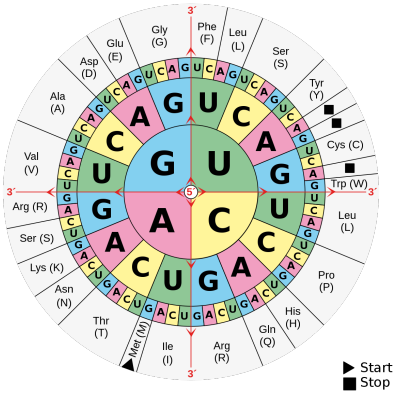
# Thesis (B.Sc. / M.Sc.)
# Development of an AI-method for Predicting Protein Synthesis Capability in Microorganisms

**Background:** Microorganism-based protein production is a vital part of industrial biotechnology, spanning from bioethanol-producing enzymes to therapeutic antibodies. A central challenge is the efficient synthesis of heterologous (i.e., not native to the producing organism) proteins. One method to enhance production is codon optimization, where the DNA sequence is strategically modified to match the host organism's preferred sequence patterns, without changing the resulting protein. Decoding intricate patterns to achieve a desired output is analogous to natural language processing (NLP) methods. This topic presents an intersection where information processing techniques meet and address biological complexities.




Codon table. It emerges that 18 of 20 amino acids are encoded by multiple synonymous codons, making the genetic redundant.

**Objective:** The aim of this project is to leverage deep learning, specifically using a Large Language Model, to identify patterns in homologous protein gene sequences that indicate high expressibility. Using these identified patterns, we aim to predict the producibility of heterologous proteins from their DNA sequences and validate these predictions experimentally.

**Research Opportunities:** We've recently developed a Large Language Model that operates on amino acid sequences for predicting protein synthesis capability. This model is currently under rigorous evaluation and experimental testing. There are two possibilities for a thesis, one with a computational focus and one with a biological focus:

- **Model Enhancement and Evaluation (Computational Focus):** Directed towards students from fields like electrical engineering, information theory, medical engineering, physics, mathematics, biologists with affinity for programming and modelling or similar. The focus is on further refining, evaluating, and potentially implementing new ideas into our Large Language Model. Familiarity with (Python) programming would be beneficial.

- **Experimental Validation in the Lab (Biological Focus):** Suited for students in biology, chemestry, medical engineering, and related fields with biolab experience. Engage in hands-on laboratory work, focusing on experimental validation. This entails introducing predicted gene sequences into organisms and comparing their expression levels. Prior experience or knowledge in a biology laboratory setting is mandatory.

The Self-Organizing-Systems Lab provides an interdisciplinary team environment. We are actively working towards a publication, offering students a chance to be part of this academic journey. Our approach is to involve students deeply in our research, encouraging them to introduce and realize their own innovative ideas. Joining our team means gaining insights into cutting-edge topics such as deep learning, Natural Language Processing (NLP), and synthetic biology.

For further information, please contact Philipp Froehlich.

TECHNISCHE UNIVERSITÄT DARMSTADT

Department 18
Electrical Engineering and Information Technology
Self-Organizing Systems Lab

Prof. Dr. Heinz Koeppl
Head of lab

Philipp Froehlich
Project supervisor

S3|06 206
Merckstrasse 25
64283 Darmstadt

philipp.froehlich@tu-darmstadt.de
https://www.bcs.tu-darmstadt.de

August 21, 2023