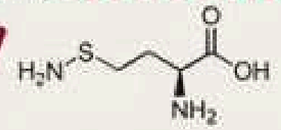
Serine

(The code is redundant)

3 Codons act as STOP signs.

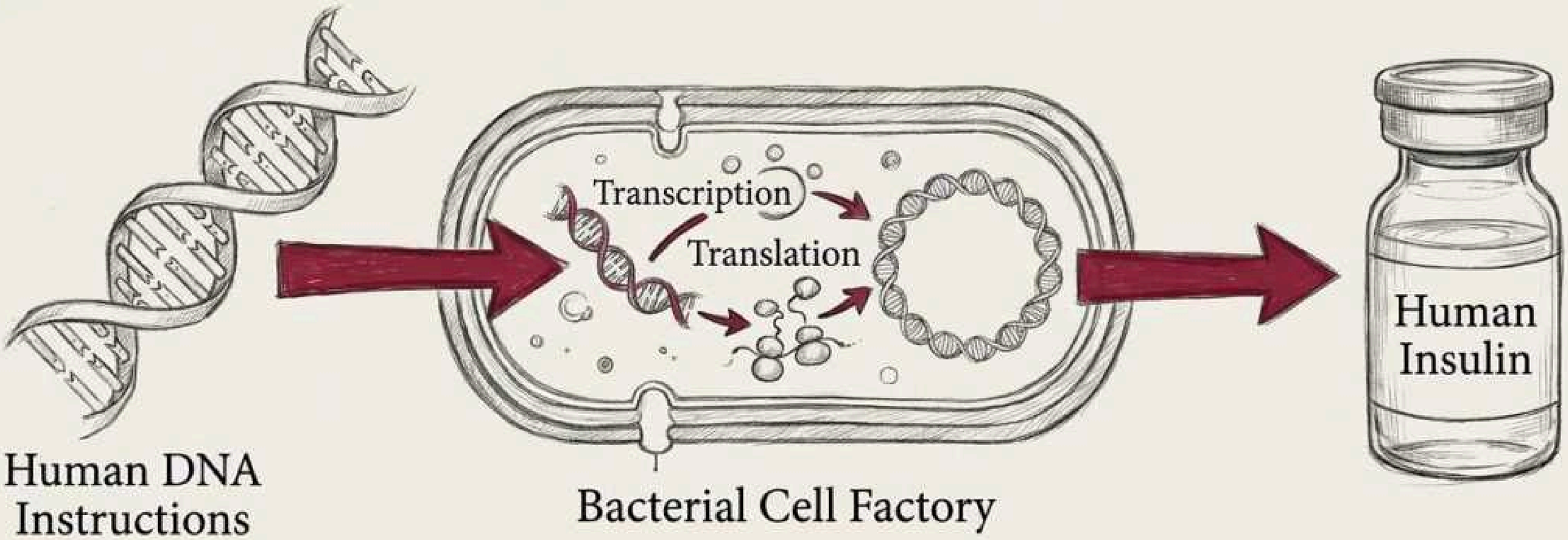
1 Codon is the Master START signal.

A-U-G = Methionine



¶ 3.10

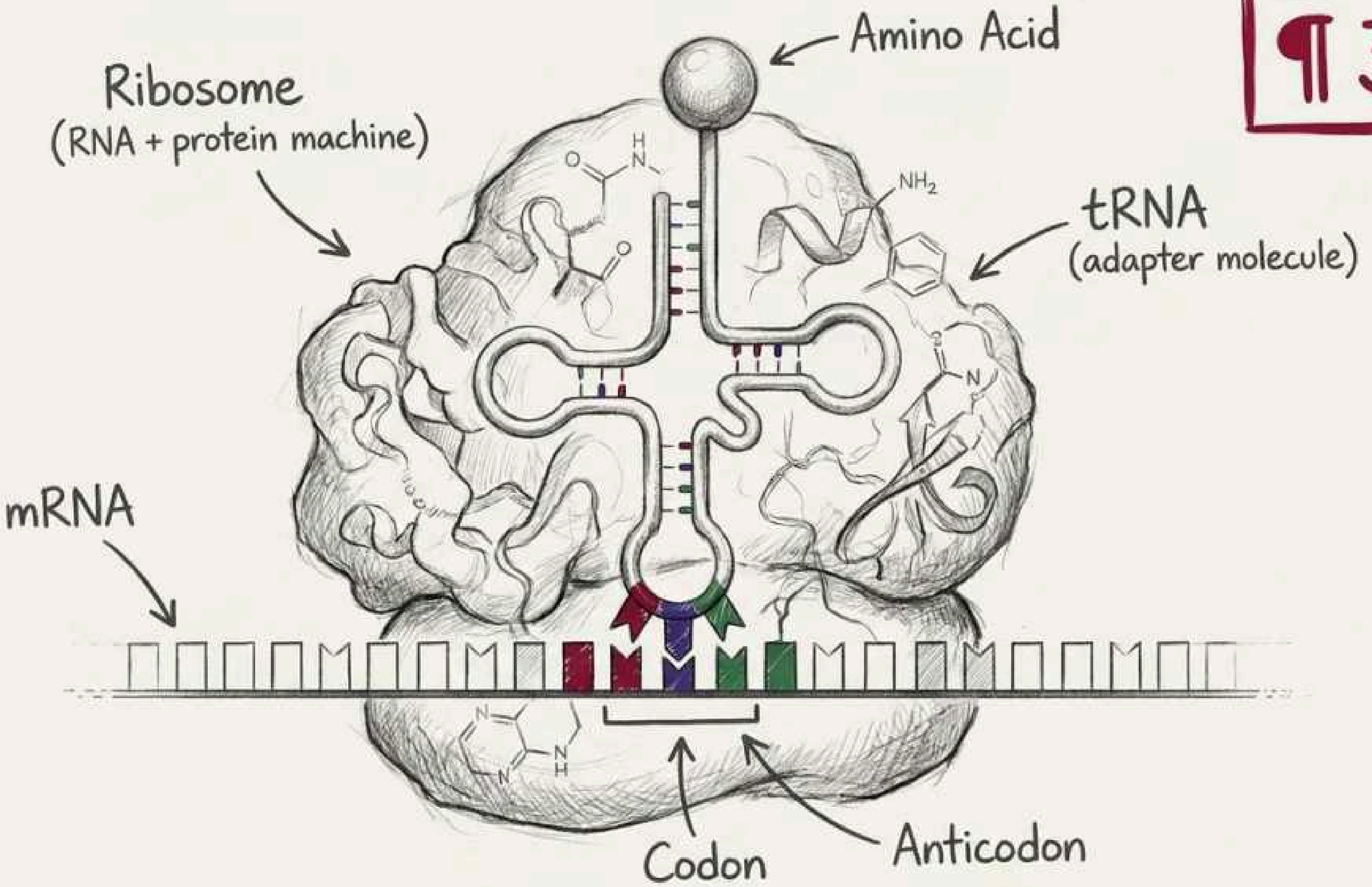
Because the code is near-universal, a bacterial cell can perfectly read human instructions.



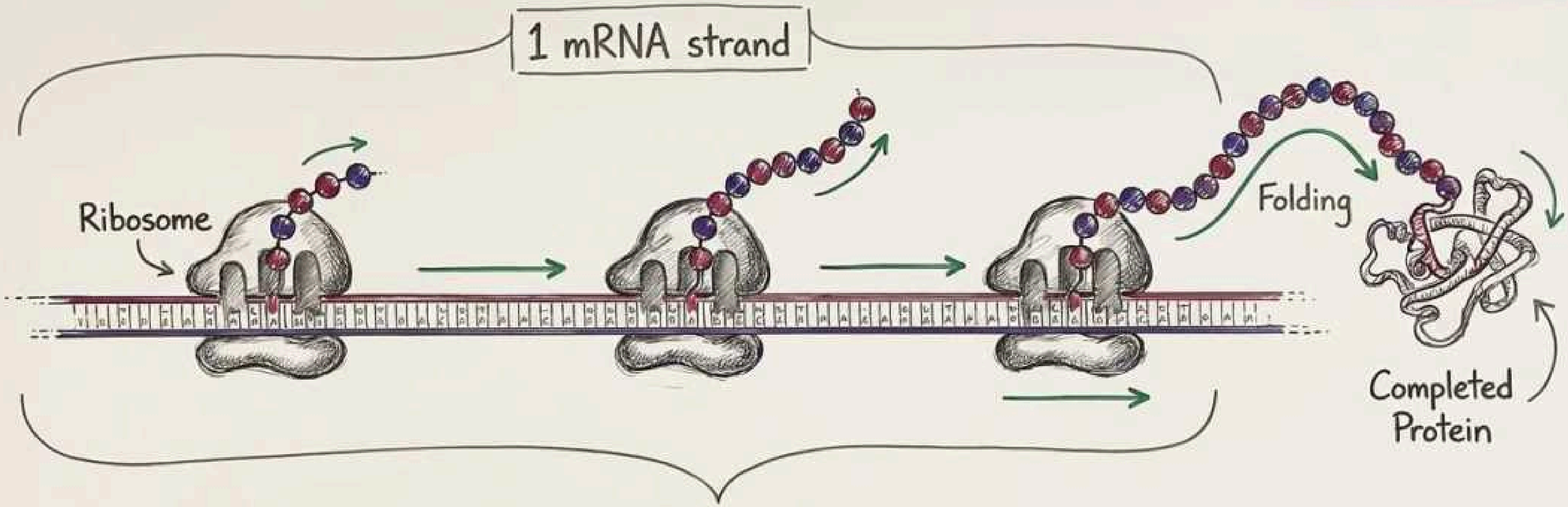
One Code = Deepest fact of biology

(Evidence for Common Ancestry)

¶ 3.11


Amino Acid
Ribosome
(RNA + protein machine)
tRNA
(adapter molecule)
mRNA
Codon
Anticodon

¶ 3.12

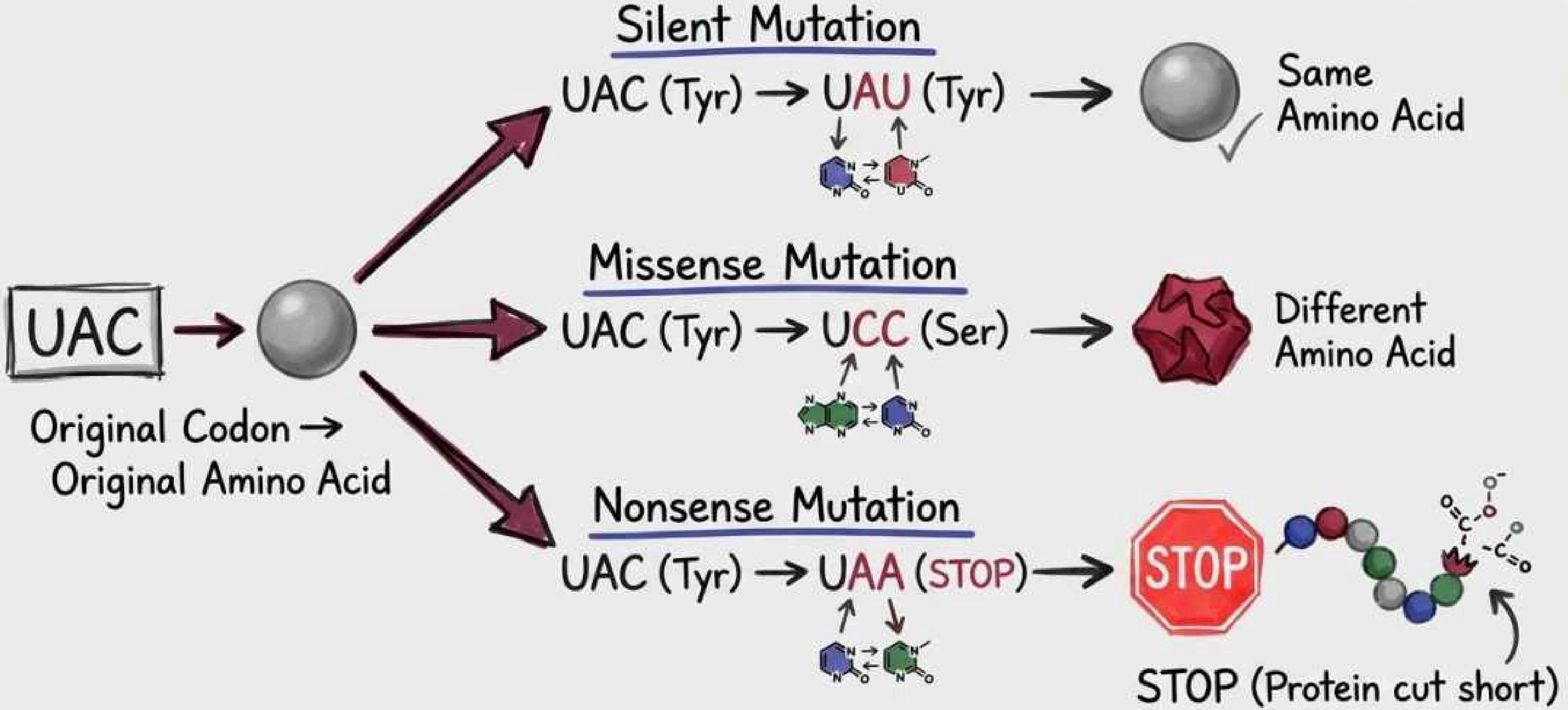


Takeaway:

1 Gene → 1 mRNA × Many Readings = Thousands of Protein Molecules

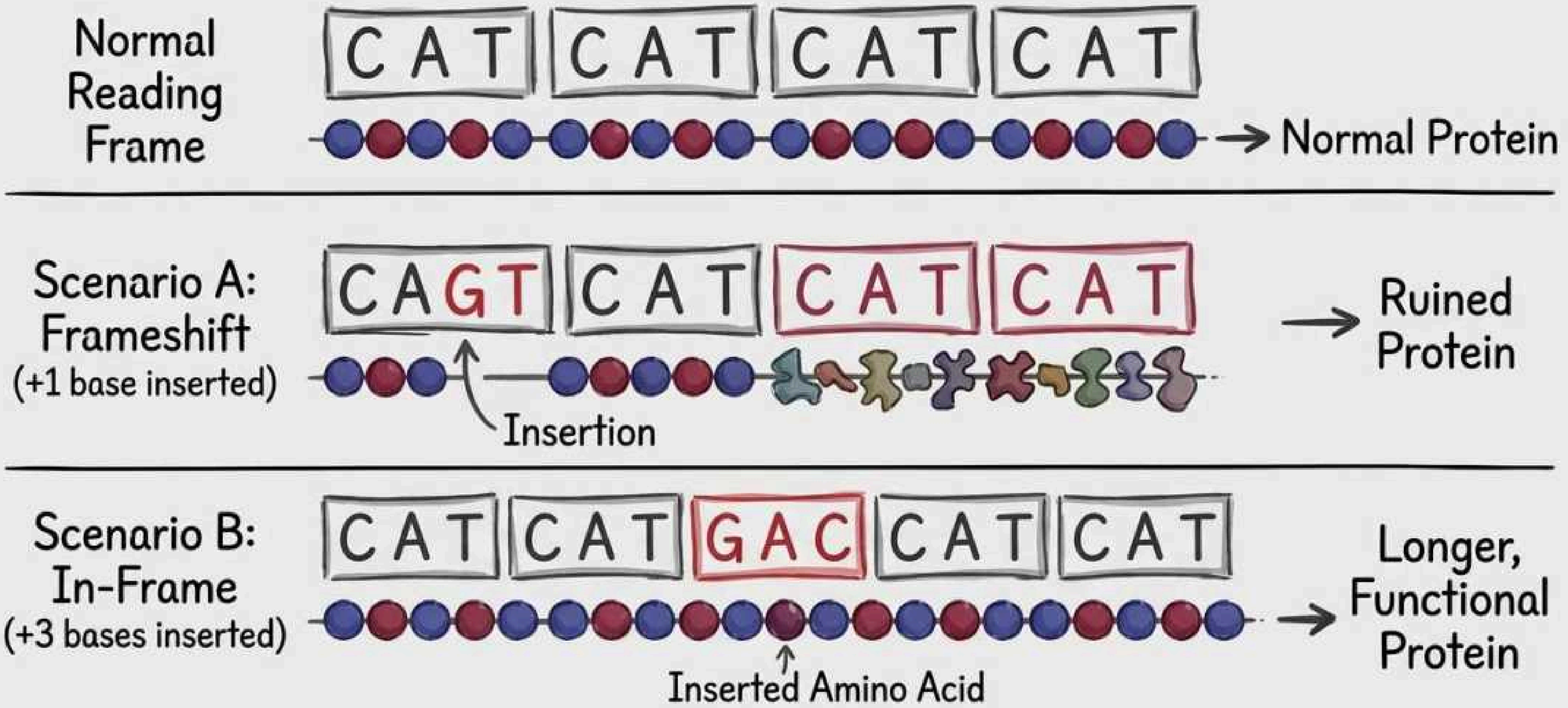
Substitution Mutations

¶ 3.13



Frameshift vs. In-Frame Insertions

¶ 3.14



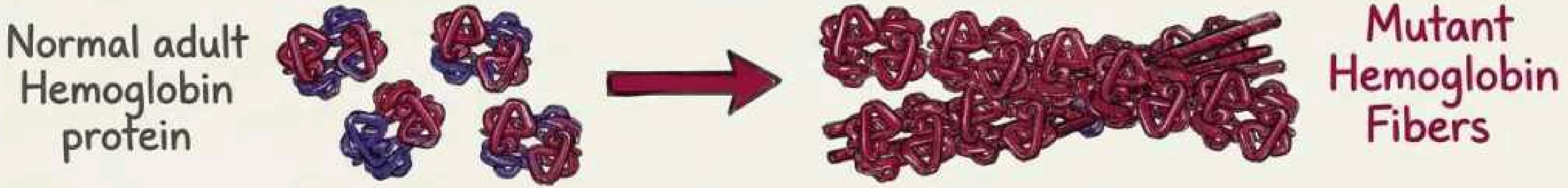
¶ 3.15

Molecular Scale (Codon Mutation)

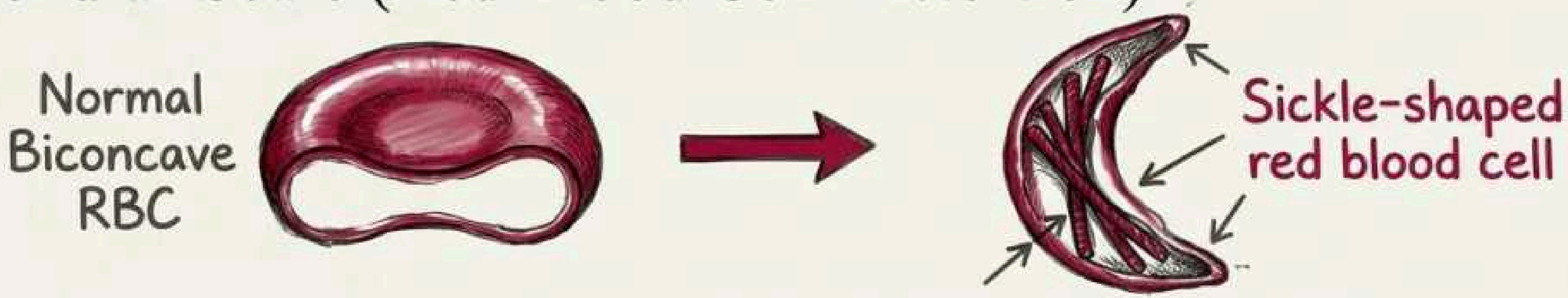
Codon Change → Glutamic Acid replaced by Valine



Protein Scale (Hemoglobin Aggregation)



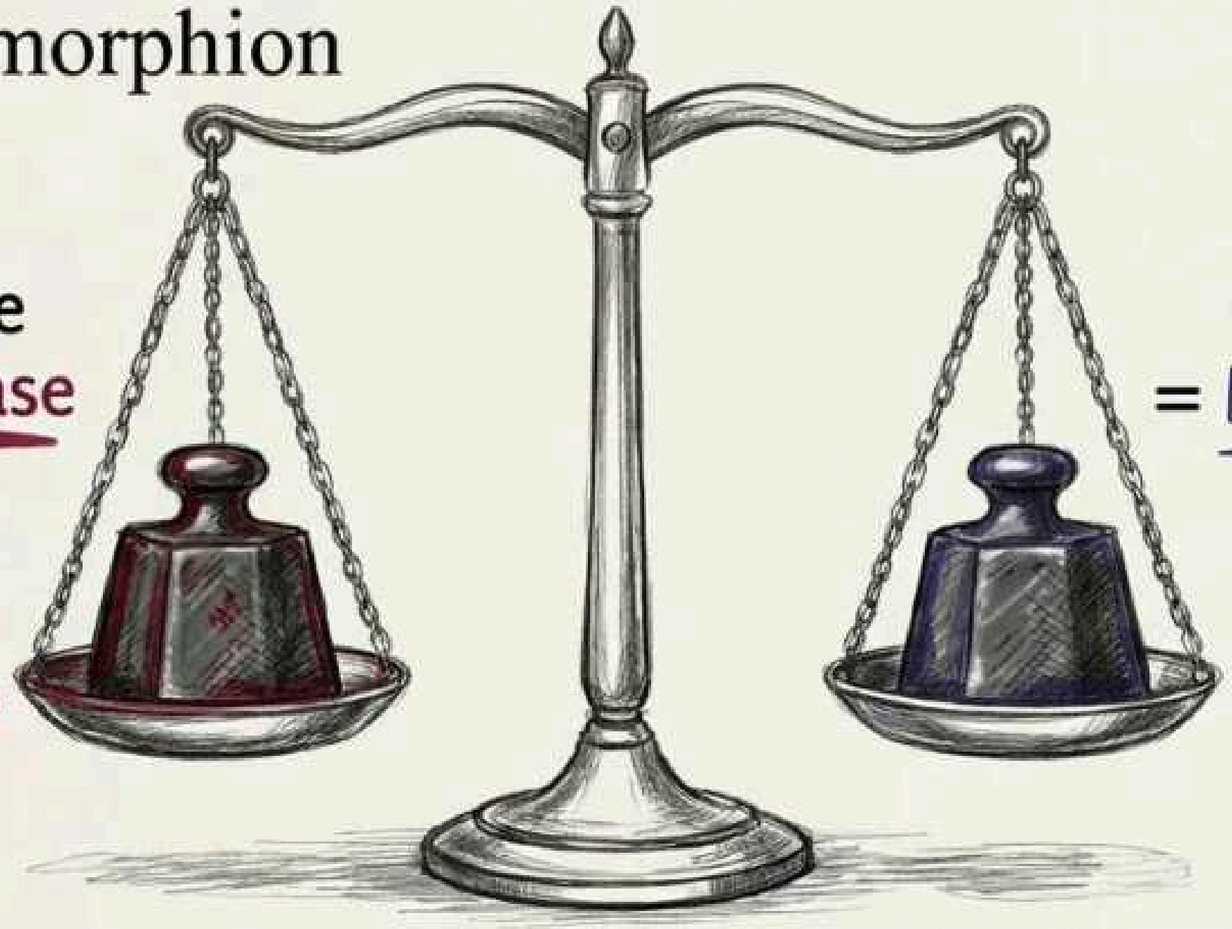
Cellular Scale (Red Blood Cell Distortion)



Balanced Polymorphion

¶ 3.16

Harm:
2 Copies of Allele
= Sickle Cell Disease



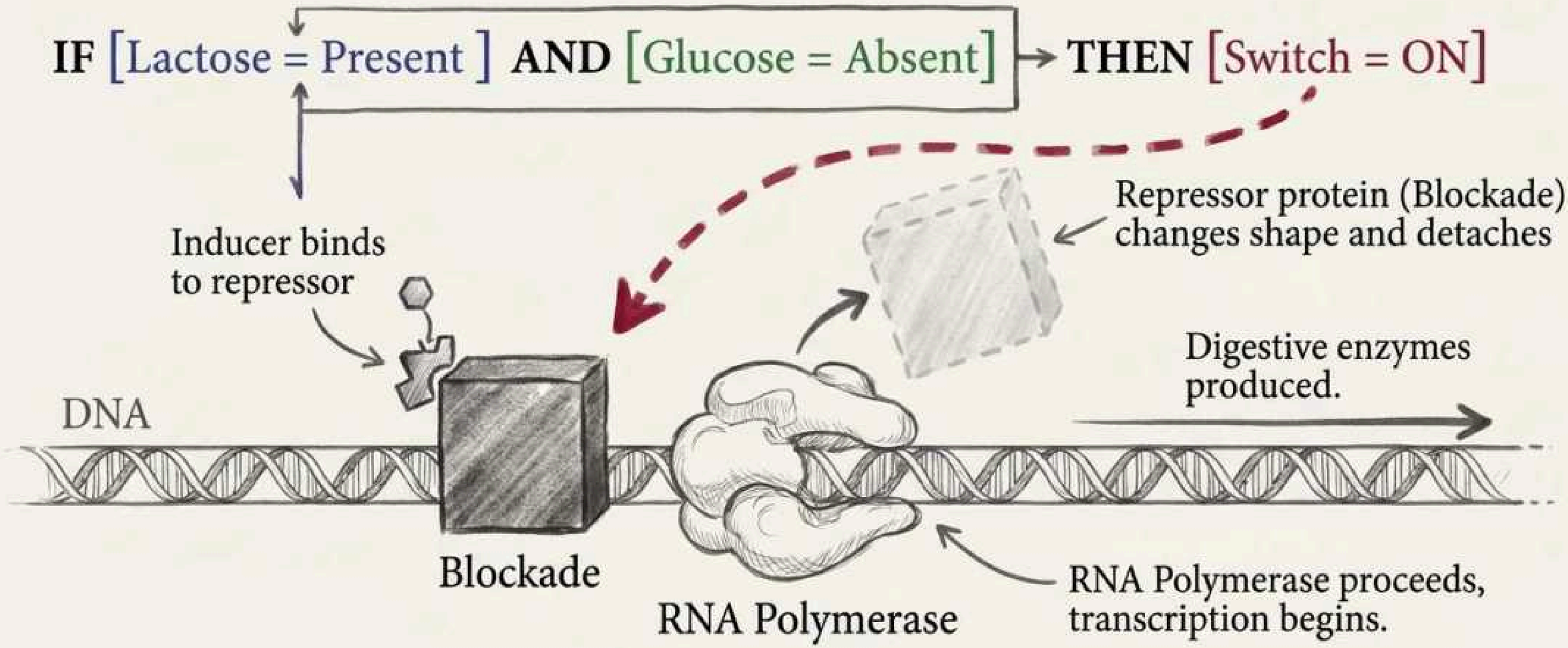
Benefit:
1 Copy of Allele
= Malaria Protection

Where severe malaria is common, healthy carriers (1 copy) survive more often, keeping the harmful allele frequent in the gene pool.

This balance between harm and benefit is a recurring theme in genetics.

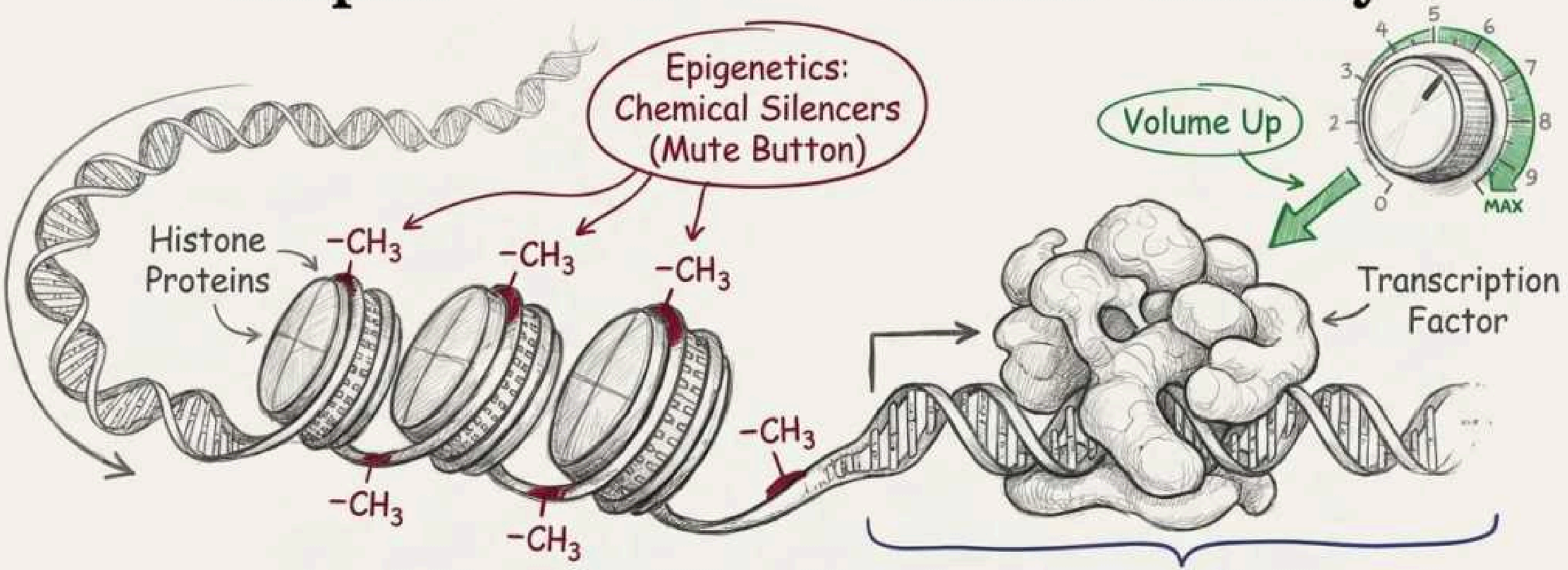
¶ 3.17

Gene Regulation: The Lac Operon Switch



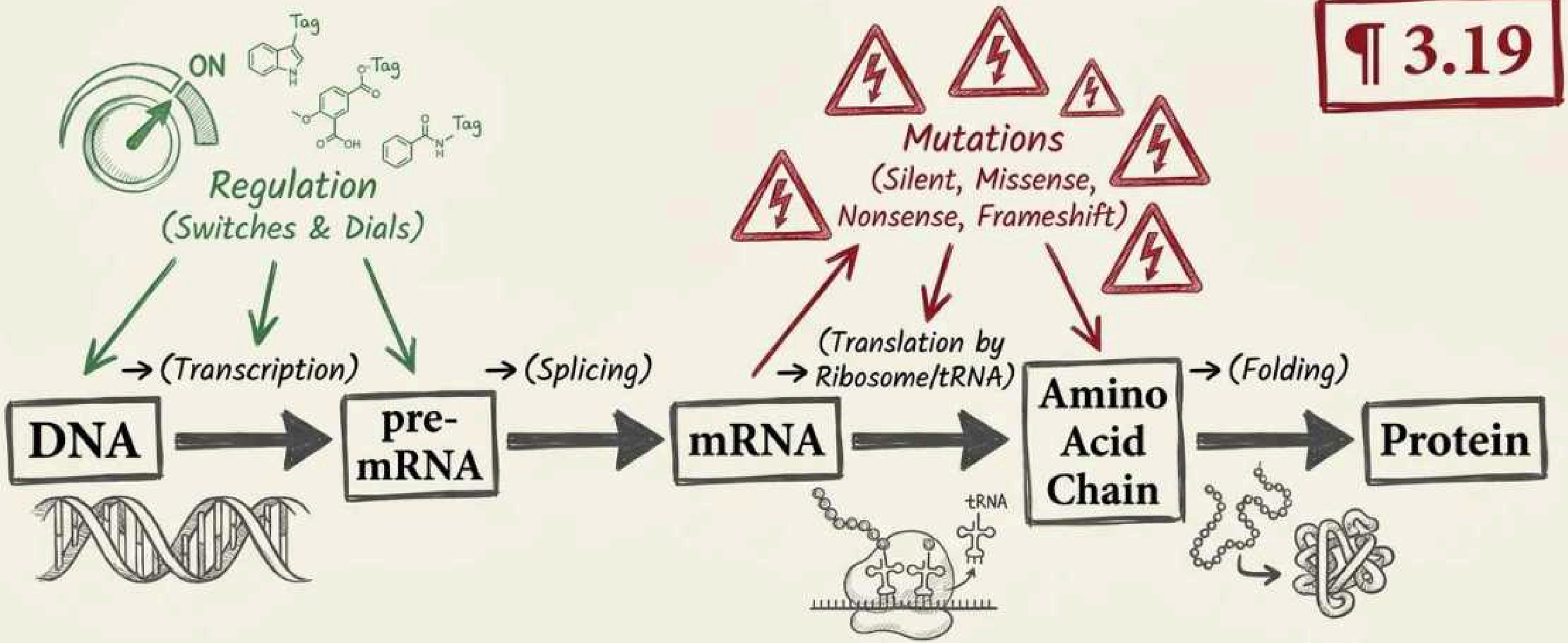
Eukaryotic Gene Regulation: Complex Controls & Cellular Identity

¶ 3.18



1 Genome -> Hundreds of Cell Types

These lasting controls, like chemical tags and protein complexes, allow a single genome to generate diverse cell types, each with a unique active gene program, contributing to organismal complexity.



A near-universal triplet code governs this two-step process.

Knowledge Check

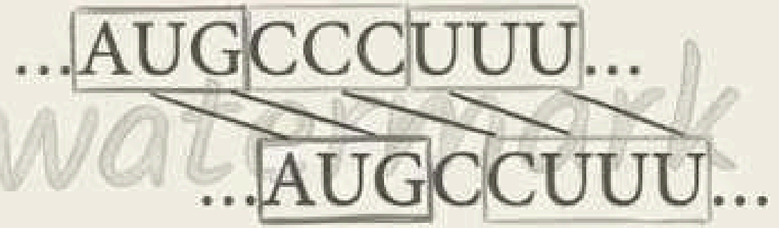
¶ 3.20

Prompt 1:
Translate: A-U-G | U-U-U | STOP



[Methionine] → [Phenylalanine] → [Release]

Prompt 2:
If one base is deleted near the start, why is it worse than a single substitution?



Frameshift garbles the whole rest of the protein.