

# Protein synthesis 4.3

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## *Intelligently designed use of energy*

### From DNA code to organism

1. The DNA code determines what enzymes (proteins) to produce.
2. Enzymes determine what and how nutrients will be metabolized.
3. Metabolic pathways determine what a cell does and what it looks like.
4. Cell activity determines what an organism does and what it looks like.
5. Every **attribute** is determined by the **metabolism** cells, which is determined by the **enzymes**, which are determined by the **DNA** code.
6. Changing the code, changes the enzymes, which changes the metabolism and attribute.
7. DNA > mRNA > Protein (enzymes) > Metabolism > Organism attributes
8. DNA > transmission > translation > enzyme > organism

### Central Dogma of molecular biology

*Information flows from nucleic acid to nucleic acid or to protein. Nucleic acid codes do not derive from protein.*

“This states that once ‘information’ has passed into protein *it cannot get out again*. In more detail, the transfer of information from nucleic acid to nucleic acid, or from nucleic acid to protein may be possible, but transfer from protein to protein, or from protein to nucleic acid is impossible. Information means here the *precise* determination of sequence, either of bases in the nucleic acid or of amino acid residues in the protein.” Francis Crick, Symp. Soc. Exp. Biol. 1958, vol 12, pp 138-163.

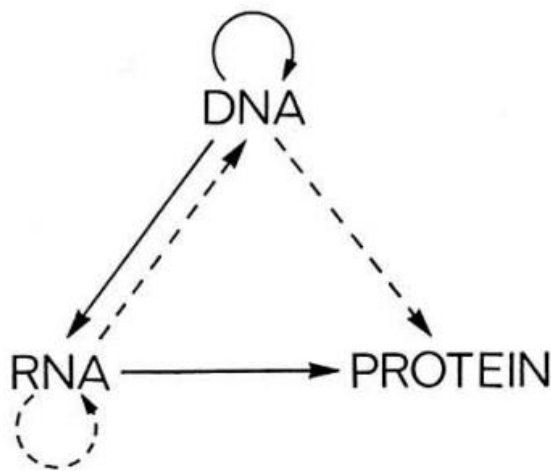


Fig. 3. A tentative classification for the present day. Solid arrows show general transfers; dotted arrows show special transfers. Again, the absent arrows are the undetected transfers specified by the central dogma.

“These are the three transfers which the central dogma postulates never occur:”

1. Protein -> Protein
2. Protein -> DNA
3. Protein -> RNA

—Francis Crick, Nature 1970, vol 227, issue 5258, pp 561-563

## Information flow

1. DNA code is **transcribed** to mRNA, which, in turn, is **translated** into protein.
2. Proteins (enzymes) carry out the DNA instructions in the cell.
3. Proteins are not transcribed or translated into other proteins, RNA, and DNA.

## Protein synthesis in two steps

1. Transcription: DNA code copied to RNA code.
2. Translation: RNA code used to assemble amino acids into protein molecules.

## Transcription

1. Occurs in the nucleus of the cell.
2. Nucleotides are the alphabet of the DNA code.
3. The sequence of the nucleotides determines a meaningful (vocabulary) code of instructions.
4. A sequence of nucleotides in DNA are copied into a matching chain of nucleotides for messenger RNA (mRNA).
  - a. DNA nucleotides [(A) Adenine, (G) Guanine, (C) Cytosine, (T) Thymine]
  - b. RNA nucleotides [(A) Adenine, (G) Guanine, (C) Cytosine, (U) Uracil]
  - c. DNA G transcribes to RNA C, DNA A transcribes to RNA U, DNA C transcribes to RNA G, and DNA T transcribes to RNA A.
5. DNA codes for the sequence of 20 different amino acids to make thousands of different kinds of proteins.

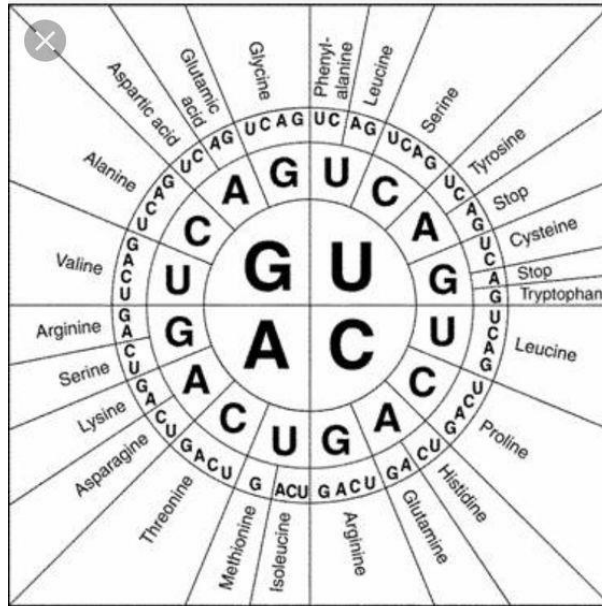
## Translation

1. mRNA migrates from the nucleus to a ribosome on the ER in the cytoplasm.
2. A ribosome contains ribosomal RNA (rRNA).
3. Transfer RNA (tRNA) molecules transfer (carry) amino acids to ribosomes.
4. tRNA meets up with mRNA at rRNA to assemble proteins.
5. Two tRNA molecules are matched to the mRNA code at the P and A sites of the rRNA.
6. The amino acids associated with the tRNA molecules link together and shift to match and add another tRNA-amino acid to the growing protein chain.
7. The sequence of amino acids is determined by the sequence of nucleotides in the mRNA.
8. The chain of amino acids grows until the stop code is detected.
9. Amino acid sequences are controlled by mRNA codons and tRNA anticodons.
  - a. A codon and anticodon consist of three nucleotides.
  - b. Codons and anticodons are matched.
  - c. Anticodons of tRNA correspond with appropriate amino acids.
  - d. Each tRNA carries one type of amino acid.
  - e. Sequence of amino acids are determined by the anticodon of tRNA matching up with the codons of mRNA

## Codons and anticodons

1. The mRNA code is read as a triplet of nucleotide bases: AUC, CUG, GGG, UCA
2. Anticodons are triplets of nucleotides on tRNA.
3. The sequence of nucleotides determines the sequence of codons.
4. The sequence of codons determines the sequence of anticodons.
5. The sequence of anticodons determines to sequence of amino acids.
6. The sequence of amino acids determines the type of protein.

## Decoding exercises



1. Refer to the **codon** key.
  - a. UUU corresponds to phenylalanine.
  - b. Valine corresponds to GUU, GUC, GUA and GUG
2. What are the codons for:
  - a. alanine-serine-proline- glycine
  - b. valine-arginine-isoleucine-glutamine
3. What amino acids are coded for:
  - a. AGAGACUGCGAACAA
  - b. GUAUGGAGCUUC
4. What is the anticodon for AGU, UCG, GUA, AUC? (UCA, AGC, CAU, UAG)
5. Complete the following table

DNA triplet	mRNA codon	tRNA anticodon	Amino Acid
ATG			
	CAG		
		UGA	
			Stop

## Introns and exons

1. Noncoding DNA is transcribed into rRNA, tRNA, and regulatory RNA.
2. Introns are non-protein-coding segments of DNA and mRNA. mRNA introns are removed from the mRNA.
3. Exons are segments of DNA and mRNA. mRNA exons are joined together after the removal of introns. These mature mRNA strands are translated into protein or are involved in regulating other genes.

## Chapter 4 summary

### Energy required for life

1. Solar energy sustains cellular growth and activity.
2. Energy must flow through life to sustain life.
3. Photons flow from the sun, electrons flow through life, heat flows into space.
4. Photosynthesis converts radiant energy into chemical energy.
5. Ingestion is obtaining nutrients for energy and growth materials.
6. Digestion is breakdown complex foods into smaller molecules.
7. Assimilation is absorption and modification of nutrients for metabolism.
8. Radiation is heat loss of thermo energy during metabolism.
9. Egestion is elimination of waste materials from cells.
10. Reclamation is the recycling of materials for biological nutrients.
11. Homeostasis requires energy to maintain cellular conditions necessary for life.

### Assimilation

1. Food is ingested and digested to provide cells with nutrients.
2. You are what you eat.
3. Nutrients include Proteins, Carbohydrates, Lipids (Fats, oils), Nucleic Acids (DNA, RNA), water, oxygen, and minerals (iron, magnesium).
4. Nutrients are catabolized and anabolized to provide cells with building materials and a supply of energy.
5. Materials are needed to replace or add membranes, DNA, RNA, mitochondria, oil, hormones, etc.
6. Every chemical reaction involved in catabolism and anabolism is controlled by proteins called enzymes.
7. Information for the cellular production of enzymes is encoded in the DNA molecule.

### Compartmentalized metabolism

1. Nucleus: control center. holds the DNA.
2. Chloroplasts: Energy conversion center. Converts light energy into glucose energy.
3. Mitochondria: power center. converts nutrients into ATP.
4. Lysosomes: cellular digestion center: Nutrients are catabolized.
5. Ribosomes: protein assembly center.
6. Golgi apparatus: synthesis center for anabolizing complex materials.
7. Endoplasmic Reticulum: conduit network for transporting materials in the cell.
8. Centrosomes: structural framework for cell shape.

### Key components for energy flow

1. Photosynthesis
2. Light phase
3. Dark phase

4. Chlorophyll a
5. Hydrogen pump
6. Electron transport chain in thylakoid membrane
7. Final electron acceptor
8. Carbon fixation
9. Cellular respiration
10. Glycolysis in cytoplasm
11. Kreb's cycle (citric acid cycle, TCA) in mitochondria matrix
12. Electron transport chain in cristae
13. Aerobic and anaerobic respiration
14. Fermentation
15. ATP
16. Enzymes
17. Central dogma