Citizen Scientists' contributions to the RNA design problem

Fernando Portela
Citizen Scientist

Geneva, June 5, 2018

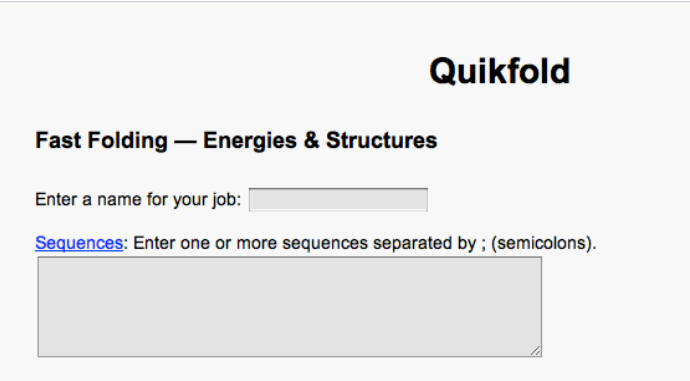
Stanford MEDICINE

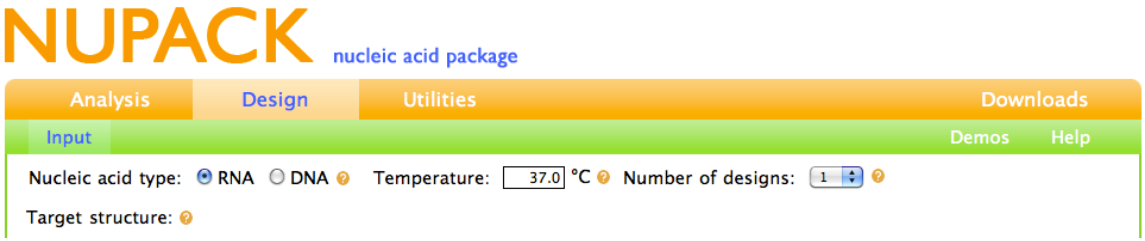
eterna

From RNA function to sequence

GGUUGGGUUGGGAAGUAUCA
UGGCUAAUCACCAUGAUGCA
AUCGGGUUGAACACUUAAUU
GGGUUAAAACGGUGGGGGAC
GAUCCCGUAACAUCCGUCCU
AACGGCGACAGACUGCACGG
CCCUGCCUCUUAGGUGUGUU
CAAUGAACAGUCGUUCCGAA
AGGAAGCAUCCGGUAUCCCA
AGACAAUC

RNA secondary structure: solved?

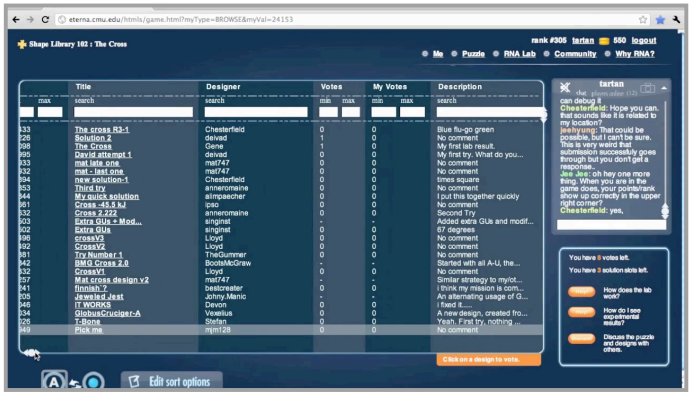




http://rna.tbi.univie.ac.at/
http://mfold.rna.albany.edu/?q=DINAMelt/Quickfold
http://www.bioinf.uni-freiburg.de/Software/INFO-RNA/start.html
http://www.nupack.org/

Played by Humans. Scored by Nature

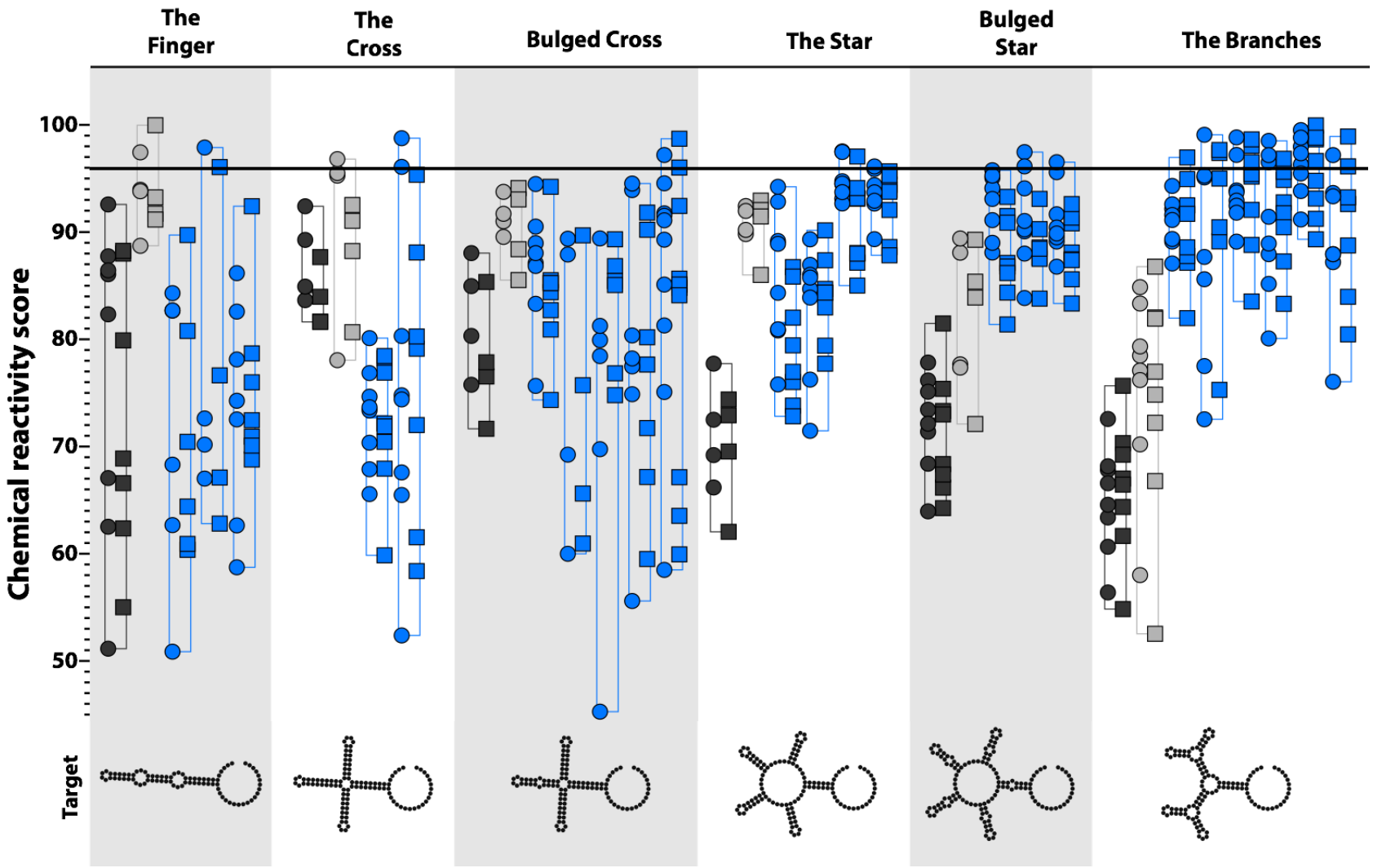
Game Interface



Voting

Synthesis

Results



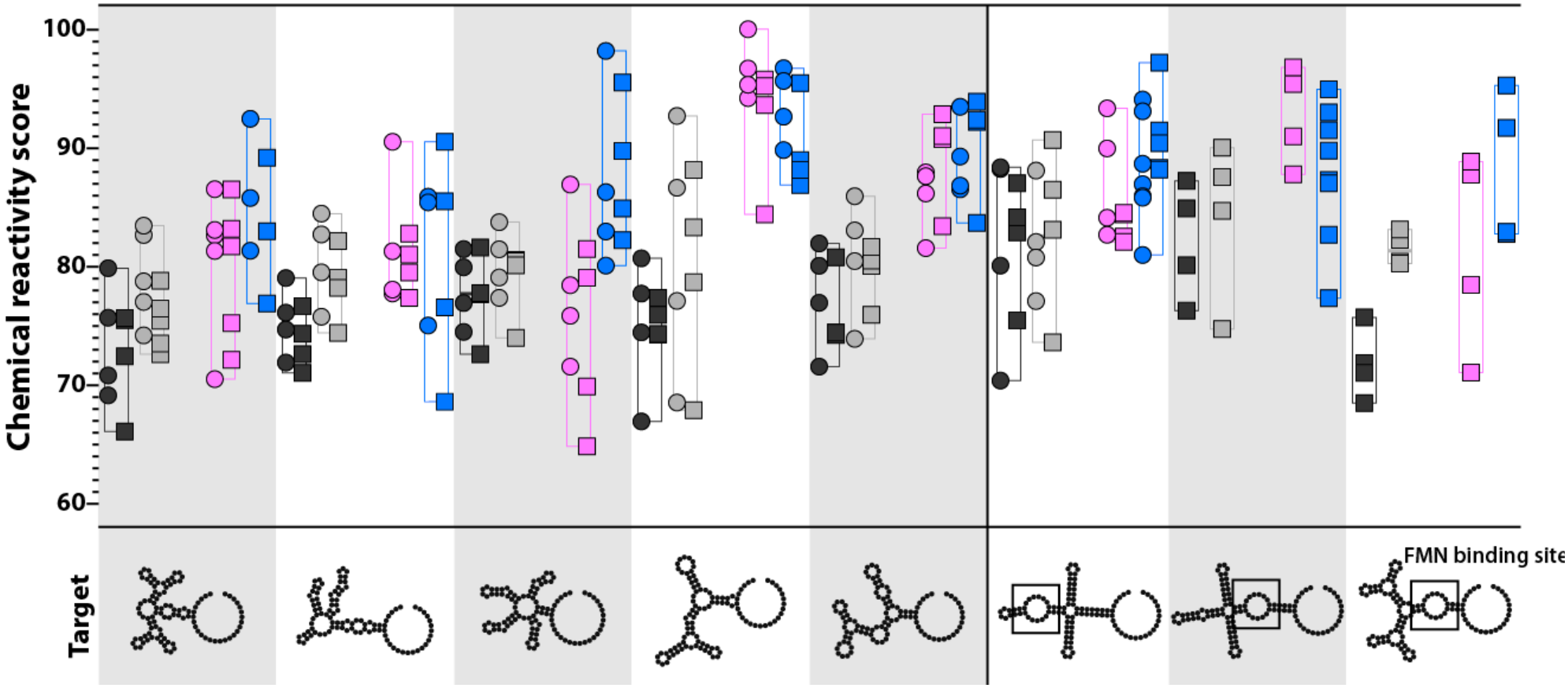
EteRNA: humans

NUPACK

RNAInverse

LASSO regression

EteRNAbot



NUPACK

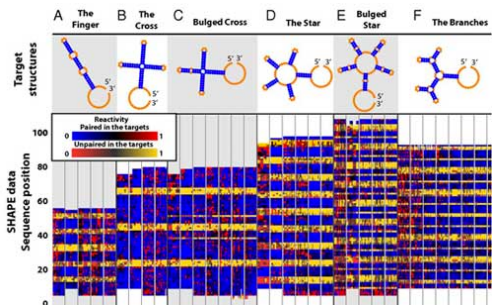
RNAInverse

EteRNAbot

EteRNA: humans

Lee et al. PNAS (2014)

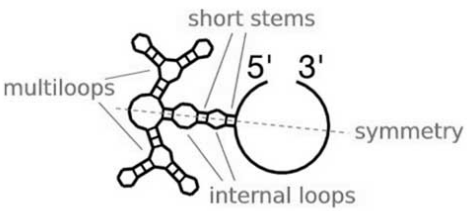
Player contributions to the RNA scientific literature



RNA design rules from a massive open laboratory

Proceedings of the National Academy of Sciences - February 2014

Lee, J., Kladwang, W., Lee, M., Cantu, D., Azizyan, M., Kim, H., Limpaecher, A., Yoon, S., Treuille, A., Das, R., and **Eterna participants**

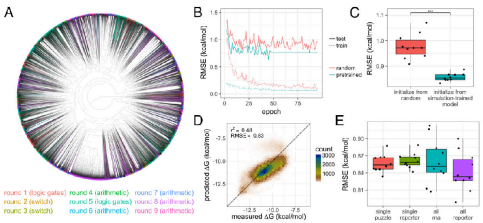


Principles for predicting RNA secondary structure design difficulty

Journal of Molecular Biology - February 2016

Jeff Anderson-Lee, **Eli Fisker**, **Vineet Kosaraju**, Michelle Wu, Rhiju Das, Minjae Lee, Justin Kong, **mat747**, Treuille, and **Eterna players**

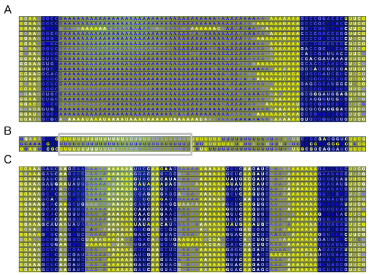
Player contributions to the RNA scientific literature



Prospects for recurrent neural network models to learn RNA biophysics from high-throughput data

bioRxiv - December 2017

Michelle J Wu, Johan OL Andreasson, Wipapat Kladwang, William J Greenleaf, **Eterna players**, Rhiju Das

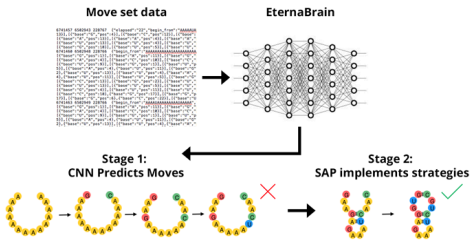


Evidence of an Unusual Poly(A) RNA Signature Detected by High-throughput Chemical Mapping

bioRxiv - April 2018

Roger Wellington-Oguri, **Eli Fisker**, **Michelle Wiley**, **Mat Zada**, **Eterna Players**

Player contributions to the RNA scientific literature



EternaBrain: Automated RNA design through move sets from an Internet-scale RNA videogame

bioRxiv - May 2018

Rohan Koodli, Benjamin Keep, Katherine R Coppess, **Fernando Portela**, **Eterna Players**, Rhiju Das

Genome-wide dissection of extracellular vesicle biology with barcoded miRNAs

submitted

Albert Lu, Paulina Wawro, David Morgens, **Fernando Portela**, Michael C. Bassik and Suzanne R. Pfeffer

An unexpectedly effective Monte Carlo technique for the RNA inverse folding problem

submitted

Fernando Portela

Development Team

Site Development

jnicol (player), ElNando888 (player), Omei (player), Siqi Tian, Ben Keep, Caleb Geniesse

Experiments & Analysis

Johan Andreasson, Ann Kladwang (Greenleaf & Das labs, Stanford)

Visual Design

Sharif Ezzat

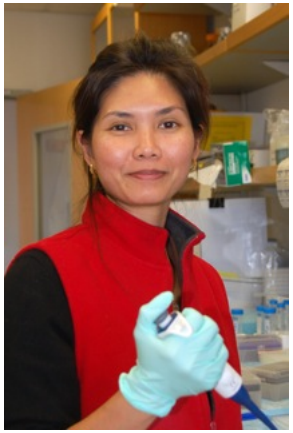
Principal Investigator

Rhiju Das

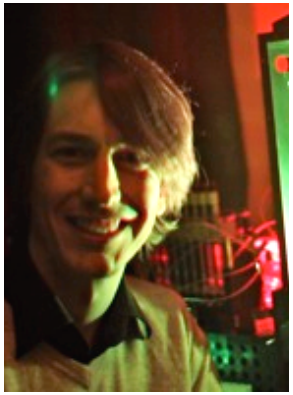
Prior Contributors

Game Creator: J. Lee. *Site Development:* V. Kosaraju, P. Kinney, S. Gaikwad, M. Lee, T. Mandel, A. Limpaecher, N. Fishel, S. Wang, E. Kelly, M. Baumgartner, S. Federwisch, S. Mohan, B. Seo, W. Kong. *Experiments & Analysis:* D. Cantu, P. Cordero, T. Mann, S. Yoon, H. Kim. *Graphics:* M. Yao, T. Hu, J. Ciscon, D. Klionsky, E. Butler, R. Zhu. *Sound:* B. Bethurum. *Principal Investigator:* A. Treuille.

Rhiju Das

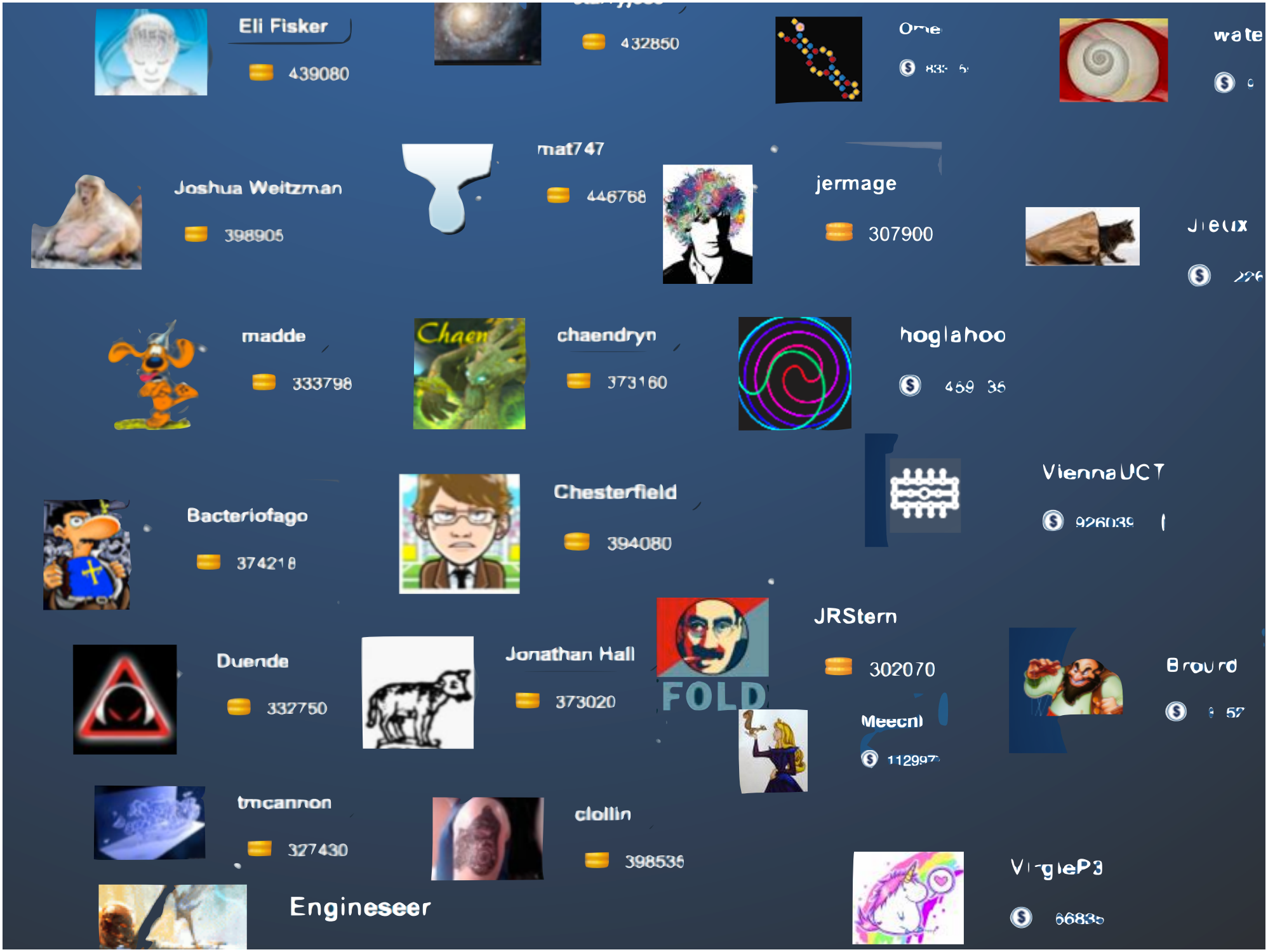


Ann Kladwang



Johan Andreasson

- Will Greenleaf (Stanford Genetics), Sungroh Yoon (Seoul National U.), Purvesh Khatri (Stanford ITI)
- Funding: Stanford Bio-X & Stanford Media-X, NSF, Keck Foundation, NIH


Eli Fisker
439080
432850
wate
Joshua Weitzman
398905
mat747
446768
jermage
307900
madde
333798
chaendryn
373160
hoglahoo
Bacteriofago
374218
Chesterfield
394080
ViennaUCT
JRStern
302070
FOLD
Duende
332750
Jonathan Hall
373020
Meecnl
tmcannon
327430
clollin
398535
Engineeser