1) A promising paradigm for methane mitigation

- Metabolic engineering: a field that aims to engineer microorganisms into biological factories that convert renewable feedstocks into valuable biomolecules.
  ➔ Provides a more sustainable alternative to sourcing many materials, especially petroleum-based products.
- Much progress with model organisms (baker’s yeast and *E. coli*) to produce malaria medicine, jet fuel, fragrances.

2) Regulatory DNA is a complex language to decipher

- Methanotrophs - bacteria that can survive on methane as their sole carbon source - are promising microbial hosts for industrial biomolecule production.
  ★ Opportunity to divert methane waste streams into valuable everyday materials.

3) Machine learning to automatically detect patterns in DNA

- Most DNA sequence signals are still unknown in methanotrophs.
- Deep learning approaches can learn relevant features directly from the data without explicit encoding.
  ➔ Use deep learning models to find patterns within methanotroph promoter sequences.
- Biological insights: what DNA patterns has the model learned?
- Novel DNA: freeze model and use for forward DNA design.

4) Addressing key challenges: overfitting, dataset size, imbalance

- Current models are overfitting to the training data, despite initial strategies to address class imbalance and limited data.
  ➔ Improvements needed to better generalize to unseen data.
- Future work: self-supervised pre-training on general sequence tasks; fine tune model to methanotroph RNA-seq data.