The Codon Decoder

By: Vera E. Mihalciik and Cameron Jahn
Marta Valle Secondary School
Midwood High School

SMART Science and Mechatronics Aided Research for Teachers
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Project Goals

- To help students learn abstract biological concepts by making them tangible and fun.
- To engage students in hands-on learning activities and make the topic interesting.
- To promote the use of technology in the classroom.
Theory

Protein Synthesis

DNA → RNA → Ribosome → Protein

Transcription → Translation
Theory
<table>
<thead>
<tr>
<th><strong>Name</strong></th>
<th><strong>Abbreviation</strong></th>
<th><strong>Codons</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Methionine</td>
<td>MET</td>
<td>AUG</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>PHE</td>
<td>UUU, UUC</td>
</tr>
<tr>
<td>Leucine</td>
<td>LEU</td>
<td>UUA, UUG, CUA, CUC, CUG, CUU</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>ILE</td>
<td>AUU, AUC, AUA</td>
</tr>
<tr>
<td>Valine</td>
<td>VAL</td>
<td>GUU, GUC, GUA, GUG</td>
</tr>
<tr>
<td>Serine</td>
<td>SER</td>
<td>AGU, AGC, UCU, UCC, UCA, UCG</td>
</tr>
<tr>
<td>Proline</td>
<td>PRO</td>
<td>CCA, CCC, CCA, CCG</td>
</tr>
<tr>
<td>Threonine</td>
<td>THR</td>
<td>ACU, ACC, ACA, ACG</td>
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<tr>
<td>Alanine</td>
<td>ALA</td>
<td>GCA, GCC, GCA, GCG</td>
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<tr>
<td>Tyrosine</td>
<td>TYR</td>
<td>UAU, UAC</td>
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<tr>
<td>Histidine</td>
<td>HIS</td>
<td>CAU, CAC</td>
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<tr>
<td>Glutamine</td>
<td>GLN</td>
<td>CAA, CAG</td>
</tr>
<tr>
<td>Asparagine</td>
<td>ASN</td>
<td>AAU, AAC</td>
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<tr>
<td>Lysine</td>
<td>LYS</td>
<td>AAA, AAG</td>
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<tr>
<td>Aspartic Acid</td>
<td>ASP</td>
<td>GAU, GAC</td>
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<tr>
<td>Glutamic Acid</td>
<td>GLU</td>
<td>GAA, GAG</td>
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<td>Cysteine</td>
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<td>UGU, UGC</td>
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<tr>
<td>Tryptophan</td>
<td>TRP</td>
<td>UGG</td>
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<tr>
<td>Arginine</td>
<td>ARG</td>
<td>AGA, AGG, CGU, CGC, CGA, CGG</td>
</tr>
<tr>
<td>Glycine</td>
<td>GLY</td>
<td>GGU, GGG, GGC, GGA</td>
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</tbody>
</table>
The Codon Decoder
Purpose

- Models the process of protein synthesis within the ribosome.
- Allows students to control which amino acids are created by manipulating RNA coding.
- Demonstrates interactions between cellular molecules.
Parts and Components

Control Board - Controls electronic components by utilizing a BS2 microcontroller.
Parts and Components

LCD Display - Gives instructions, shows various proteins created.
Parts and Components

Potentiometer Knobs - Control input values for nitrogenous bases.
Parts and Components

Button - Moves user through the different steps of the program.
Parts and Components

Key - Gives abbreviations and defines which codons will create the various amino acids.
Parts and Components

Display Windows - Show a growing chain of amino acids that is the beginning of a protein.
Parts and Components

Mechanics - Display wheels are controlled by a system of servo motors, pulleys and timing belts.
Circuitry

Potentiometer Circuit

P8-10

220Ω

0.01 μF

+5V

100KΩ

Vss
Circuitry
LED Circuit

P11-15

470Ω

Vss
Circuitry

Button Circuit

+5V
10KΩ
P7

Vss
Circuitry

Speaker Circuit

\[ \text{P1} \quad + \quad \text{Piezo} \quad - \quad \text{Vss} \]
Circuitry

Serial LCD Circuit

The Codon Decoder
Circuitry

Servo Motor Circuit

+5V

P2-6

White

Red

Black

Vss

Servo
Next Steps

- Expansion of program to include more proteins and other capabilities.
- Development of the Codon Decoder as a classroom assessment tool.
Acknowledgements

- National Science Foundation
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