Rao Lab: Molecular Engineering, Quantitative Biology, and Human Placental Development

Research interests:

1. **Molecular engineering:** We engineer proteins and peptides with interesting properties for several different applications such as biosensing and bioseparations.
2. **Measurements for quantitative biology:** We develop platforms for high throughput structure-function characterization or engineering of proteins of interest in cell biology or biotechnology applications.
3. **Early human placental development:** We develop in vitro models to study early human placental development and its sensitivity to environmental exposures.

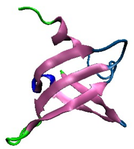
A complete list of our publications can be found at:

http://tinyurl.com/836ss35c

Molecular Engineering

Engineering proteins and peptides with novel function

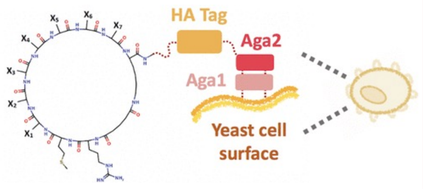
We have used proteins from organisms that grow under extreme high temperatures as **"templates" for making specific binders**.



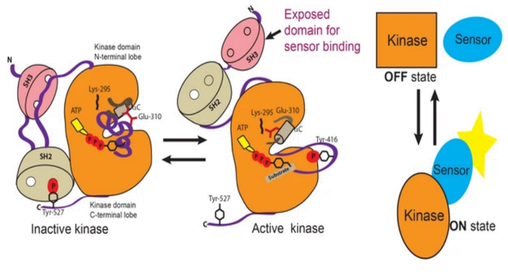
Sso7d from Sulfolobus solfataricus

Specific residues on these template proteins are mutated to generate a library of mutants. Subsequently, this library is screened using combinatorial library screening platforms like yeast surface display or mRNA display. These platforms "barcode" individual mutants by linking the genotype (i.e., nucleotide sequence coding the protein) to the protein or peptide sequence).

We have generated **cyclic peptides with specific binding function** using genetically encoded combinatorial libraries



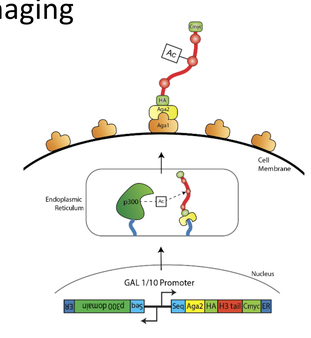
Cyclic peptides with binding function



Engineered proteins for live cell imaging

Protein biosensors for live cell imaging

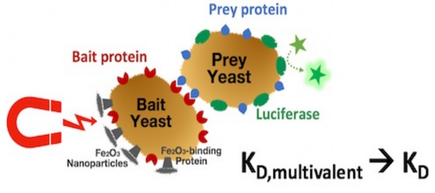
We have used engineered proteins to make biosensors for live cell imaging



Rapid interrogation of epigenetic modifications on yeast

Measurements for quantitative biology

We have developed platform technologies for **high throughput characterization of protein-protein binding interactions or enzyme-substrate interactions** that are relevant to cell biology or applications in biotechnology.

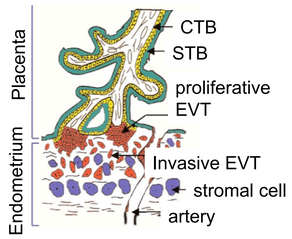


Quantitative yeast-yeast two hybrid

Early human placental development

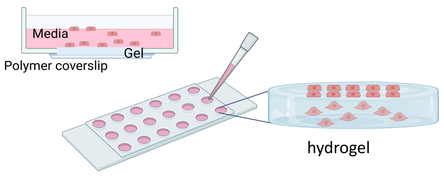
Key cell types in the placenta

Upon embryo implantation, the outer trophectoderm layer of the blastocyst-stage embryo gives rise to the epithelial cytotrophoblast (CTB), which forms the two major differentiated cell lineages in the placenta – the multinucleate syncytiotrophoblast (STB) and the extravillous trophoblast (EVT).

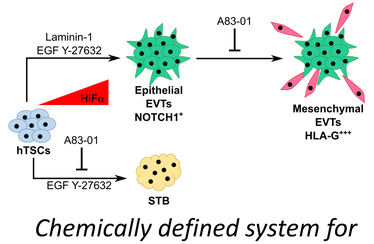


Need for in vitro models of the human placenta

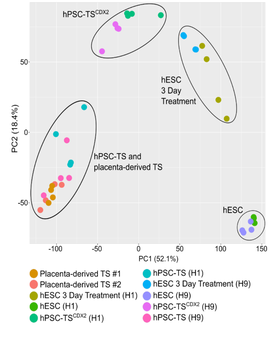
Abnormalities in very early placental development can lead to pregnancy complications such as preeclampsia and pre-term birth. Yet, early human placental development is poorly understood due to restrictions on research with fetal tissue, and significant differences in placental development between humans and experimental animals. Thus, in vitro models are a critical need for mechanistic studies. **We use 2D and 3D cell culture models in conjunction with quantitative image analysis and cell biology tools to study molecular mechanisms regulating human trophoblast development**



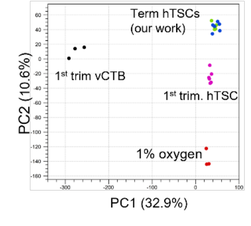
3D culture model for trophoblast differentiation



Chemically defined system for trophoblast differentiation



Derivation of human trophoblast stem cells from human pluripotent stem cells



Derivation of human trophoblast stem cells from placentas at birth