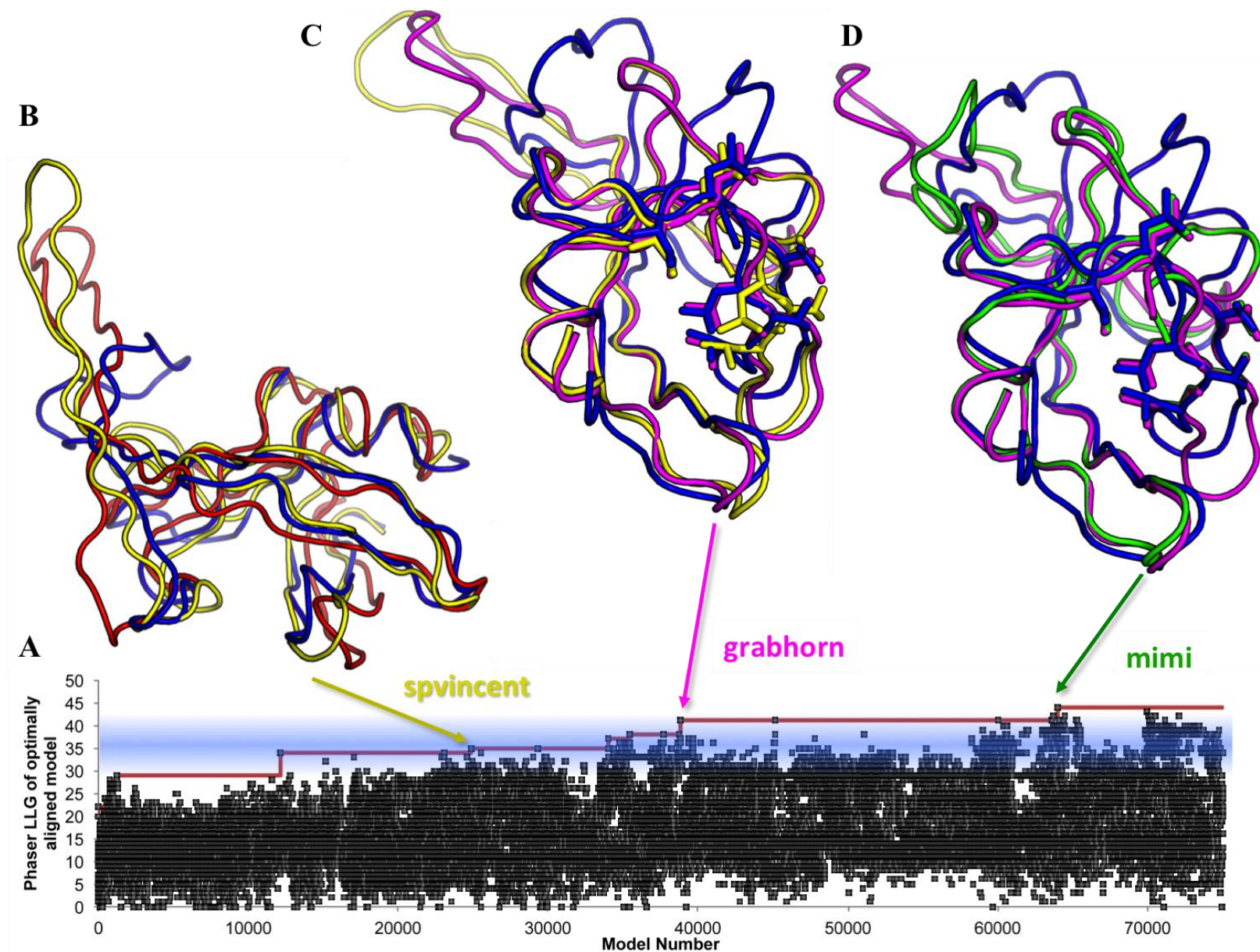


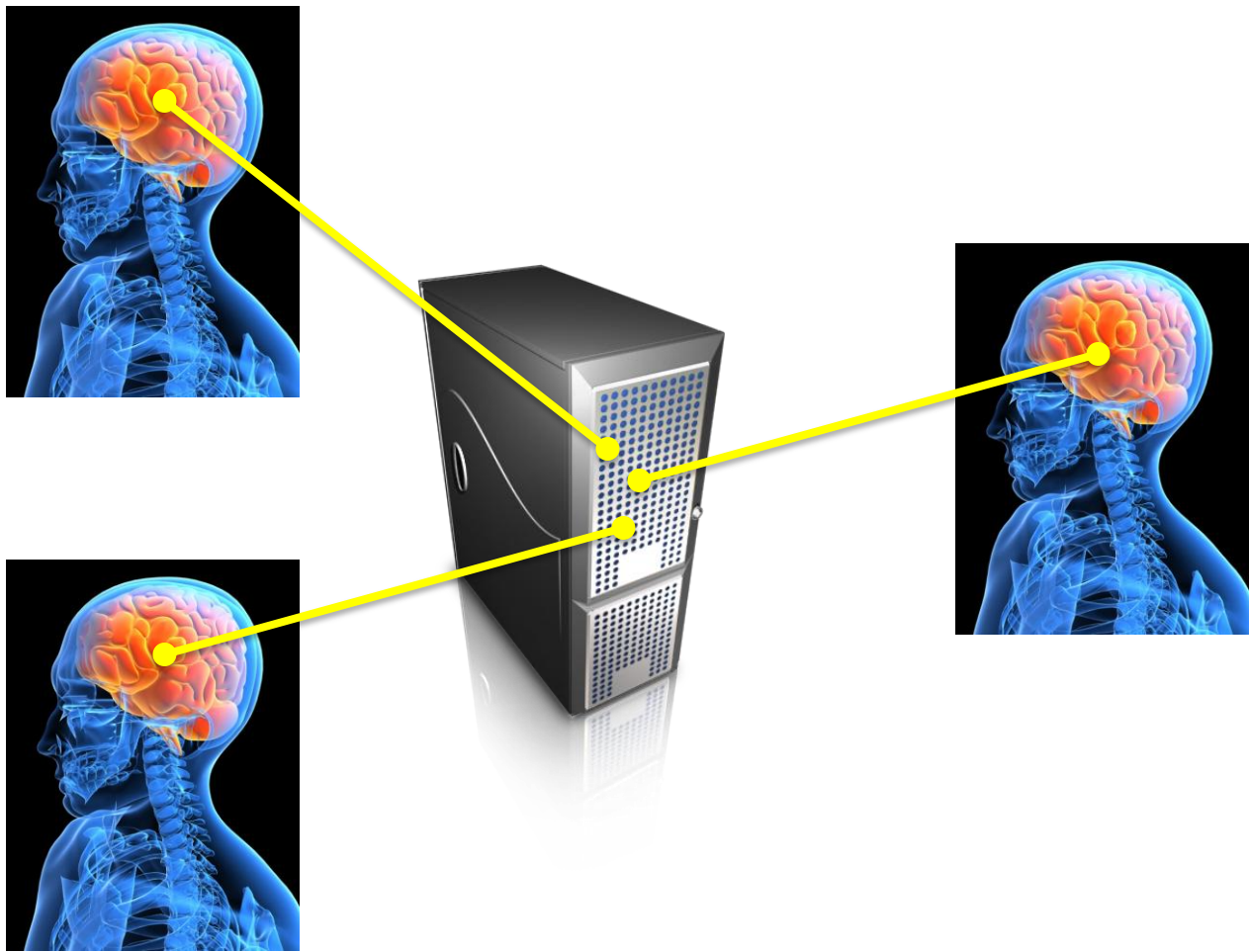


Solving Hard Problems with Games

Zoran Popović

*Center for Game Science
Computer Science and Engineering
University of Washington*





Solving Hard Problems with Human-Computer Symbiosis

Coadaptation:

1. People → Experts
2. Programs/Games → Optimal problem tools

Games are an ideal vehicle of coadaptation



Center for Game Science



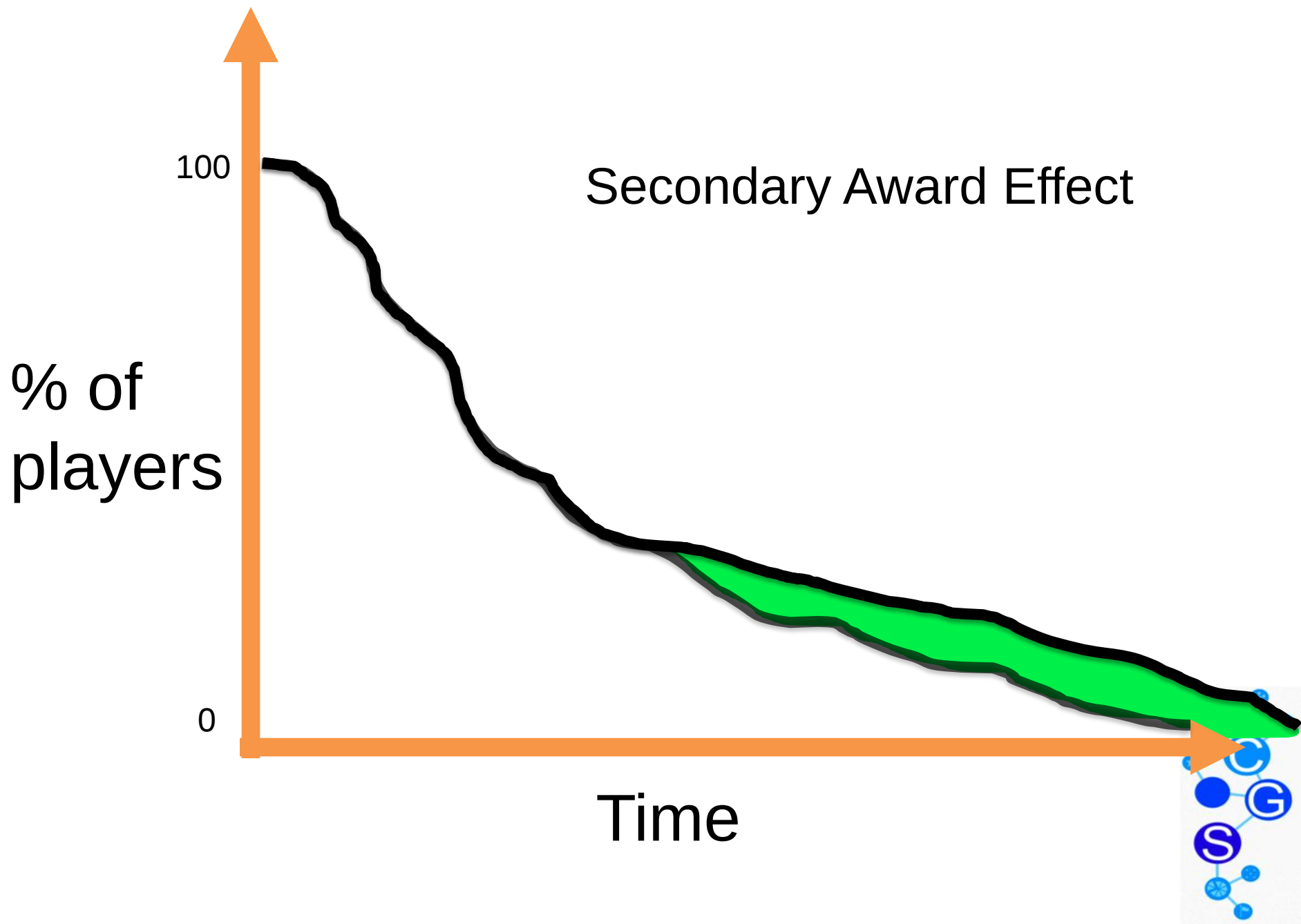
- Over 35 PhD, ugrads, SDEs, designers, artists
- 6 games currently in development

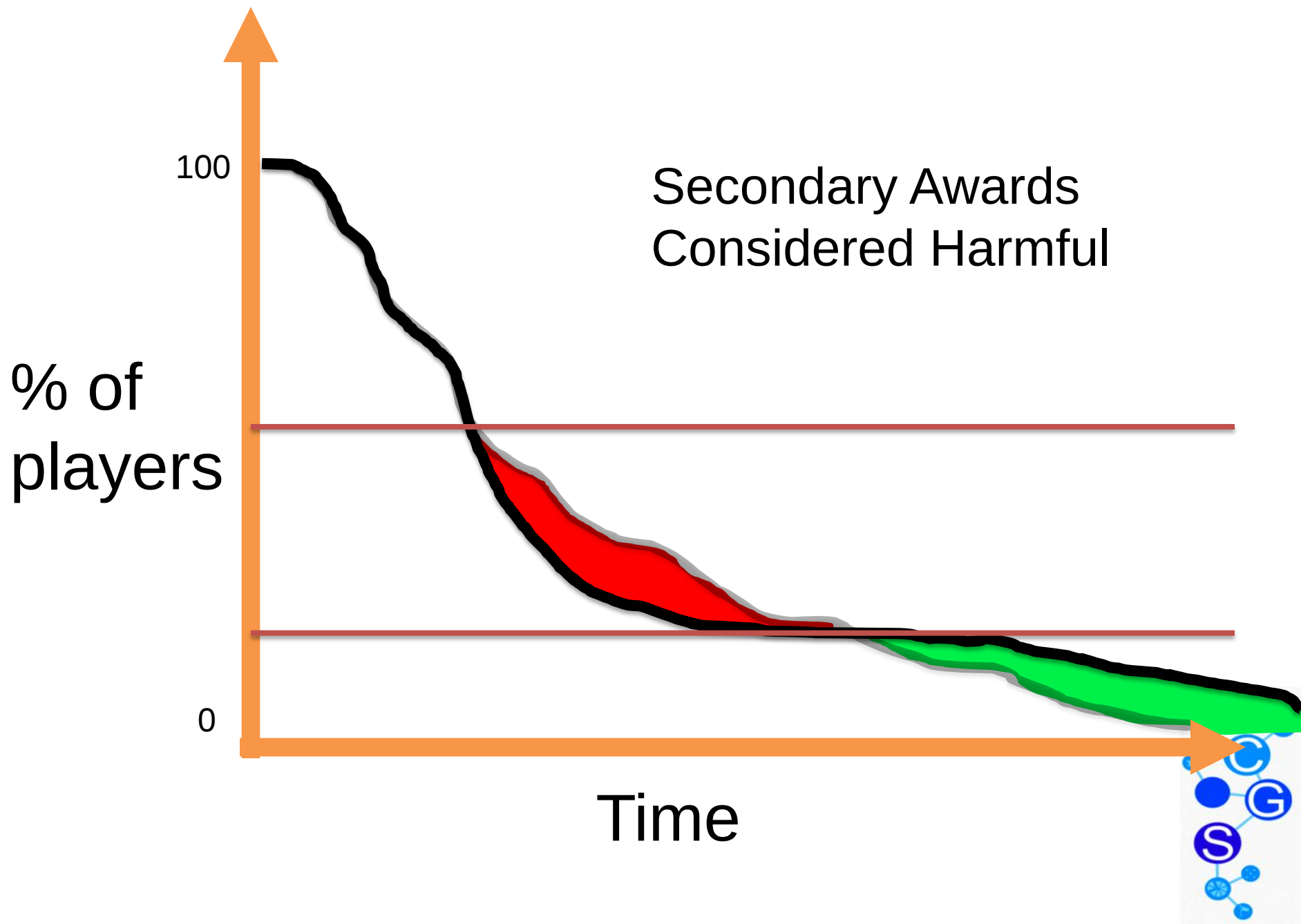


The Challenge:

1. hard to make an entertaining game
 2. even harder do it and solve a hard problem
 - constraints on game design
 - make real discovery, really learn something
 - Long term involvement
- cannot separate the two objectives

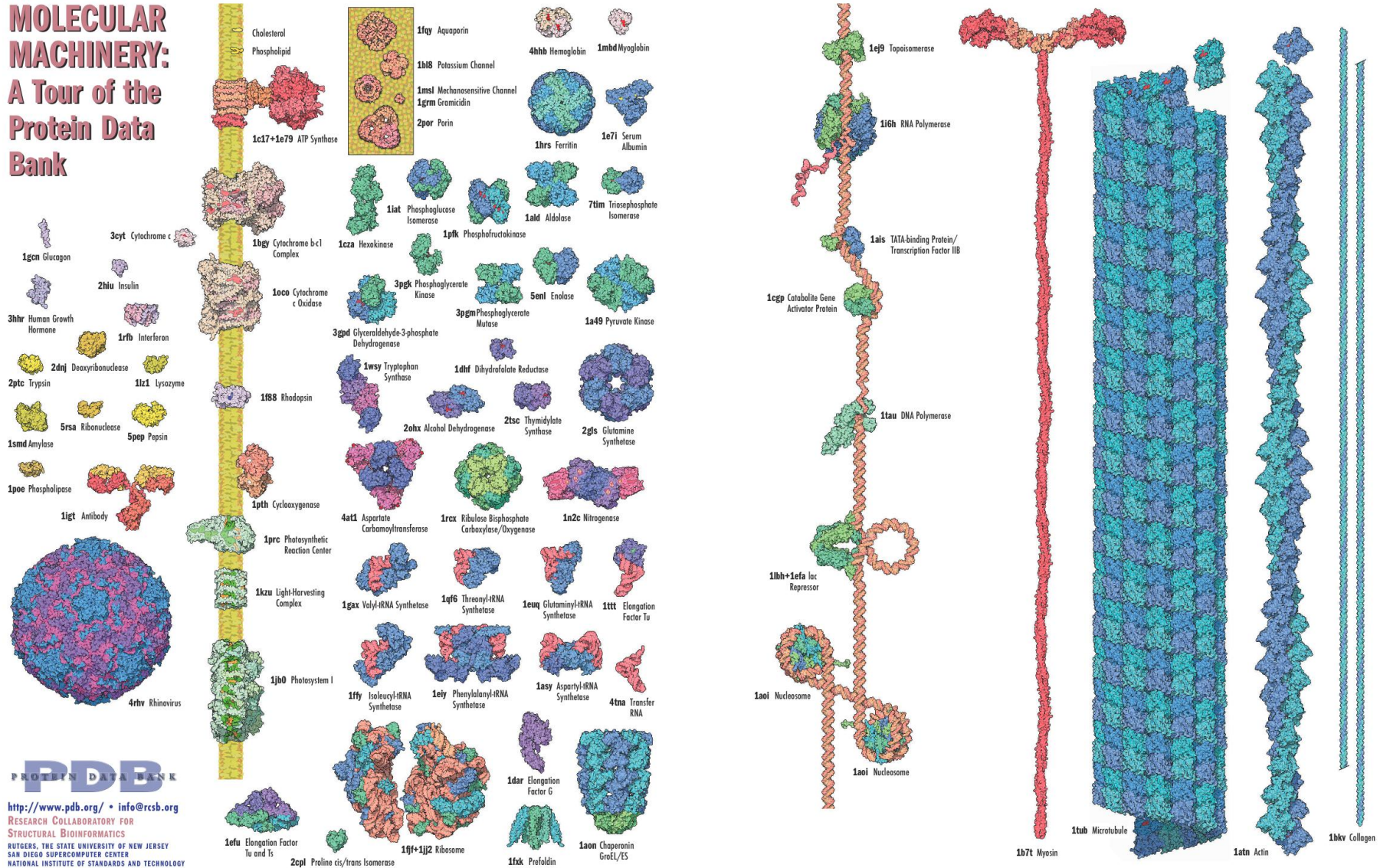






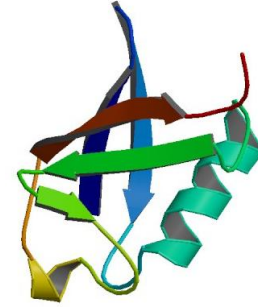
Proteins

MOLECULAR MACHINERY: A Tour of the Protein Data Bank

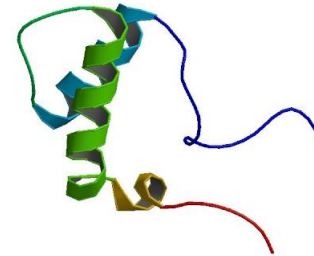


Proteins

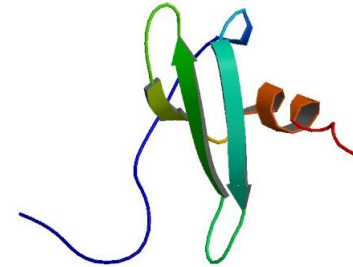
MQIFVKTLTGKTILEVEPSDTIE...



MGKYDKQIDLSTVDLKKLRVKEL...



KPVLSYRCPCRFFESHVARANV...



⋮

Sequence

⋮

3D Structure



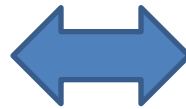
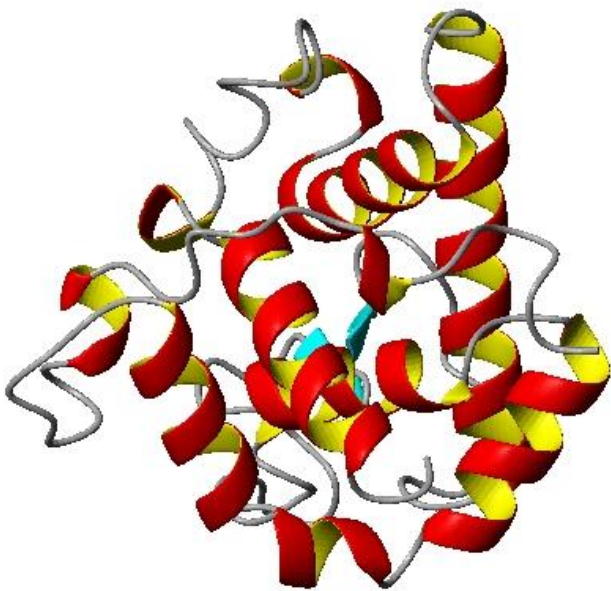
Challenges

- Solve difficult problem
- By people who know nothing about it
- while ensuring they have fun

But at the beginning...

- Don't know how to teach the rules
- Don't know appropriate problem visualization
- Don't know appropriate human-centered tools

Proteins as Puzzles



Approach it as science



Foldit

Pull Mode

Rank: 317 Score: 2534
Soloist Beginner Puzzle 8 (<150): Fruit Fly
▶ No conditions

▼ Cookbook

▼ Group Competition

#	Group Name	Score
1	Rice Biochemistry	9174
2	Team Commonwealth	9168
3	Ukraine	9088
4	Team Canada	9085
5	Firebird BioChem	9073
6	SETI.Germany	9030
7	Boinc.be	9001

▼ Soloist Competition

#	Player Name	Current	Best
1	Mike Crunching For Physics	-	9242
2	weitzel	-	9235
3	ys719	-	9222
4	jmarkic	-	9211
5	kevin_karplus	-	9186
6	J1NXter	-	9185
7	eb.eric	-	9183

Shake Sidechains Wiggle All Wiggle Backbone Wiggle Sidechains Freeze Protein Remove Bands Disable Bands Align Guide Reset Structures Reset Puzzle Help Glossary

▶ Actions ▶ Undo ▶ Social ▶ Modes ▶ Behavior ▶ View ▶ Menu

Chat - Group Chat - Puzzle Chat - Global Notifications

auto show auto show auto show auto show



Challenges

visualization

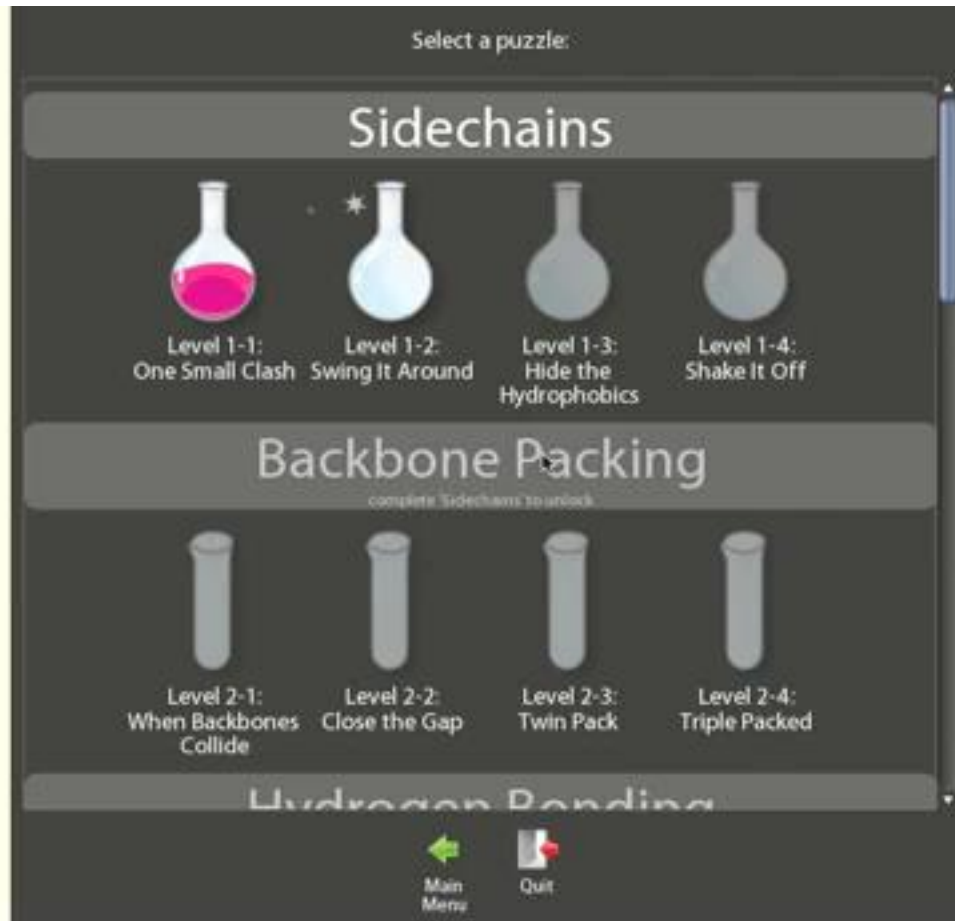
interaction

scoring

training

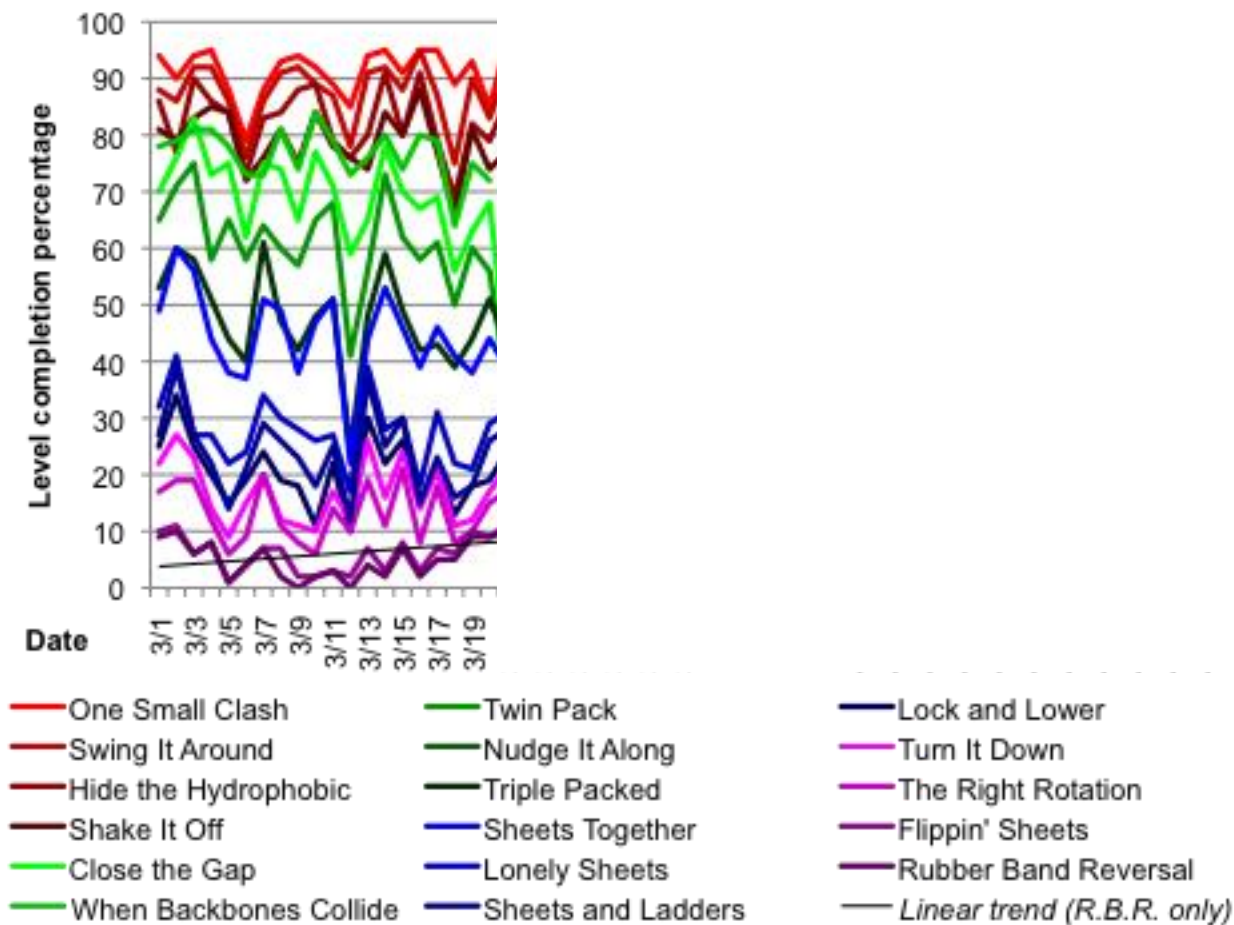


Training

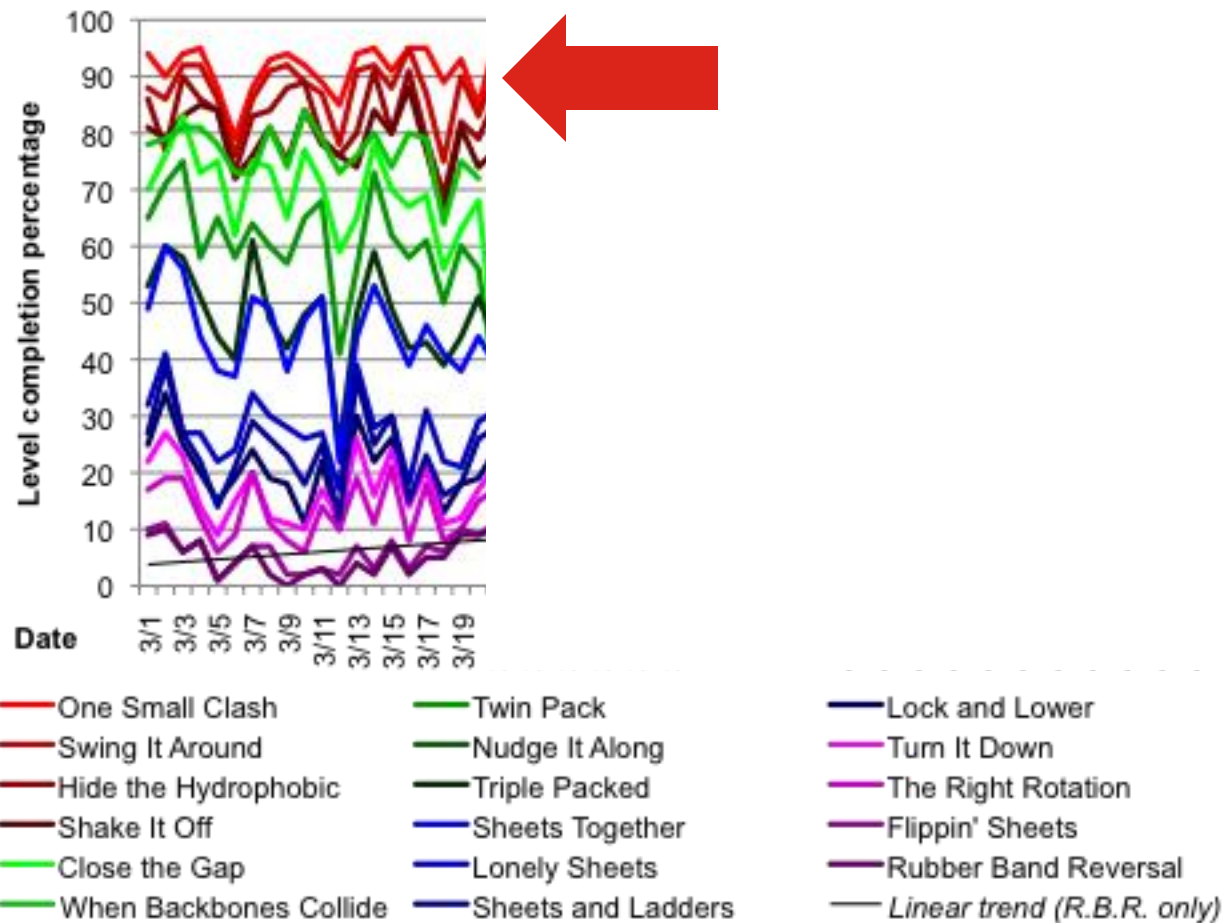


Training

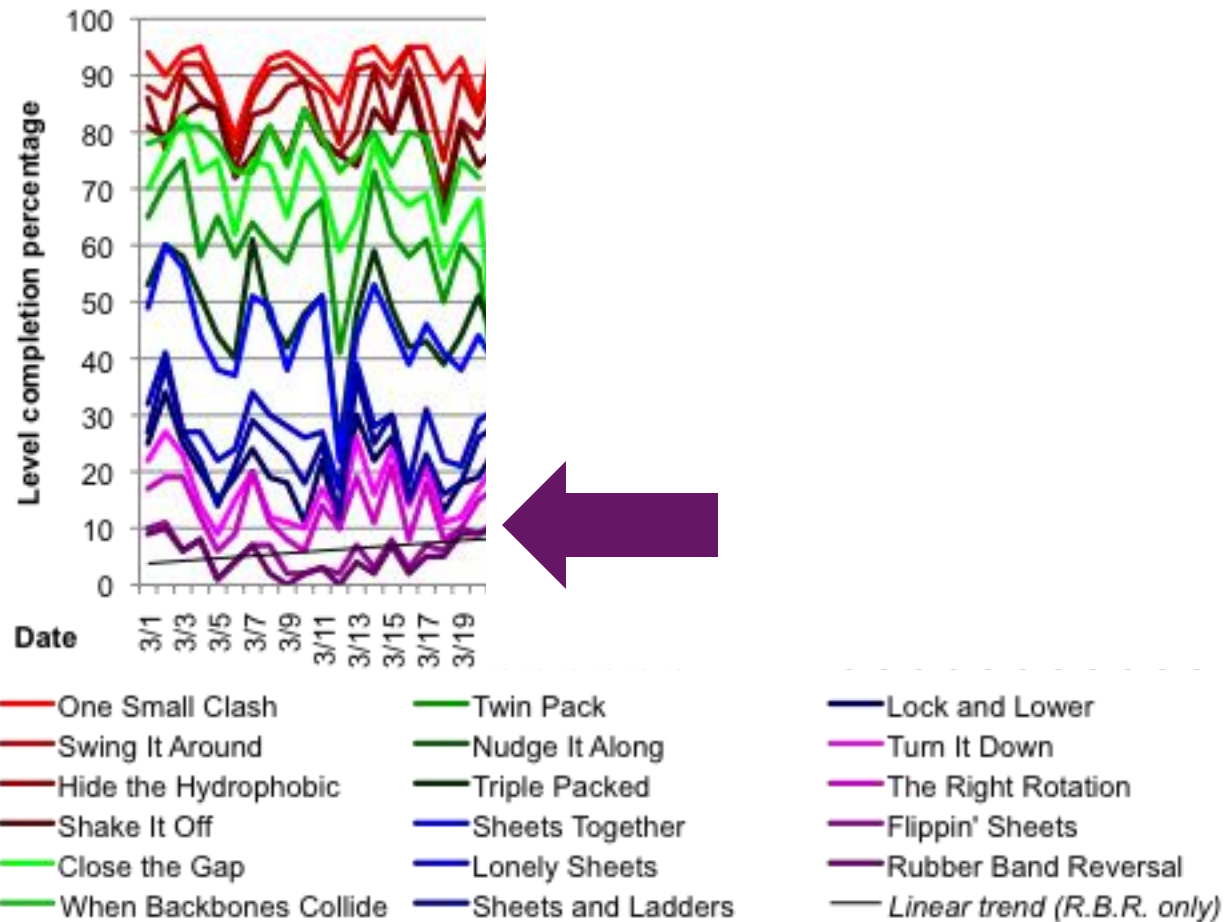
refinement



Training refinement

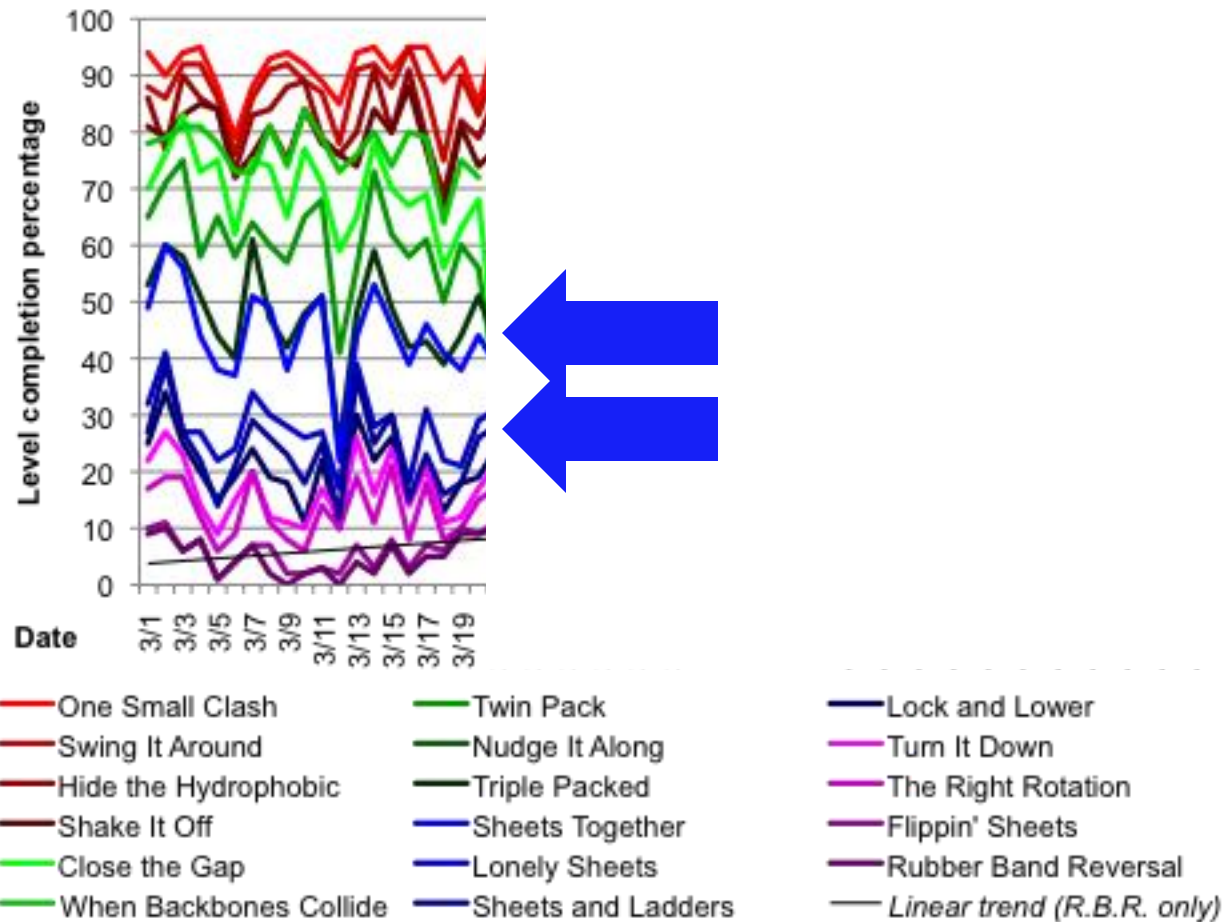


Training refinement

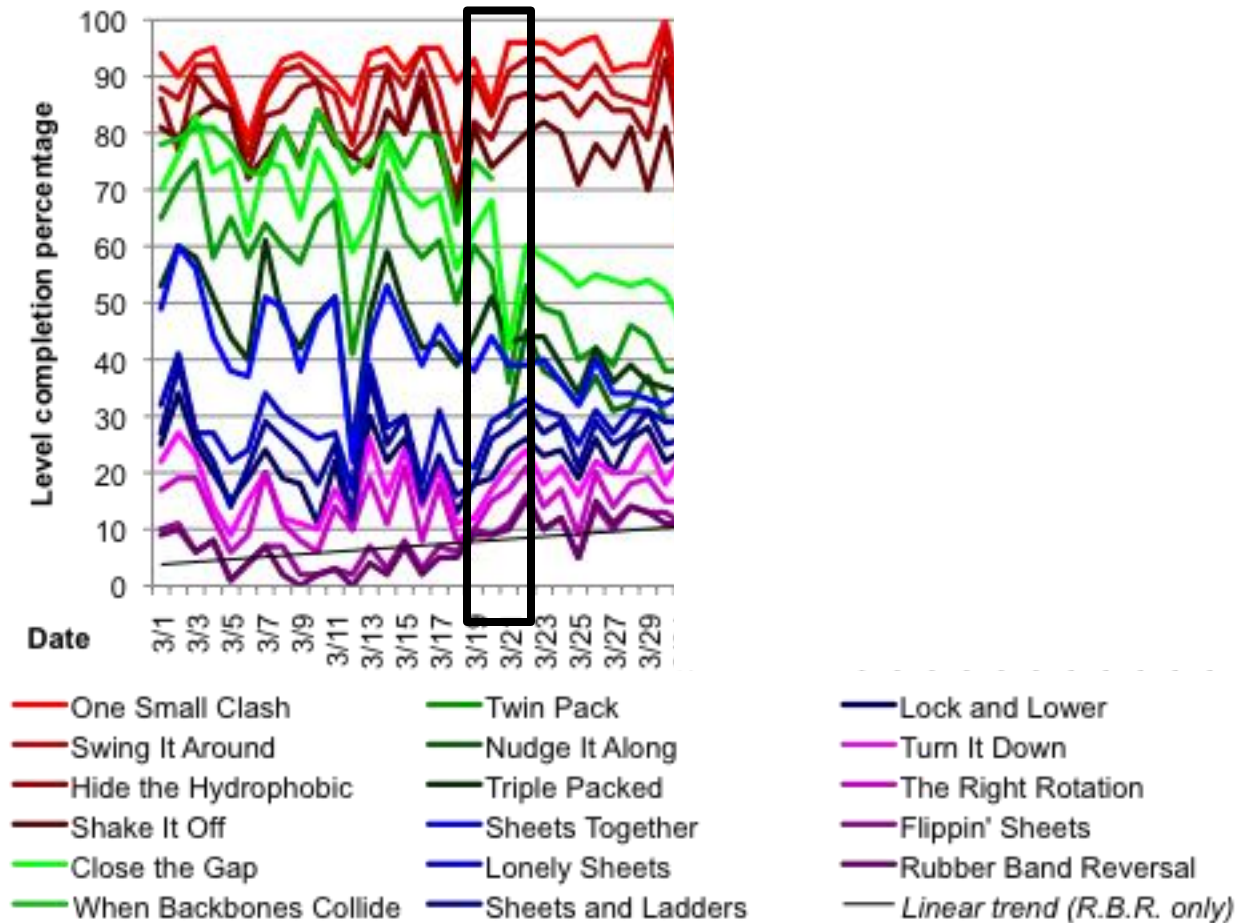


Training

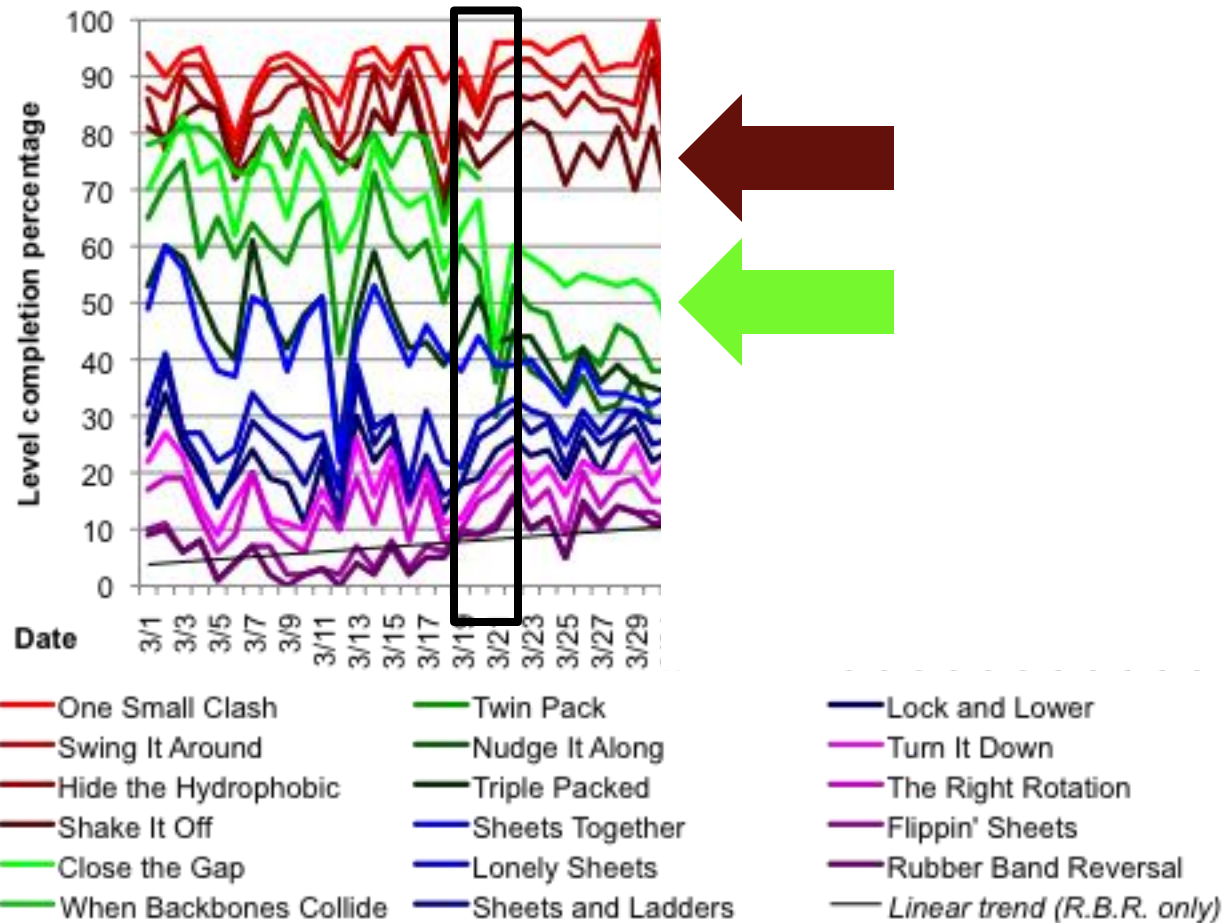
refinement



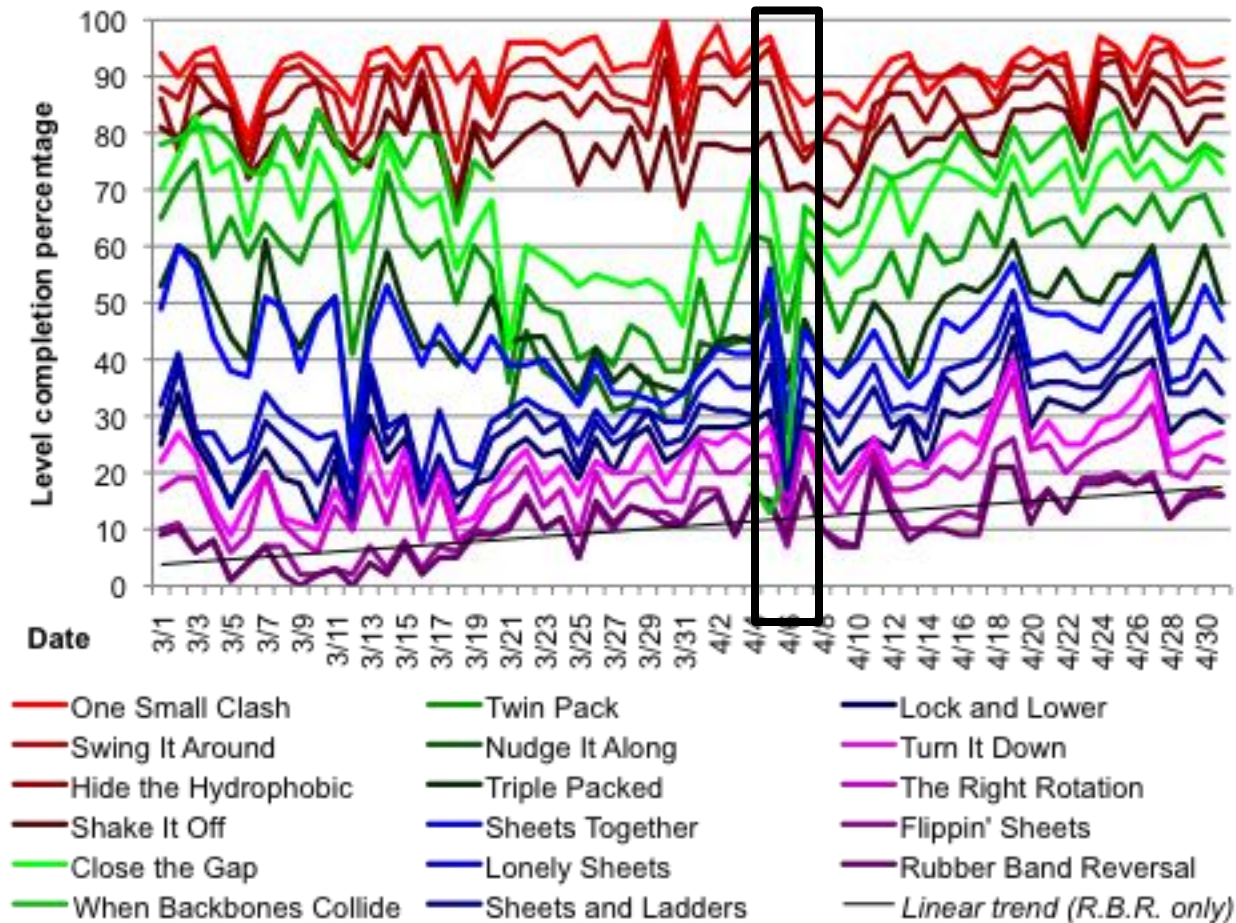
Training refinement



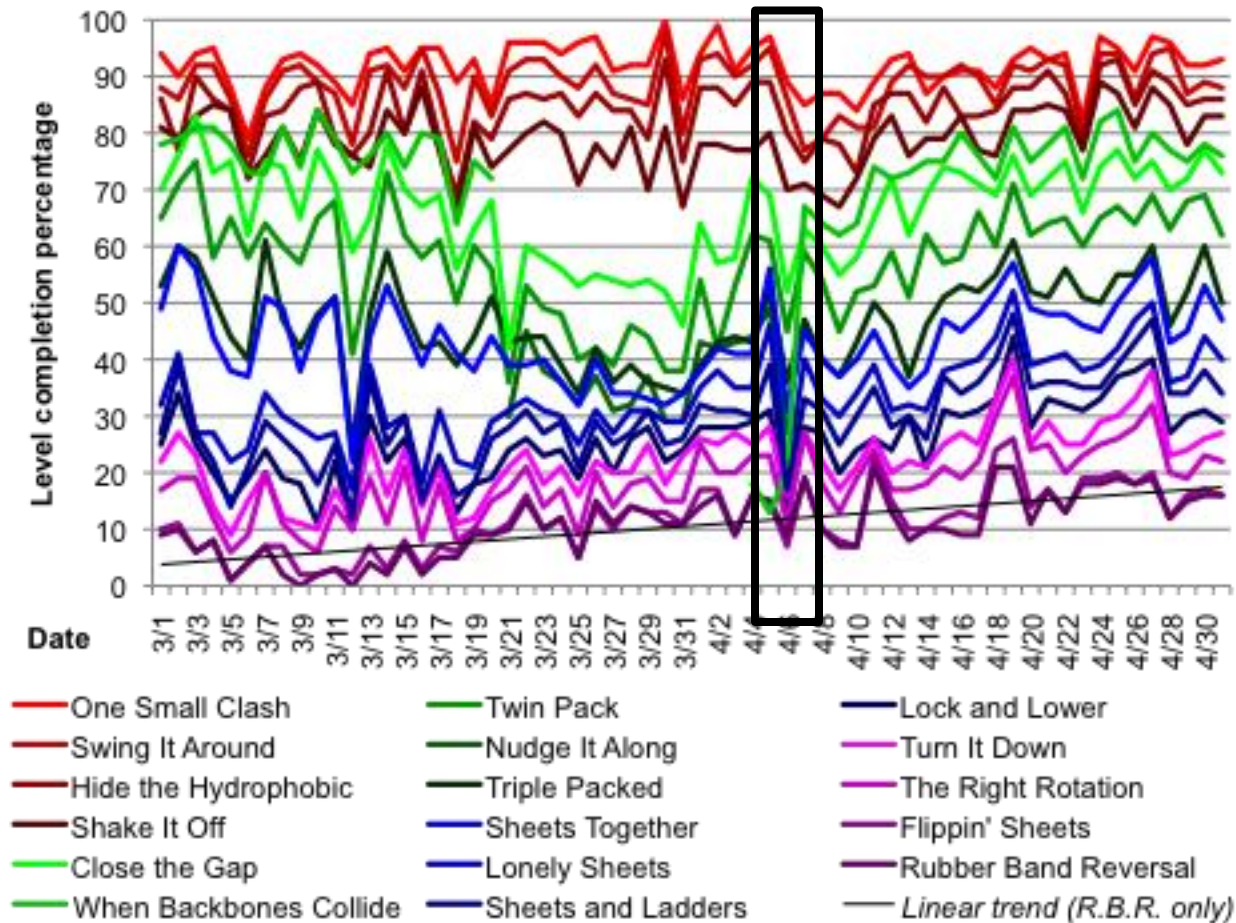
Training refinement



Training refinement

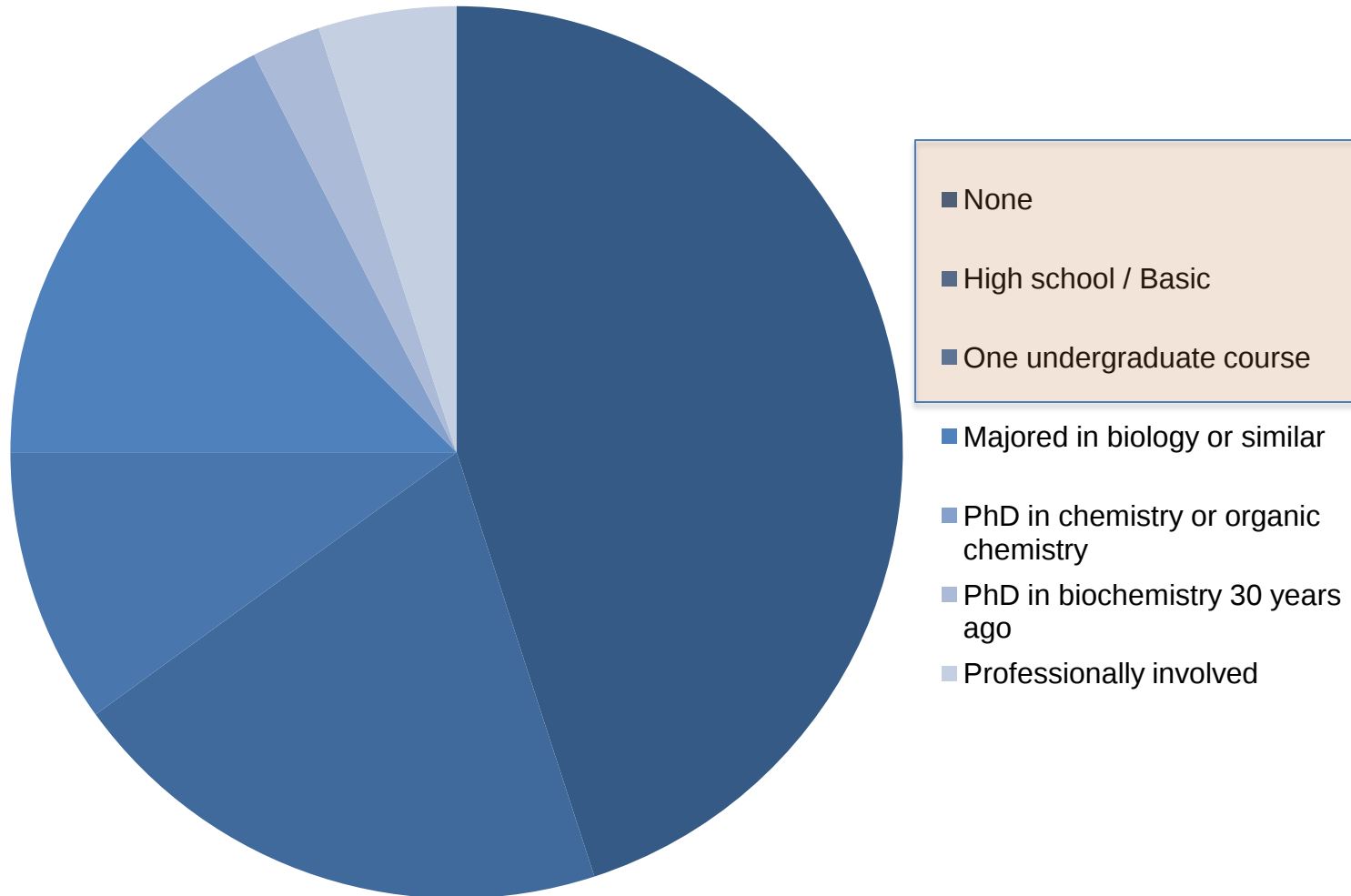


Training refinement

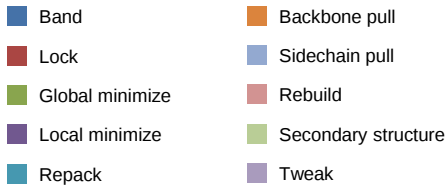
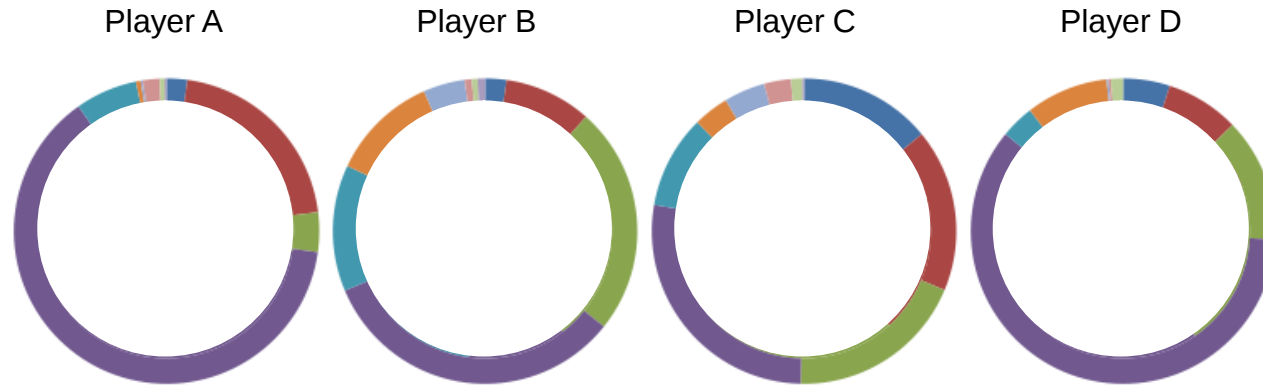


Biochemistry not just for experts...

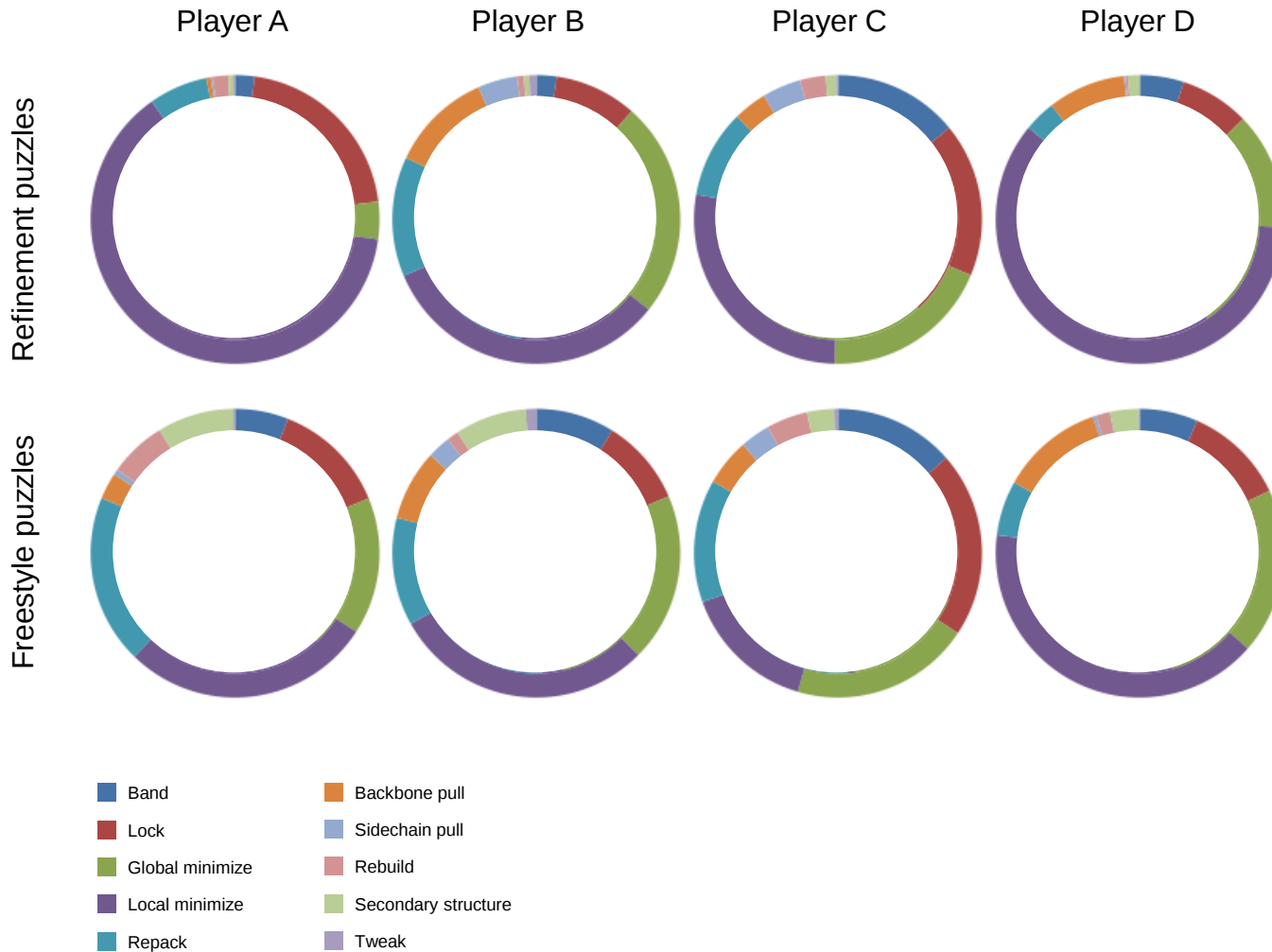
Prior knowledge of biochemistry



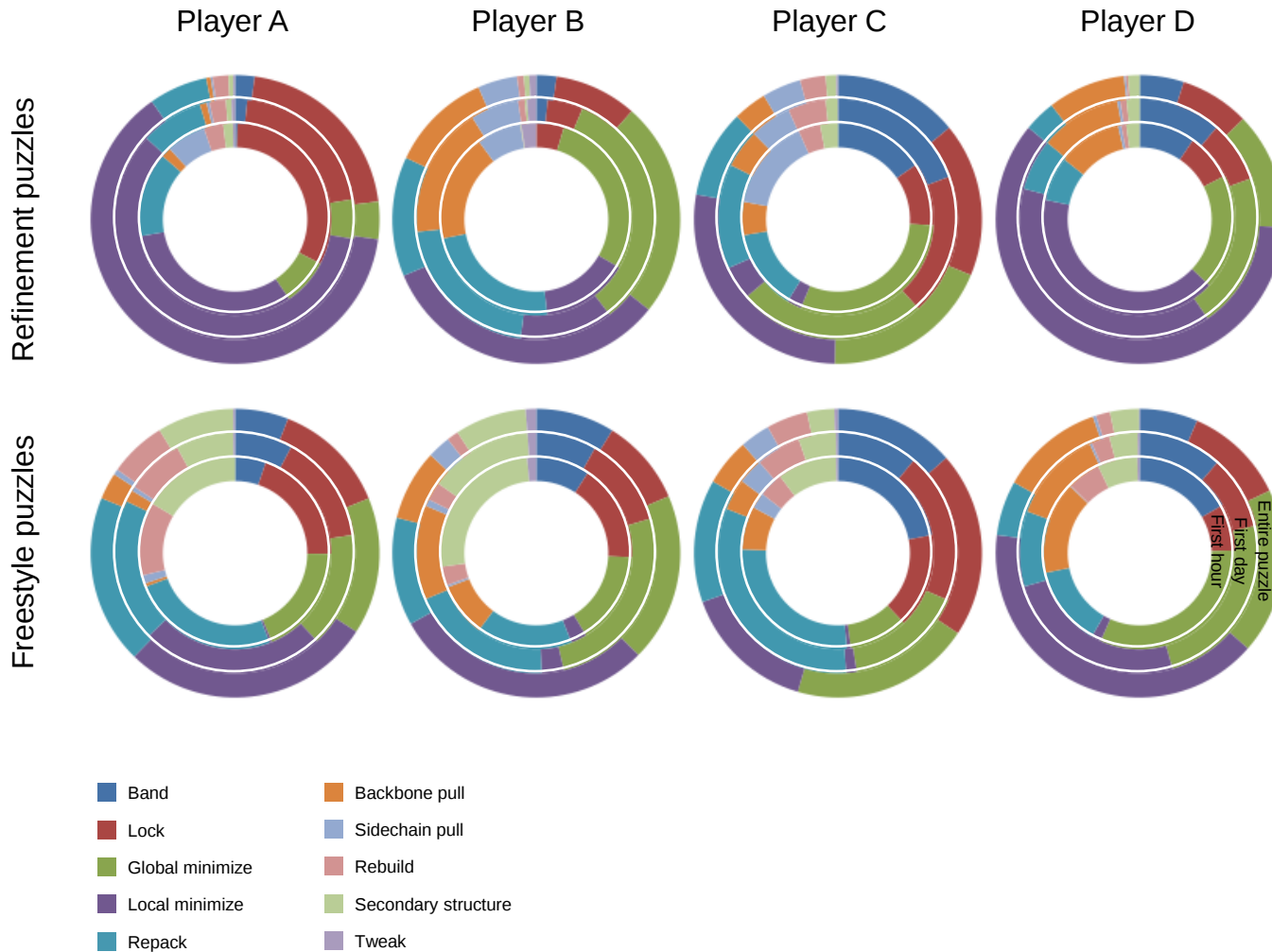
Players search over strategies



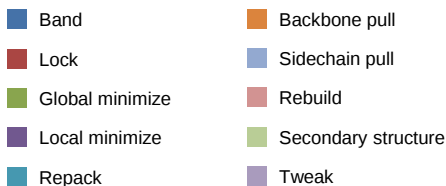
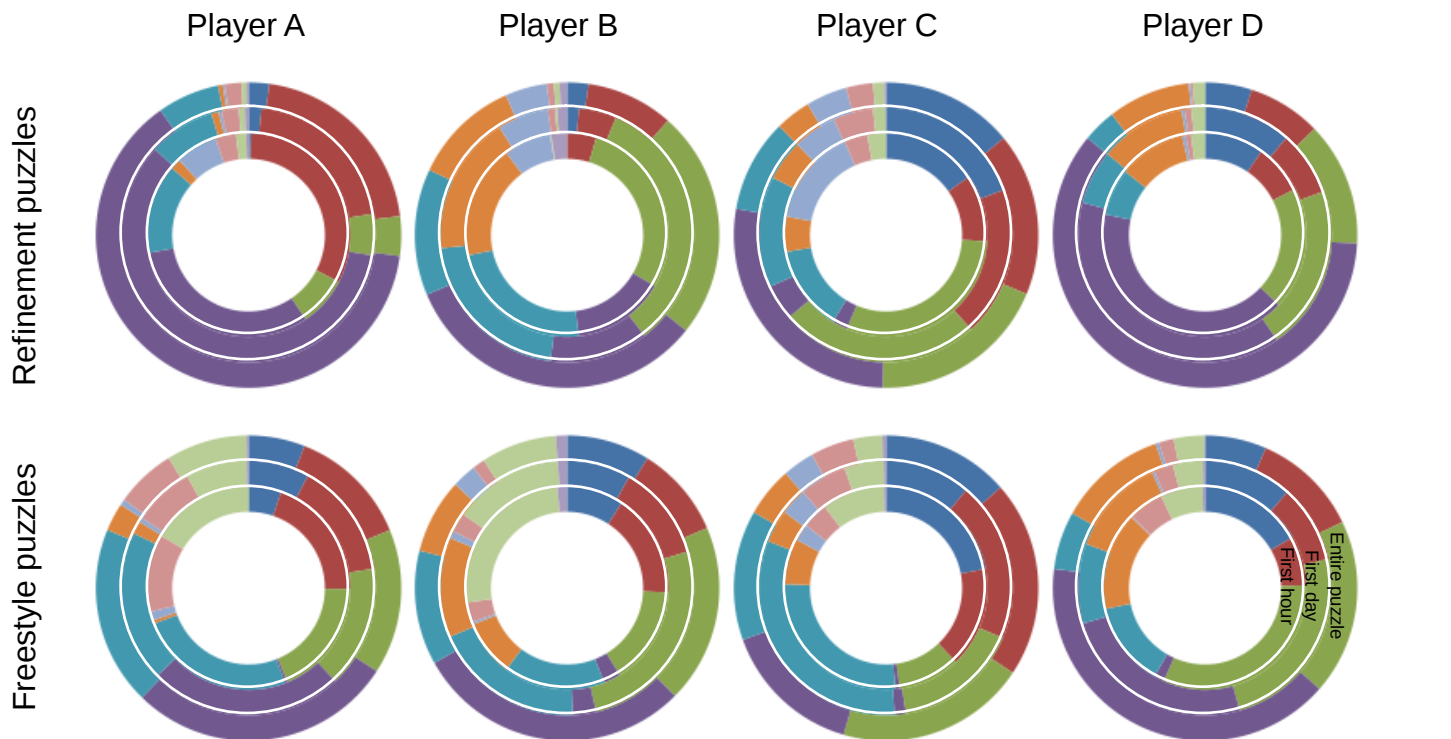
Players search over strategies



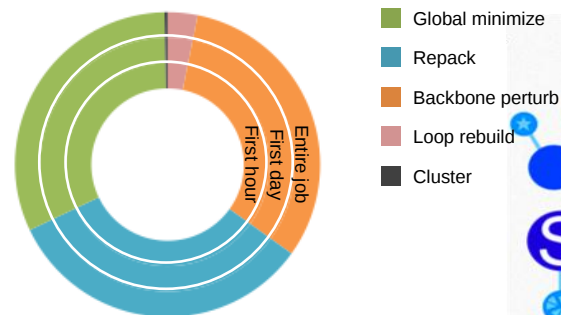
Players search over strategies



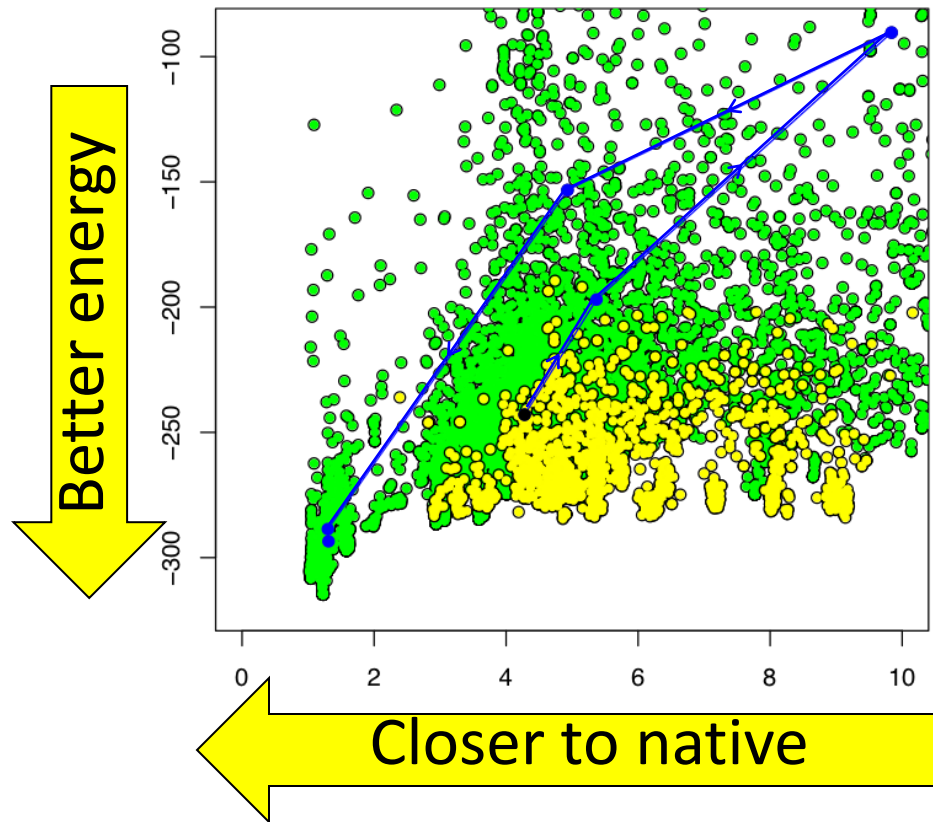
Players search over strategies



Rosetta rebuild and refine



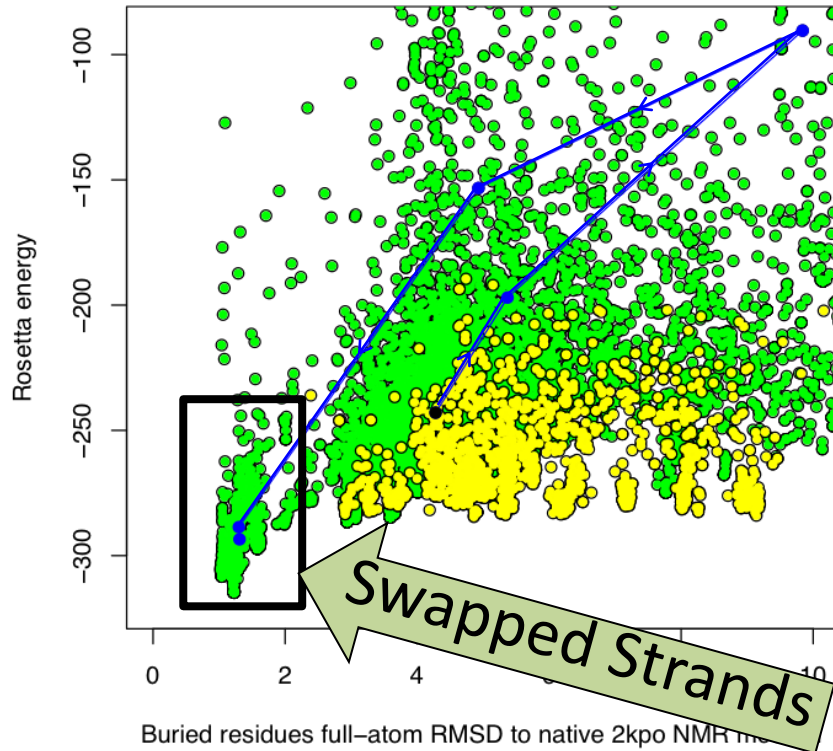
Comparison to Algorithm



Player solutions
Top player path
Algorithm solutions



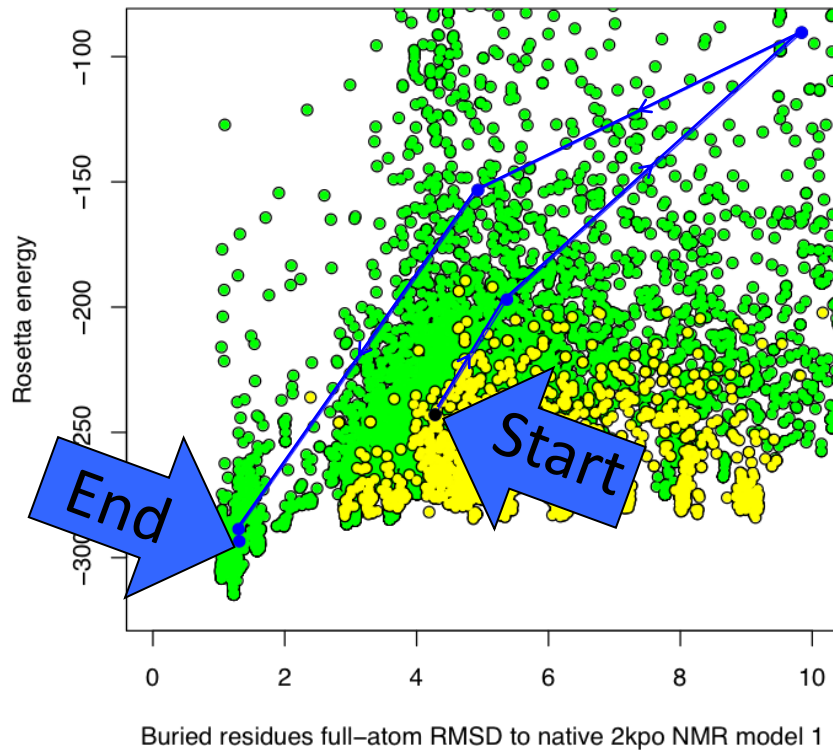
Comparison to Algorithm



Player solutions
Top player path
Algorithm
solutions



Comparison to Algorithm



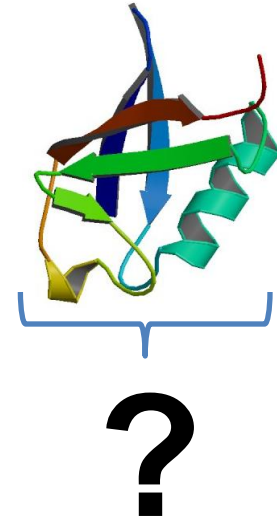
Player solutions
Top player path
Algorithm
solutions



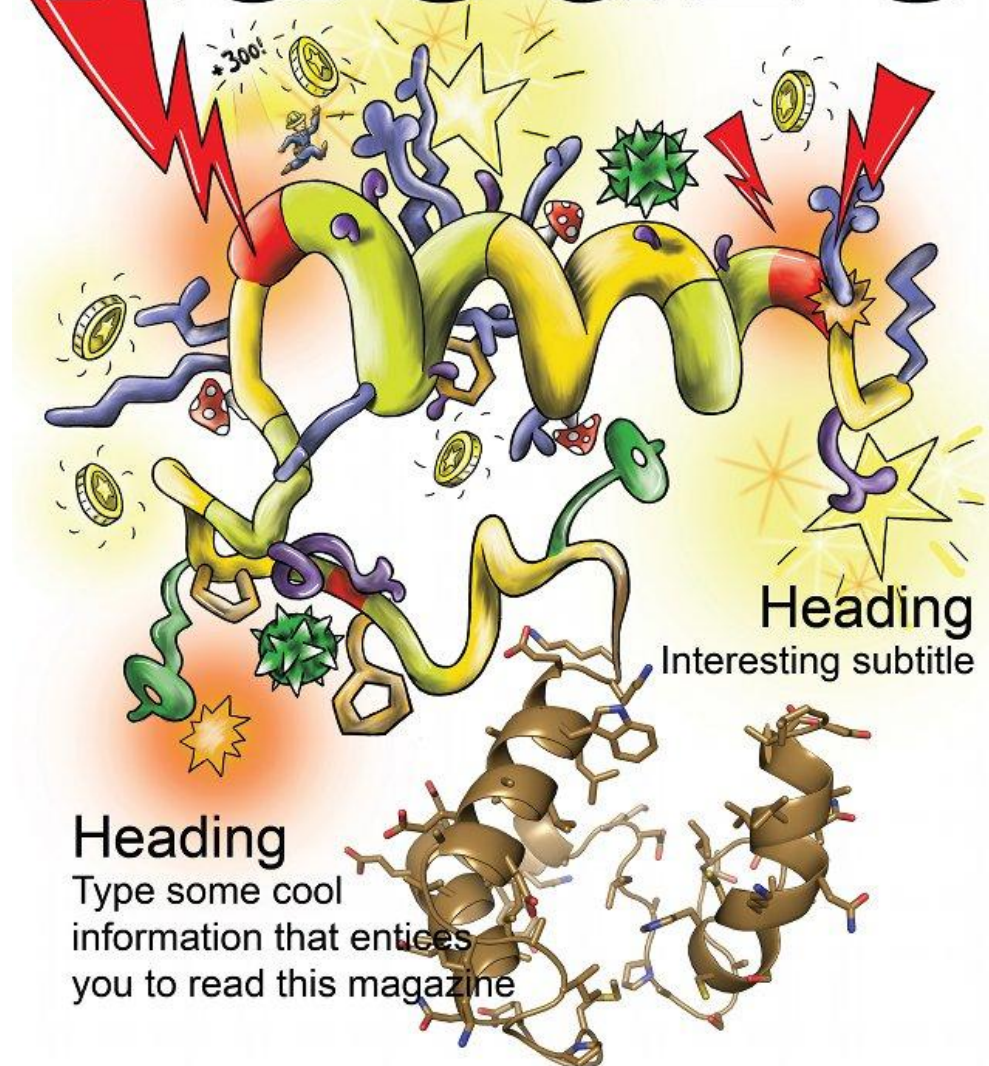
Protein Structure Prediction

Problem Solving

MQIFVKTLTGKTILEVEPSDTIE...

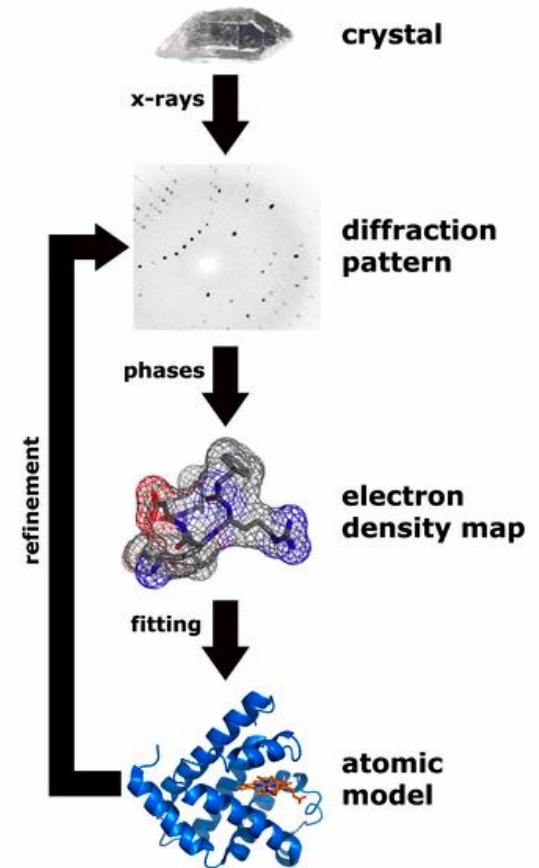


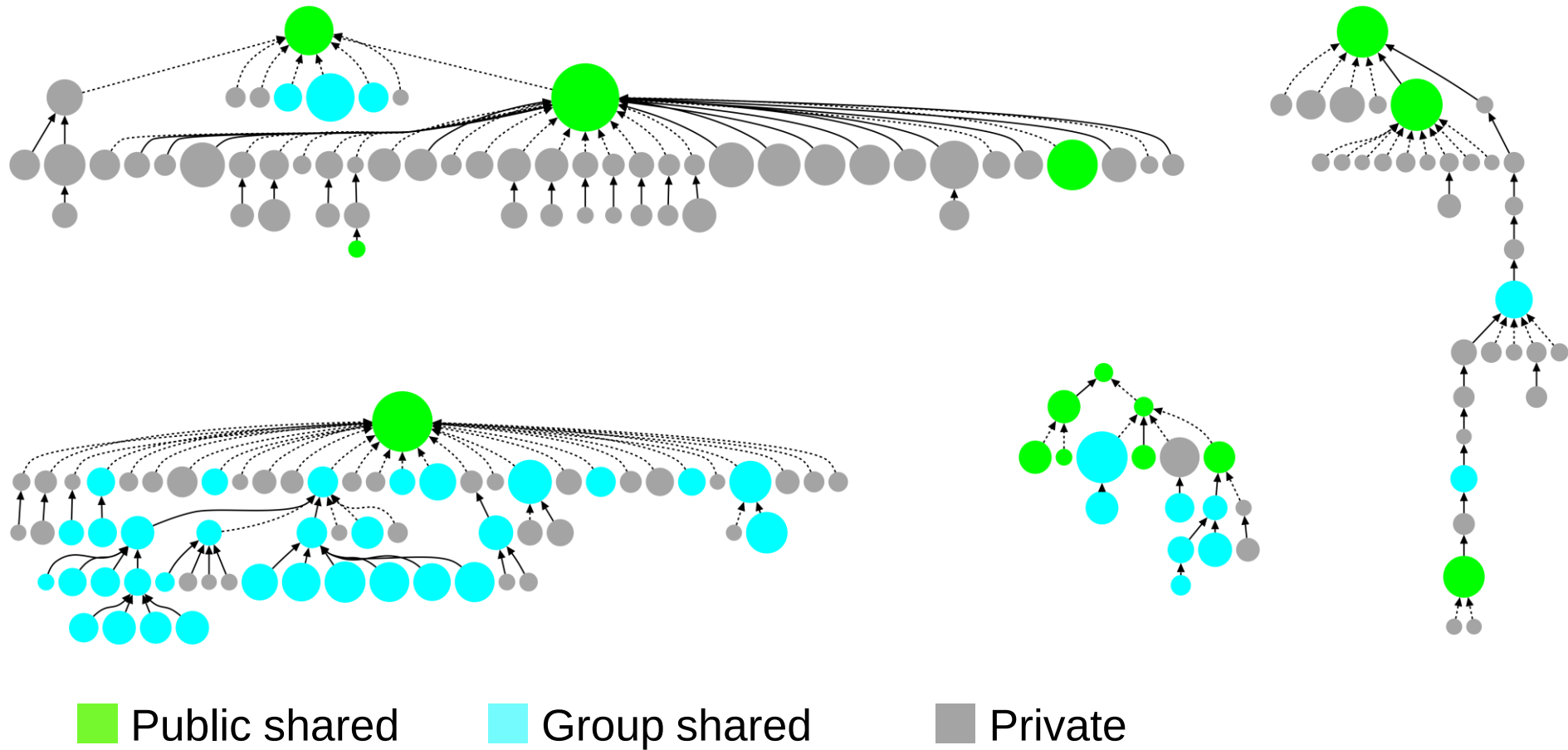
nature



Experimental Structure Solved

- Mason-Pfizer Monkey Virus Retroviral Protease (MPMV PR)
- Plays a role in AIDS in monkeys
- Experimentalists worked on for ~15 years
- Computational methods failed to solve
- Gave to players for 3 weeks



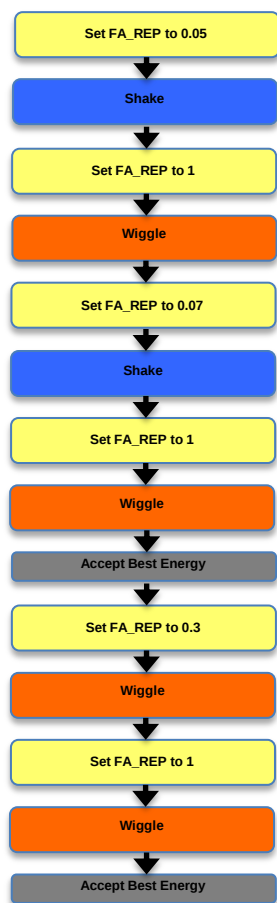


players are taking and modifying shared recipes

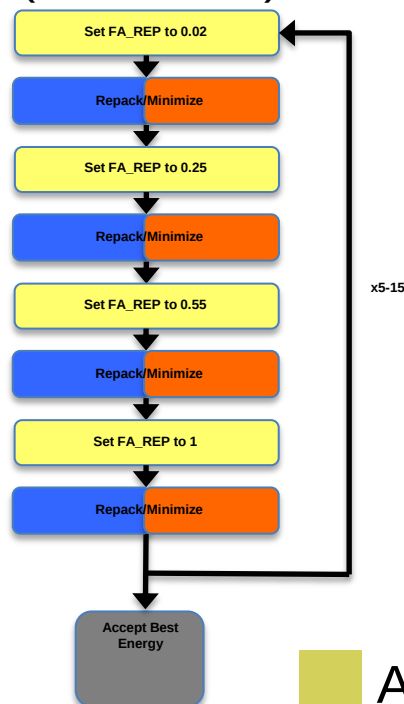


Algorithm Comparison

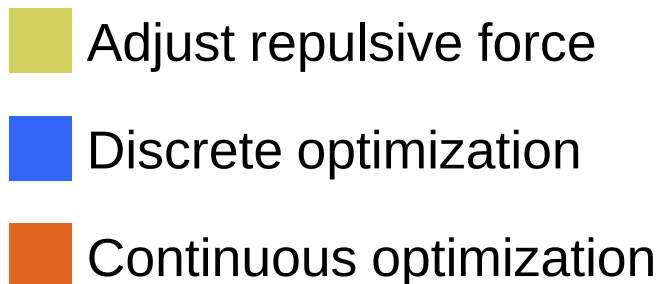
Player
Algorithm
(Blue Fuse v1.1)



Scientist
Algorithm
(Fast Relax)



- Independent discovery of scientists' algorithmic techniques



Protein Design Changes

The screenshot displays the Foldit protein design game interface. At the top left, a 'Design Mode' panel provides instructions: 'Left click: mutate menu' and 'Right (ctrl) or Middle (shift) click: insert/delete menu'. To the right, a score bar shows 'Score: 408 of 9350'. Further right is an 'Intro to Design' button. The central area features a 3D model of a protein structure with various colored segments (green, red, orange, blue) and sidechains. A tooltip points to a sidechain, stating: 'Some of these sidechains are too large. You can change them in Design Mode.' with a 'Next' button. At the bottom left, a navigation bar includes 'Actions', 'Undo', 'Modes' (with 'Pull Mode' and 'Design Mode' icons), and 'Menu'. At the bottom right, a chat panel shows 'Chat - Puzzle Levels' and 'Chat - Global' with 'auto show' options.

New tutorial levels



Experimental Validation

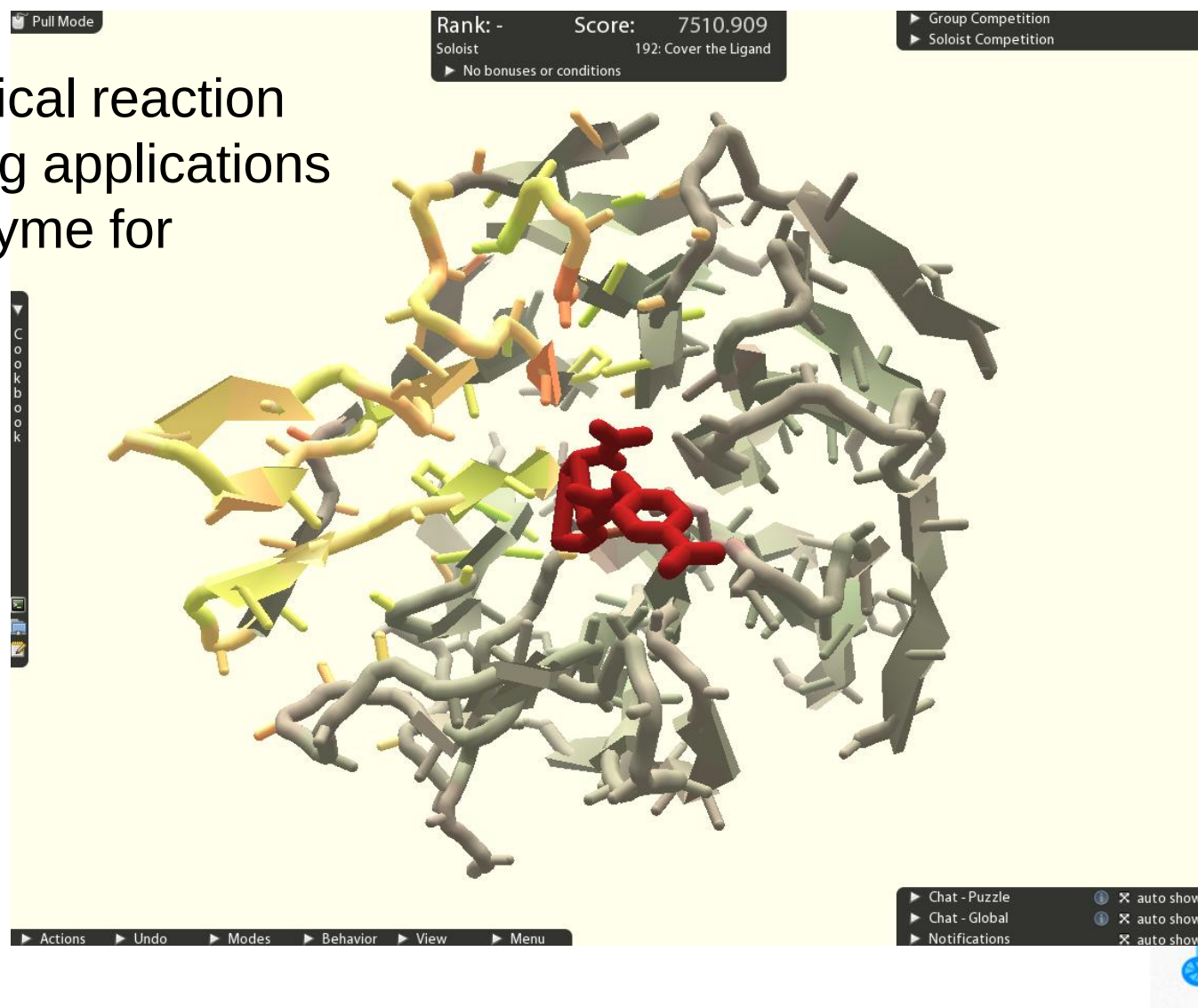


Fibronectin Design



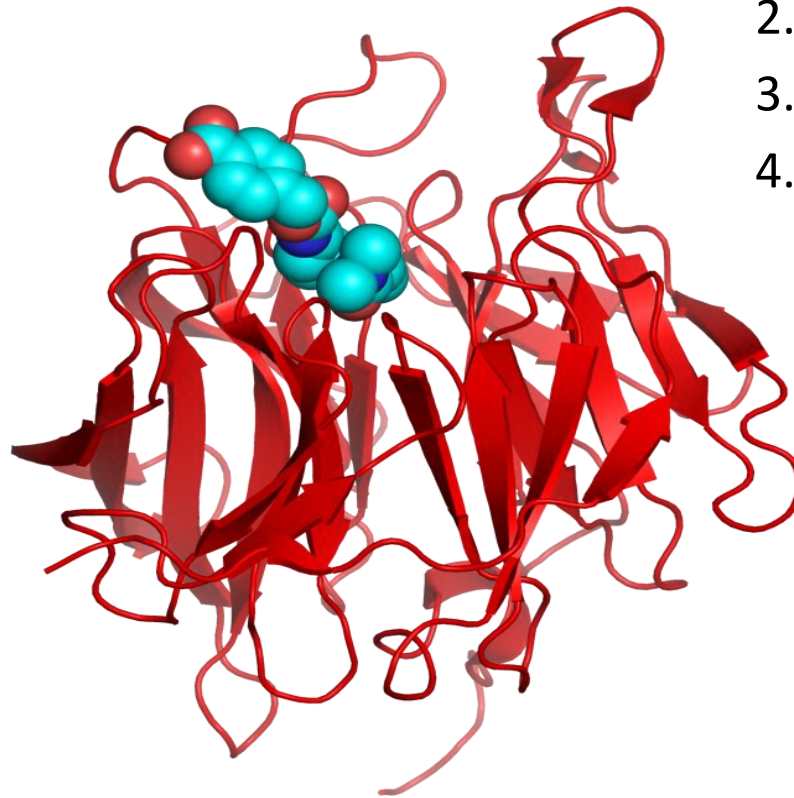
Diels-Alder Design

- Useful chemical reaction
- Potential drug applications
- Improve enzyme for reaction



Diels-Alder Design

Starting scaffold



Puzzle Rounds:

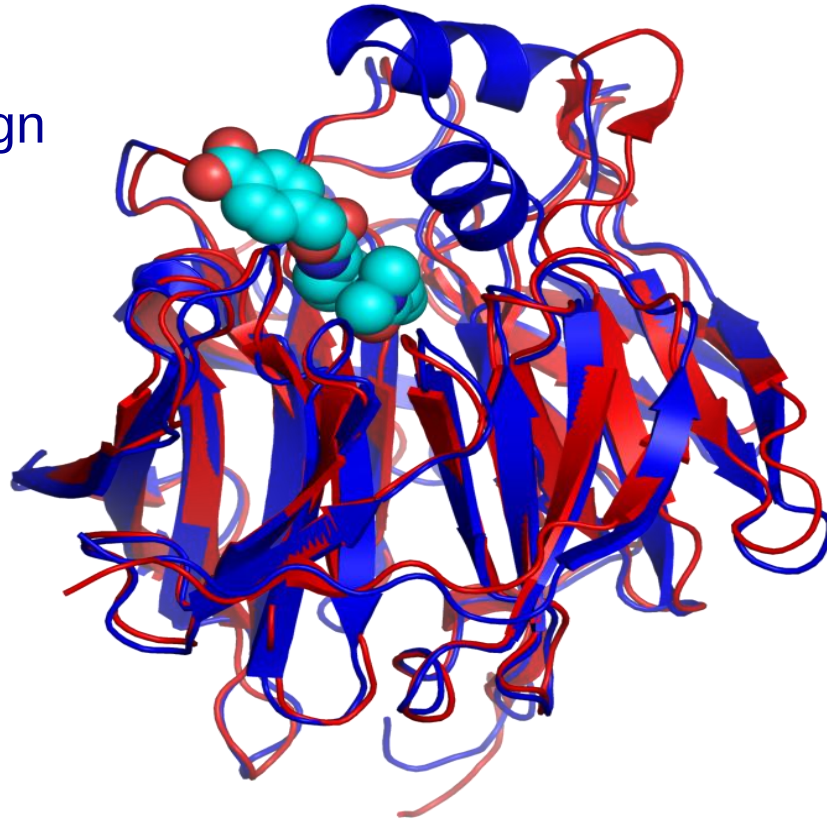
1. Ligand moved
2. Helix binding ligand
3. Supporting helix
4. Refine/confirm helices



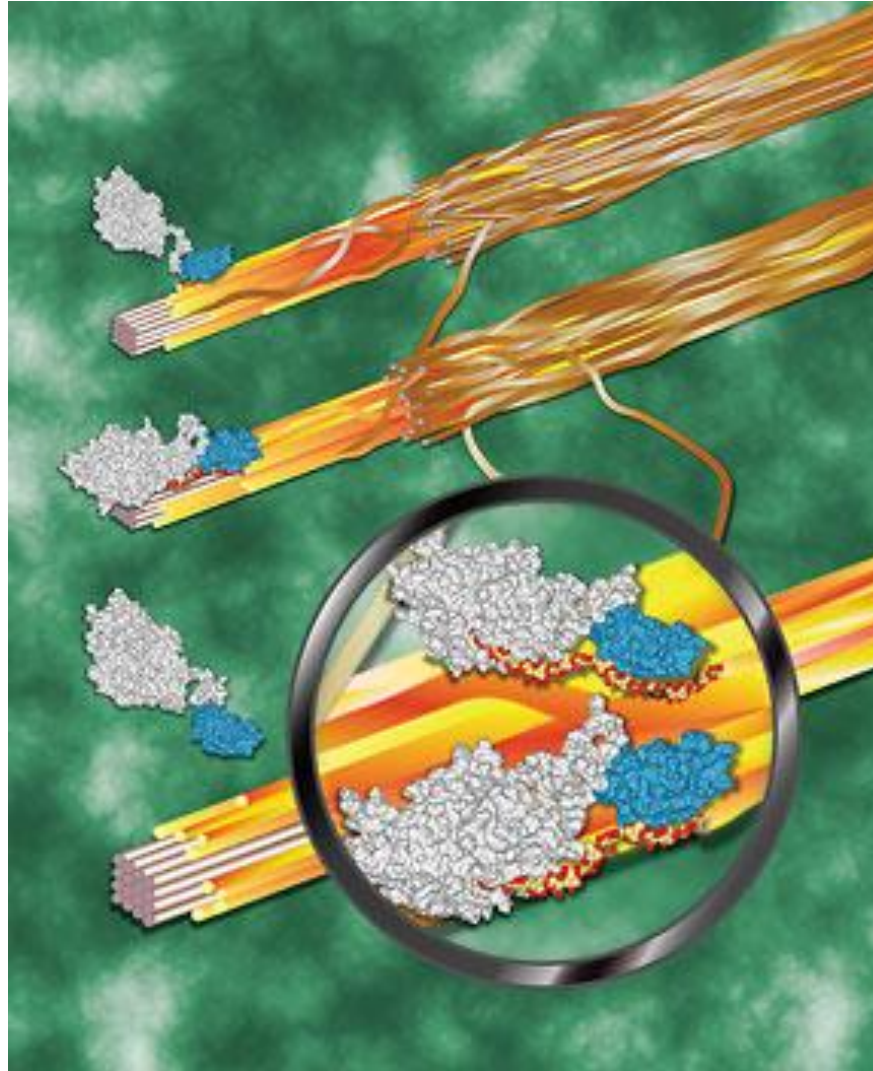
Diels-Alder Design

Starting scaffold

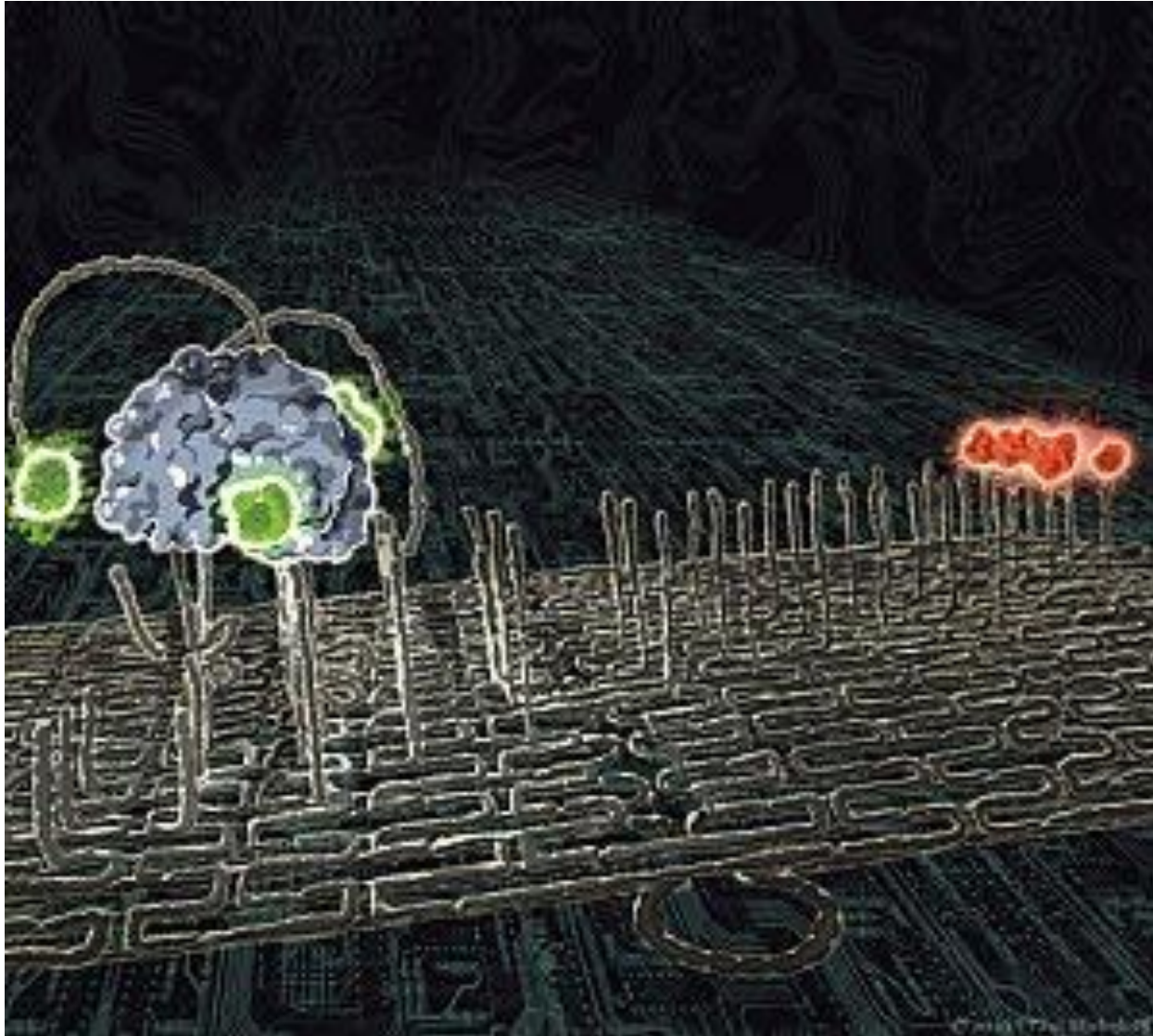
Player/scientist design



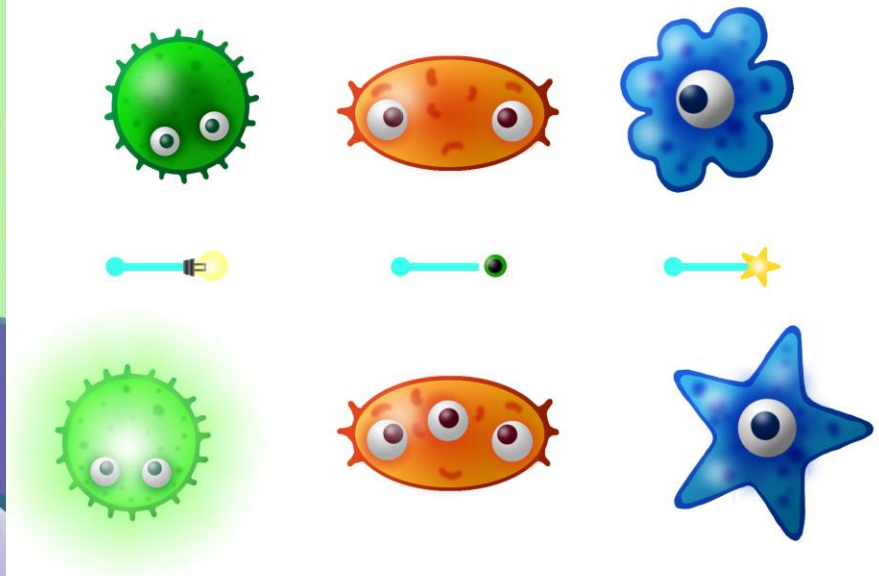
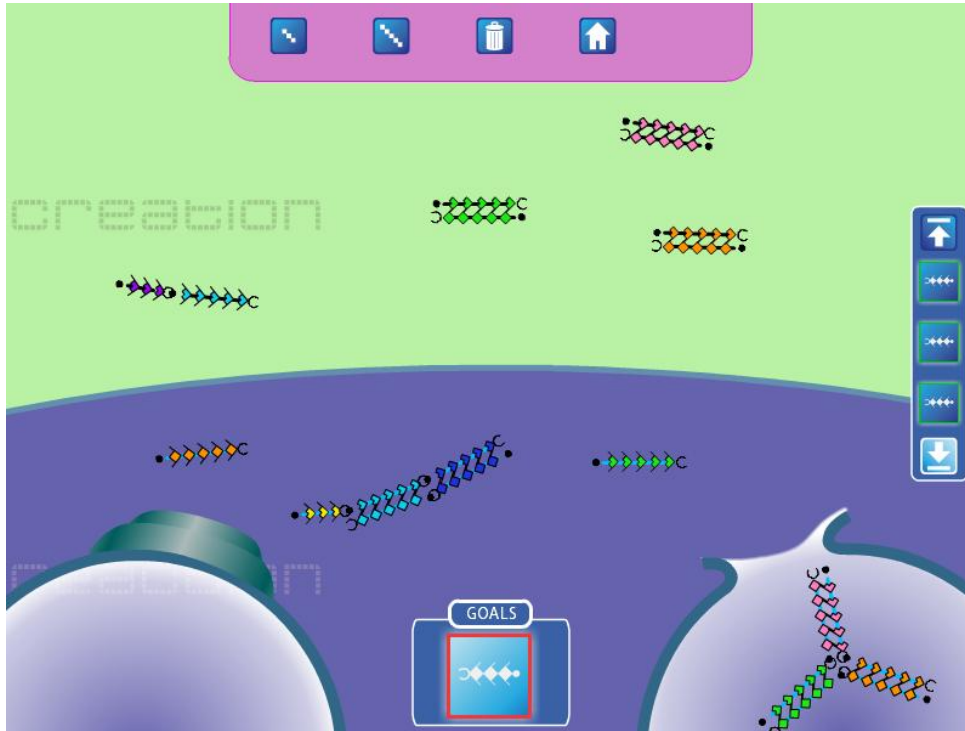
Biofuel Process Discovery



Nanotechnology



DNA game



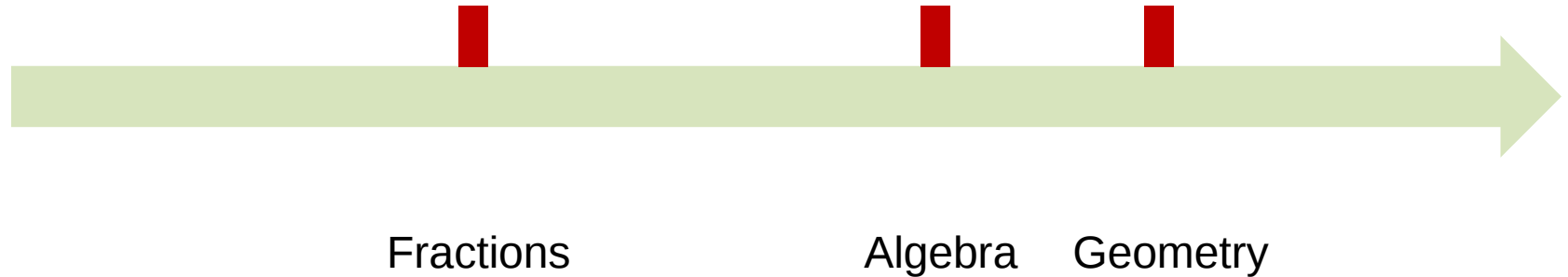
Main Developers: Rich Snider, Dmitri Danilov
Domain Expertise: Georg Seelig



Novice to Experts



Math Bottlenecks



“Difficulty with fractions... is **pervasive** and is a **major obstacle to further progress** in mathematics.”

- US National Mathematics Advisory Panel final report, 2006, 2008



We cannot make an effective fractions game

We do not know

optimal pathways

student-specific adaptations



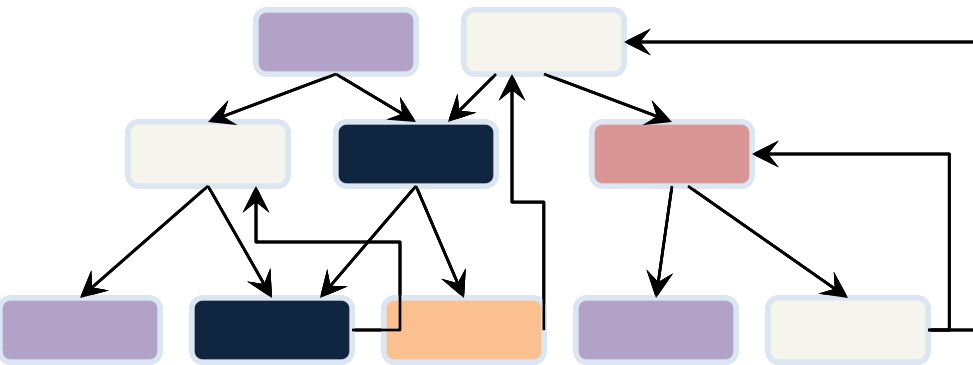
Games for ~~STEM Learning~~

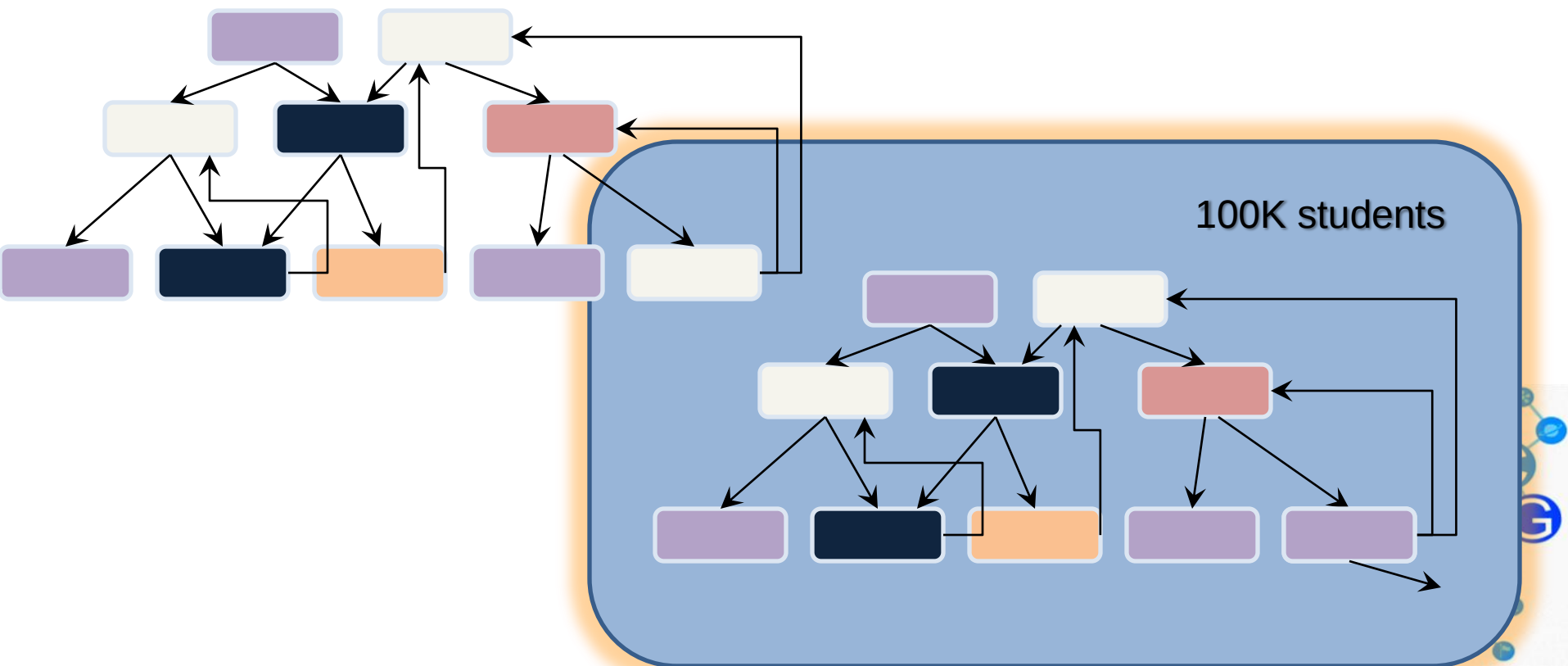
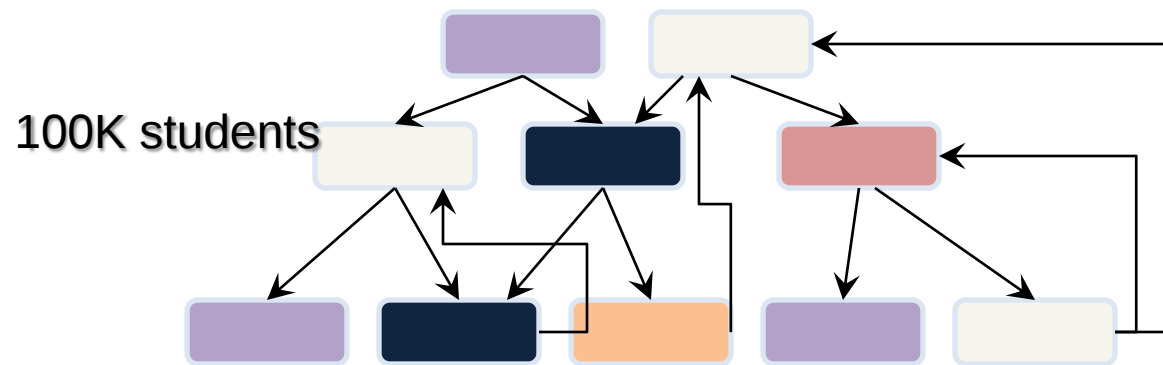


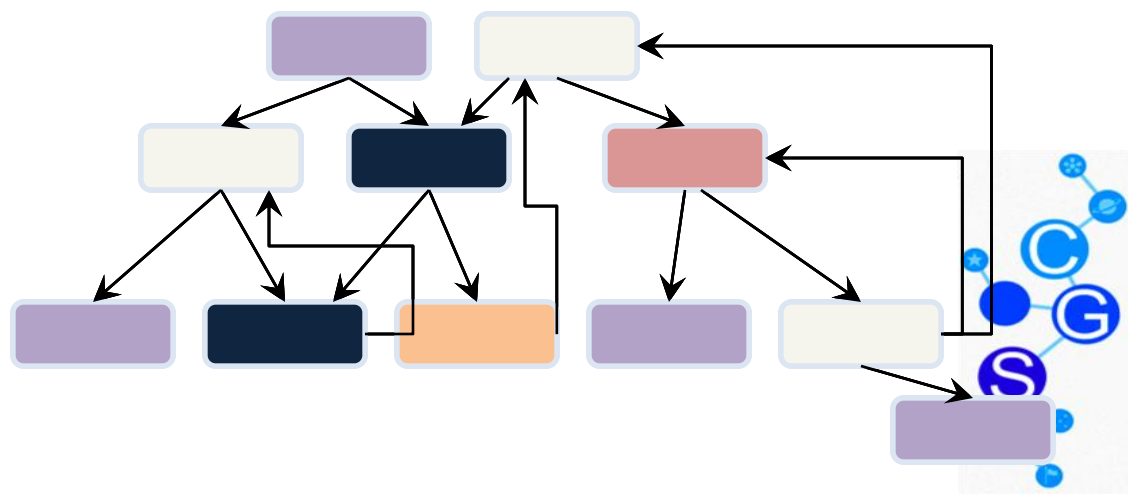
Games for Massive Data-gathering to Optimize Learning Pathways



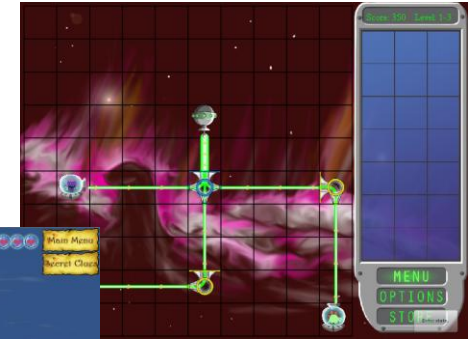
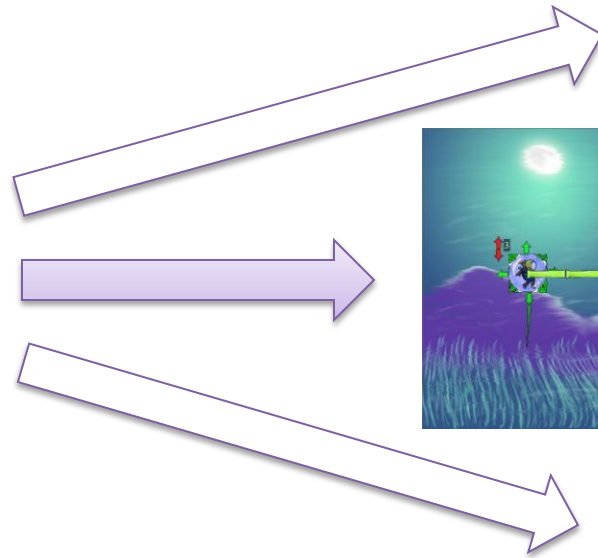
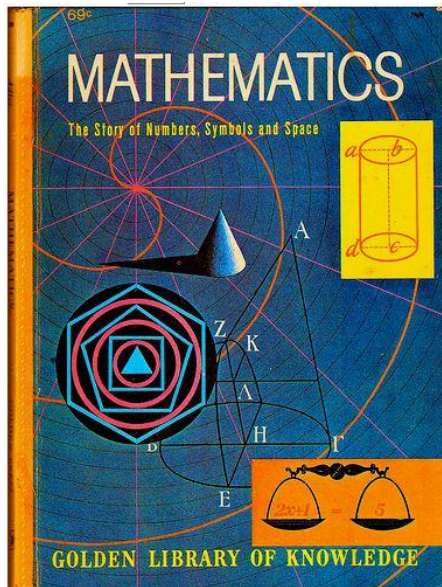
In-game assessment and intelligent tutor refinement





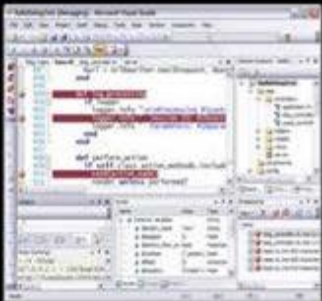


Textbooks -> games



Game For Software Verification





CSFV New Capabilities



SAVE

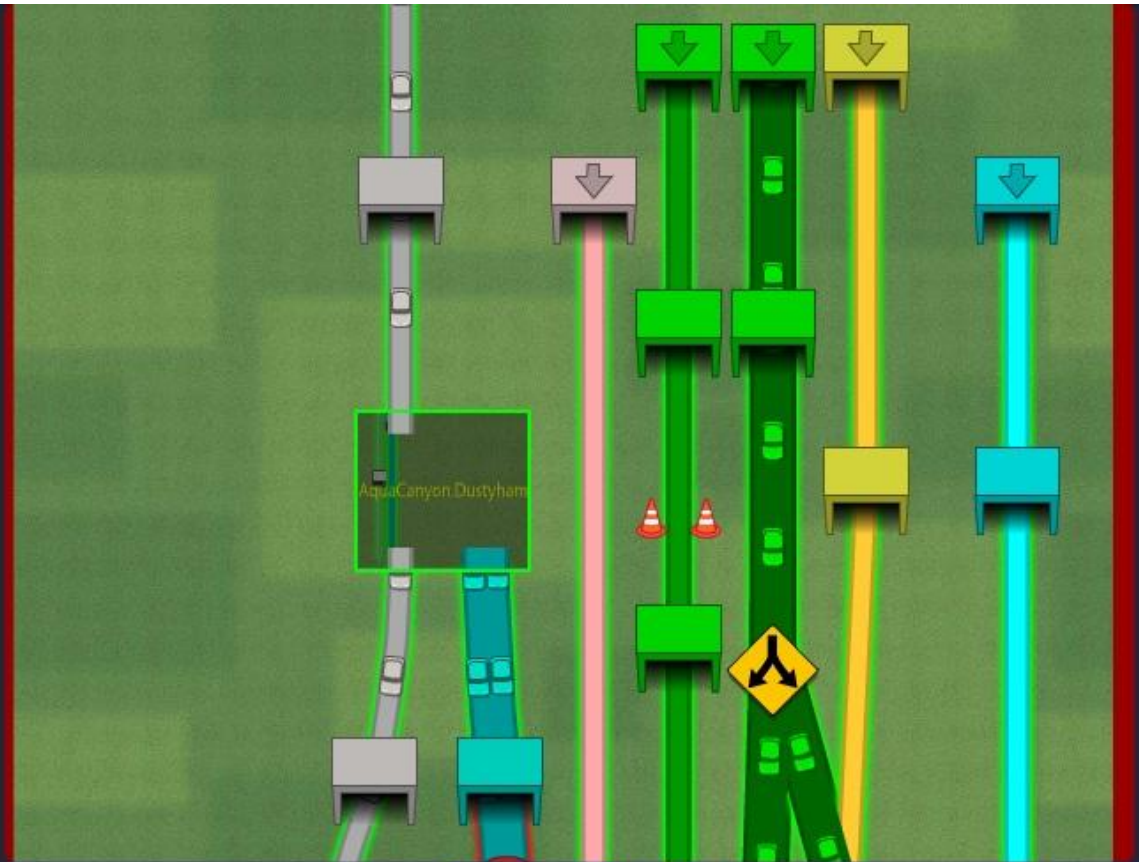
BACK

SUBMIT



SCORE

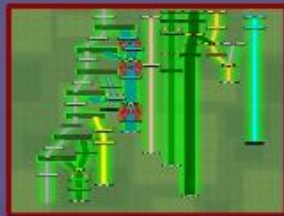
3827



AquaCanyon.OddCorner



AquaCanyon.Harshville



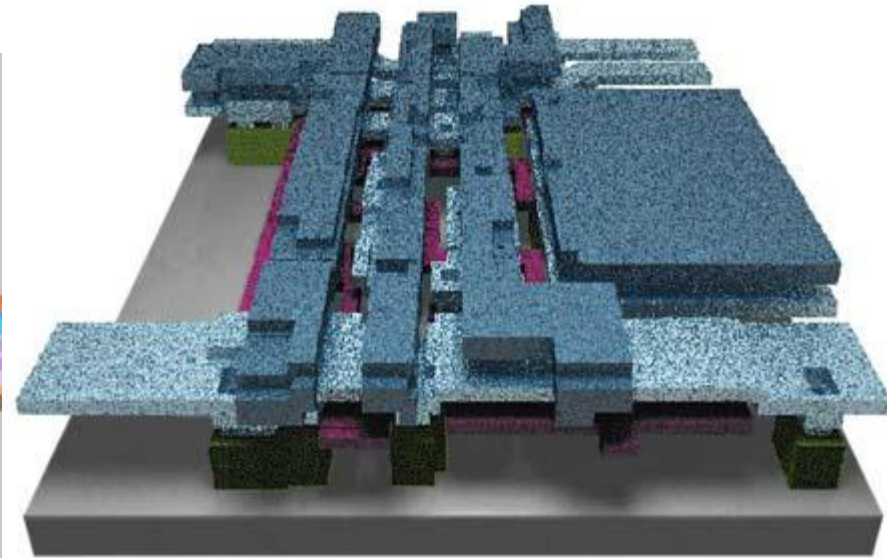
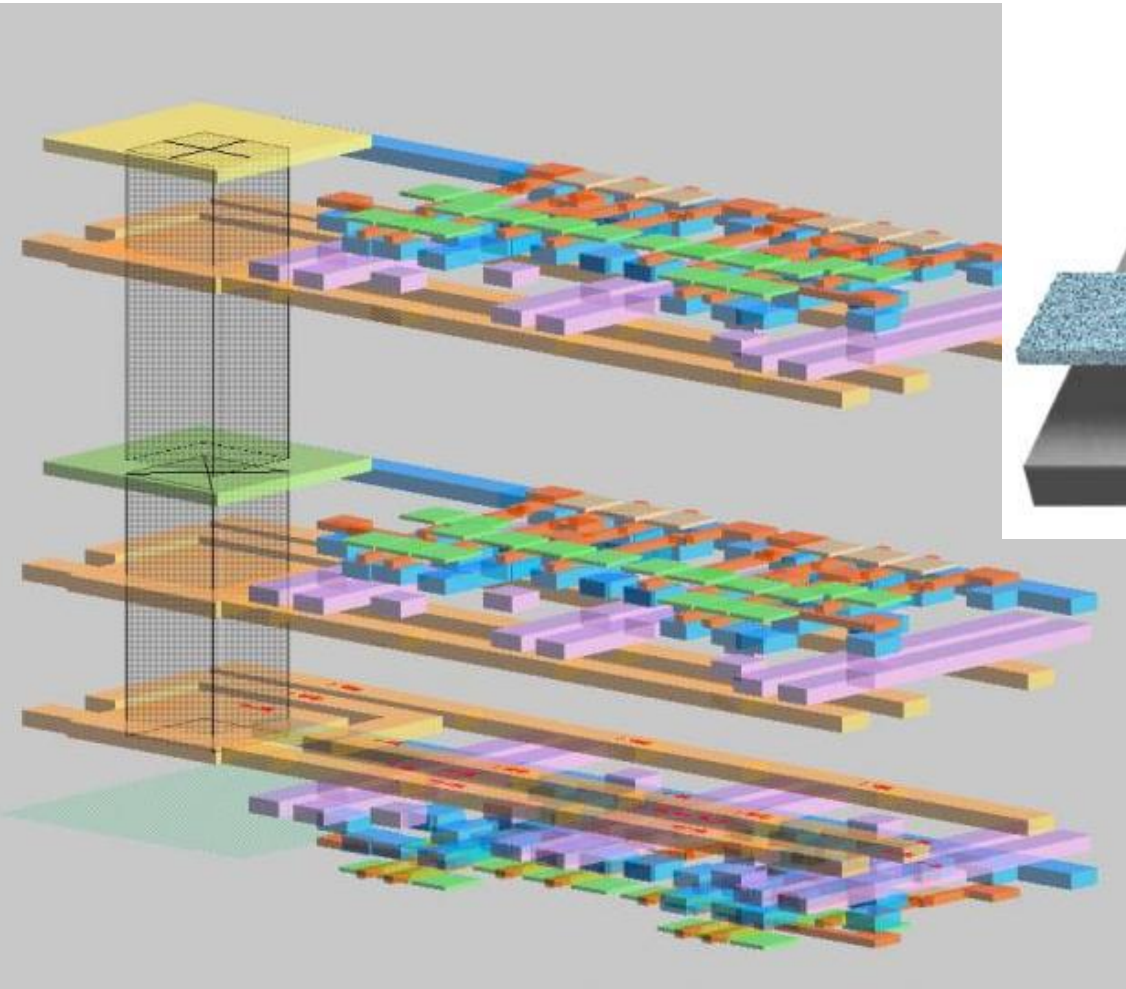
AquaCanyon.Madton



AquaCanyon.WearyDepot



Chip Layout Design



Thank you

Contact:

zoran@cs.washington.edu

