EVE ONLINE™

GAMES for good

BORDERLANDS SCIENCE

Emily Martin, Lucy Mao, and Julia Rozanski

Lab of Jérôme Waldispühl: Renata Mutalova, Parham Ghasemloo Gheidari, Roman Sarrazin-Gendron, Alexander Butayaev

Eve Online: Learning Immunology Clustering through Video Games

? Can we leverage human pattern recognition and MMORPGs to help cluster highly domain specific information and uncover similarities between human behaviour and classical clustering algorithms?

DATA

Flow cytometry data gathered from the protein structures of the Covid-19 virus was implemented as a clustering task in game for players to solve. Their solutions were then overlapped and cleaned for use as training data.

Flow cytometry: a technique to analyze properties of individual cells through a laser-based detection system

Flow Cytometry Data

Player solutions overlap

Cleaned player solutions

METHOD

Creating masks as well as extrapolating other perceptual data from player solutions to train a U-Net model on image segmentation tasks to mask out clusters found in images.

PASSED

Players complete in-game task
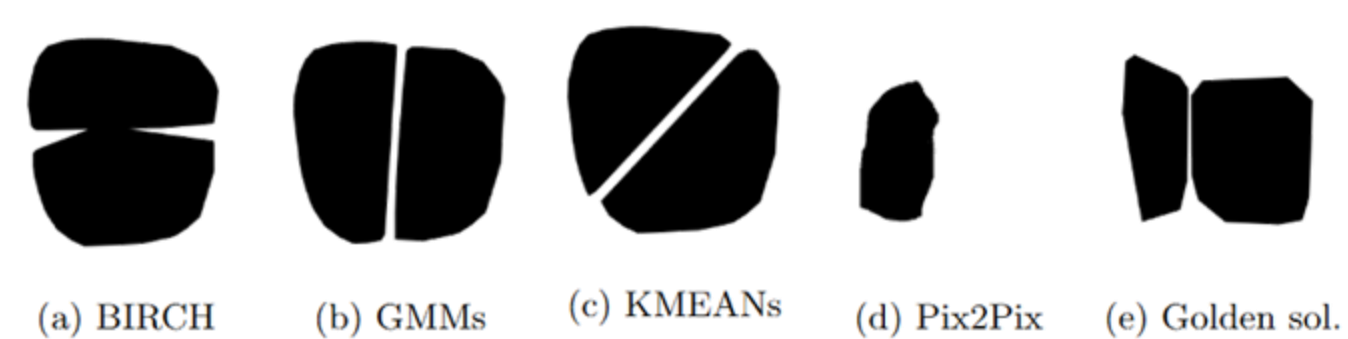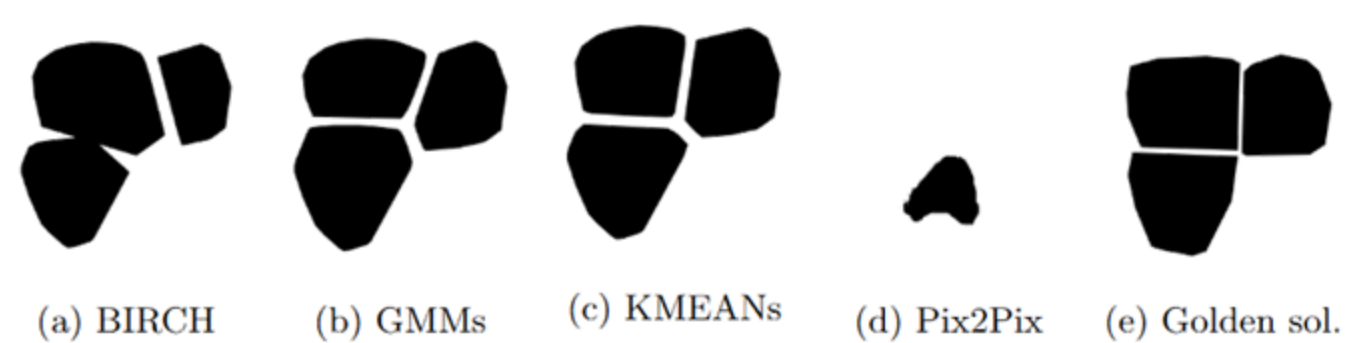
Collect player data

Clean Data

Train U-Net Model
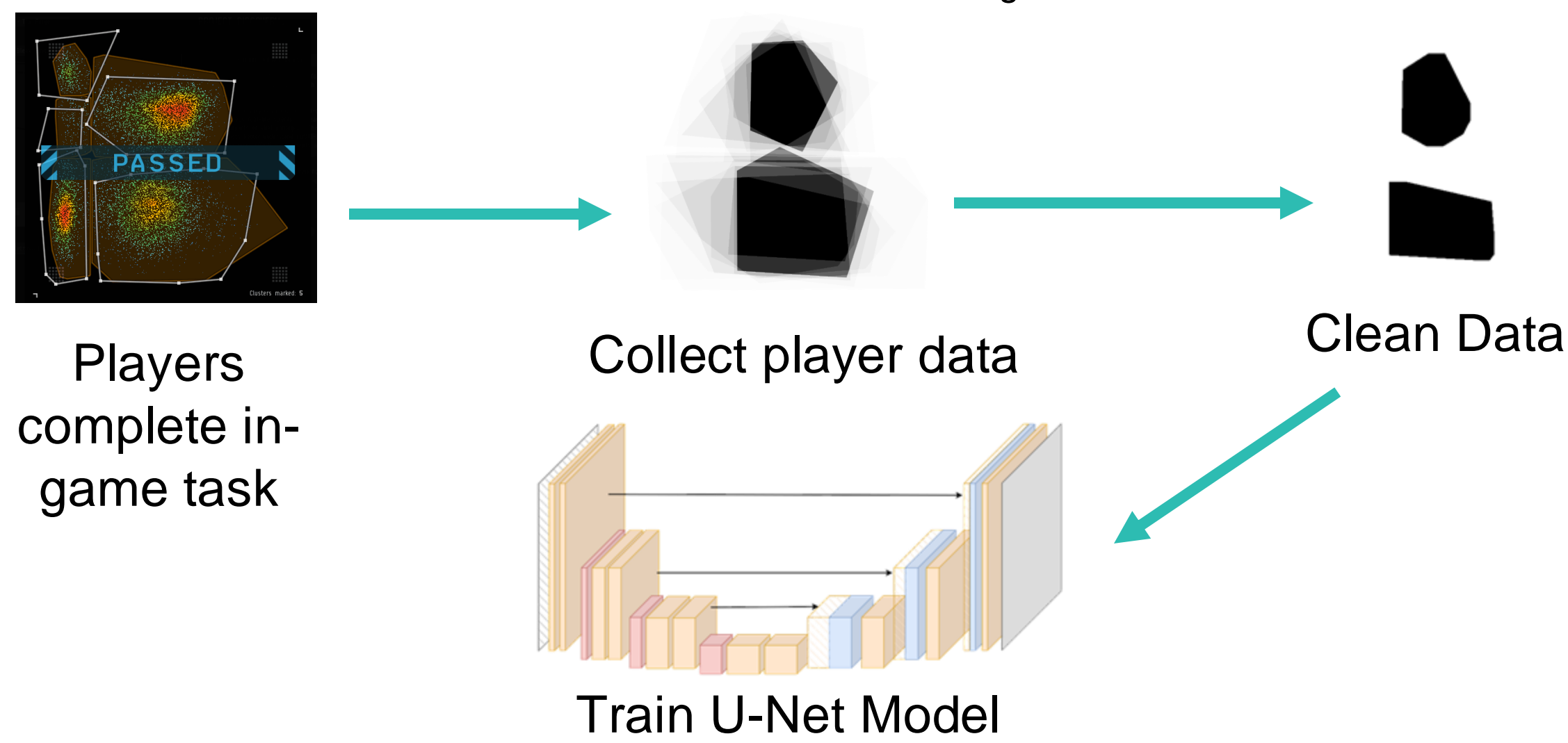
Classical Clustering Results
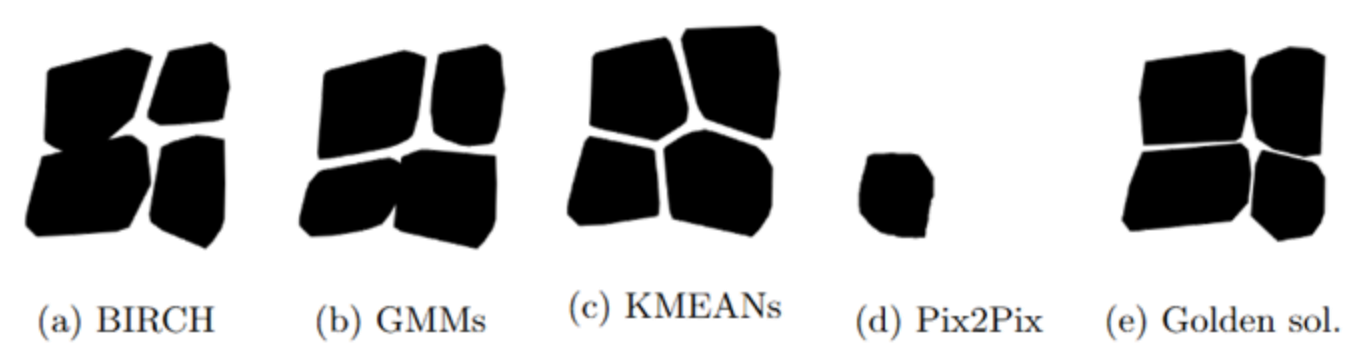
Clustering was done for images with different number of clusters. The results were compared against a conditional generative model—which was one of the first iterations of imitation learning, that did not produce good results—and the clusters hand drawn by domain experts. The findings showed mixed results

(a) BIRCH (b) GMMs (c) KMEANS (d) Pix2Pix (e) Golden sol.

Figure 2: Two Clusters

(a) BIRCH (b) GMMs (c) KMEANS (d) Pix2Pix (e) Golden sol.

Figure 3: Three Clusters

Images	BIRCH	GMMs	KMEANs	Pix2Pix
Image 1	0.853	0.842	0.824	0.414
Image 2	0.902	0.901	0.899	0.146
Image 3	0.932	0.832	0.834	0.253

Table 1: Evaluation of the three clustering algorithms using DICE as the metric

Images	BIRCH	GMMs	KMEANs	Pix2Pix
Image 1	0.744	0.842	0.824	0.261
Image 2	0.902	0.727	0.700	0.079
Image 3	0.872	0.854	0.808	0.145

(a) BIRCH (b) GMMs (c) KMEANS (d) Pix2Pix (e) Golden sol.

Figure 4: Four Clusters

Table 2: Evaluation of the three clustering algorithms using Intersection over Union as the metric

U-Net (CNN) Model Results

Two Clusters

Consensus   Prediction

Three Clusters

Consensus   Prediction
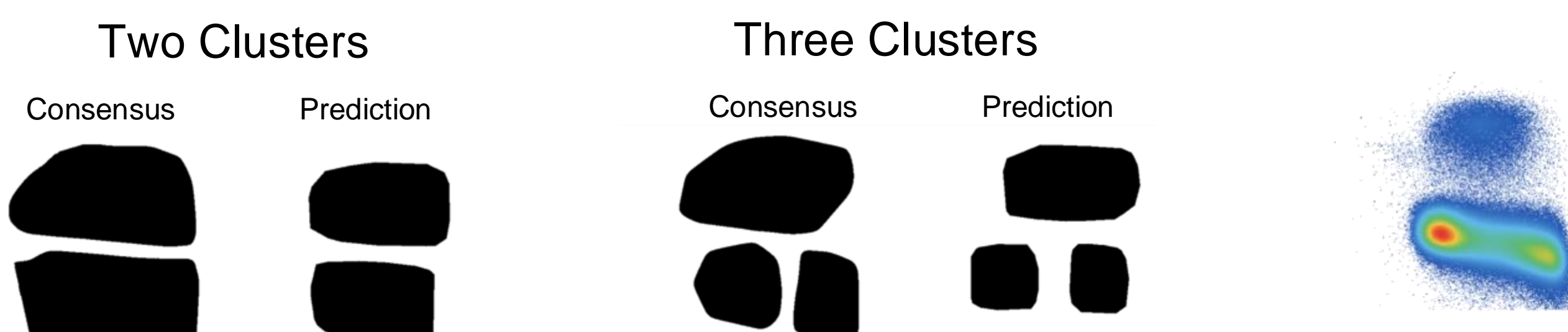
The U-Net model was able to imitate human behaviour that it saw when training on the consensus player data. It surpasses the performance of classical clustering models and better fits to human performance especially in its ability to capture the overlap of the clusters. This result shows that there is something different that is being learned and done by humans that classical clustering models cannot achieve. Additionally, it shows that there is signal that can be captured across human behaviour to be utilized in training models for similar perceptual tasks.

Borderlands Science Automated: Video Game Players Teach AI to Align Genetic Sequences

? Can we use gameplayer-inspired logic from Borderlands Science to develop AI agents capable of producing high-quality multiple sequence alignments (MSAs)?

HAVE YOU EVER NOTICED that some people are very good at digesting certain food and some are not?
The human body struggles to digest fibers and complex carbs, but gut bacteria handle it for us! Without the right microbes, digestion suffers, leading to issues like inflammation, diabetes, or obesity.

How to play?

Score Panel

The guide

Yellow Token

Task
Match colored blocks with **the guide** to score points.

Objective
Beat the **target score**!

Method
Insert **yellow tokens** below the colored blocks to adjust the height of the blocks. Be careful, you only have a limited number of tokens!

From the gut to the game!

The Microsetta Initiative collects stool samples from thousands of participants, and extracts bacterial DNA from it. Next, the bacterial genomes are aligned using computational models. This is a difficult and error-prone process. Thankfully, humans can help correct these errors by playing Borderlands Science!
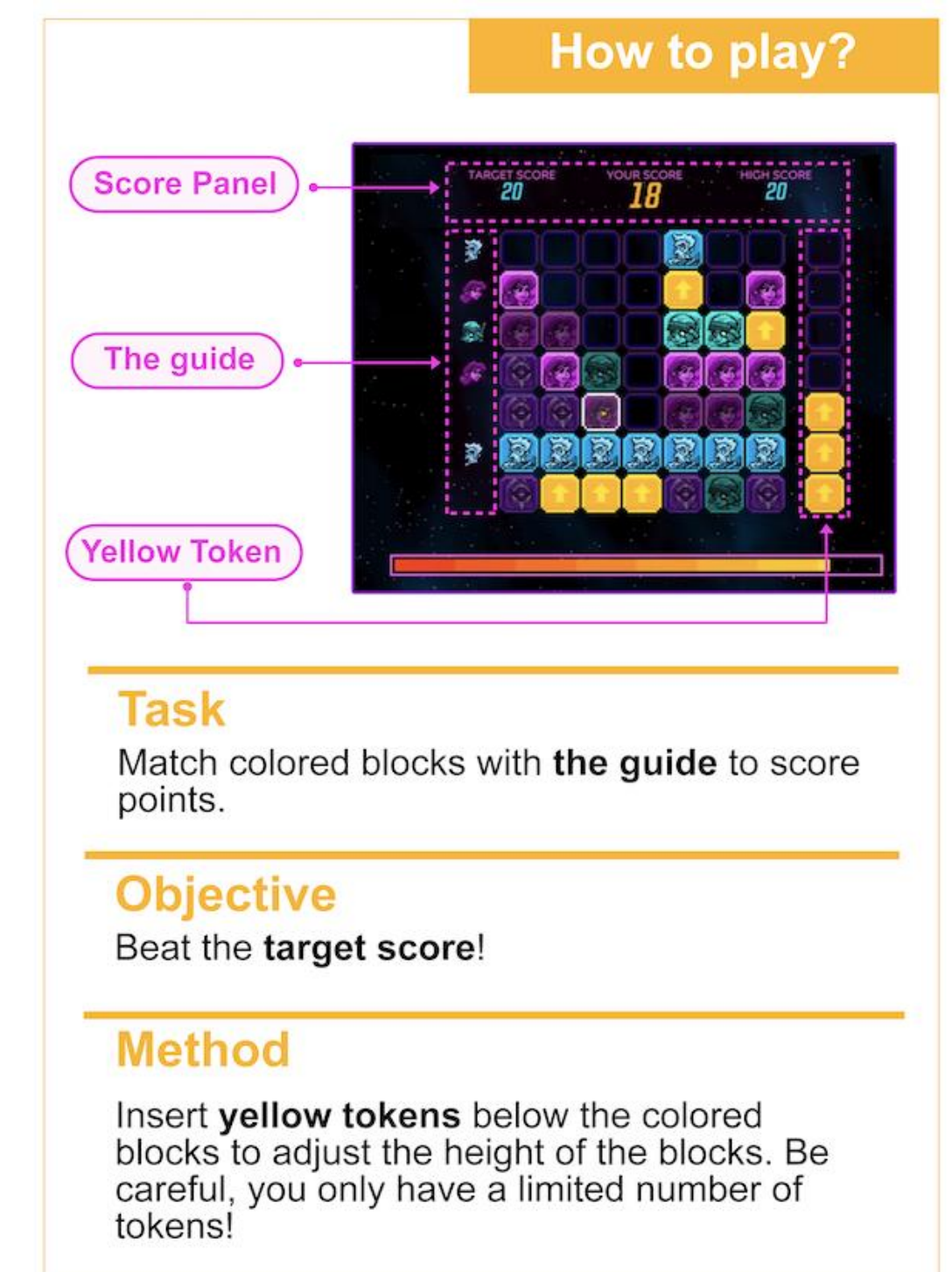
Released in April 2020, Borderlands Science is a mini-game within Borderlands 3 in which players solve puzzles in a virtual arcade booth located within the game's universe. Isn't this fun?!
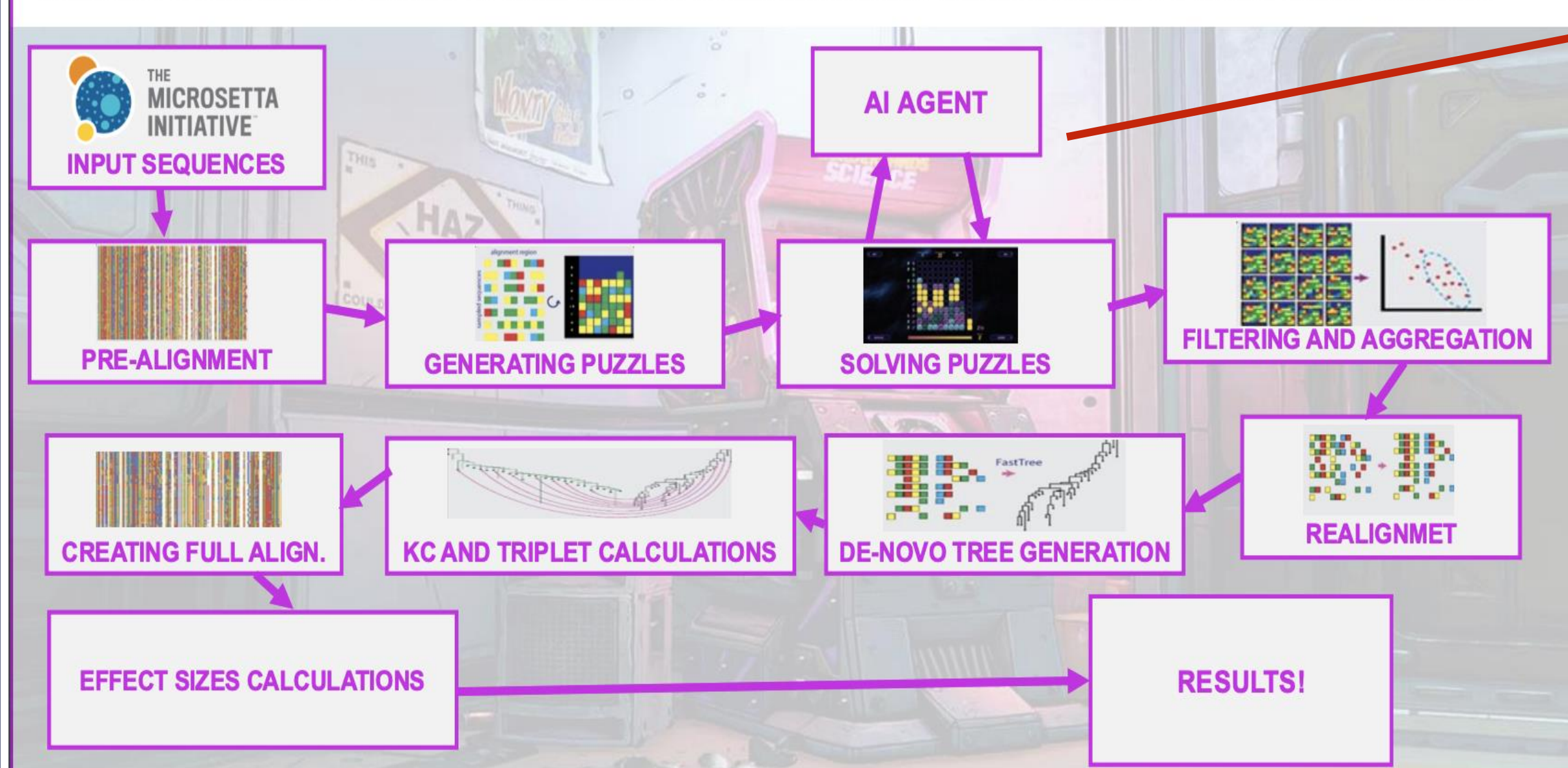
By aligning the colored blocks in the game and trying to get the highest score, players are actually aligning gut microbe DNA and helping to identify their functions!

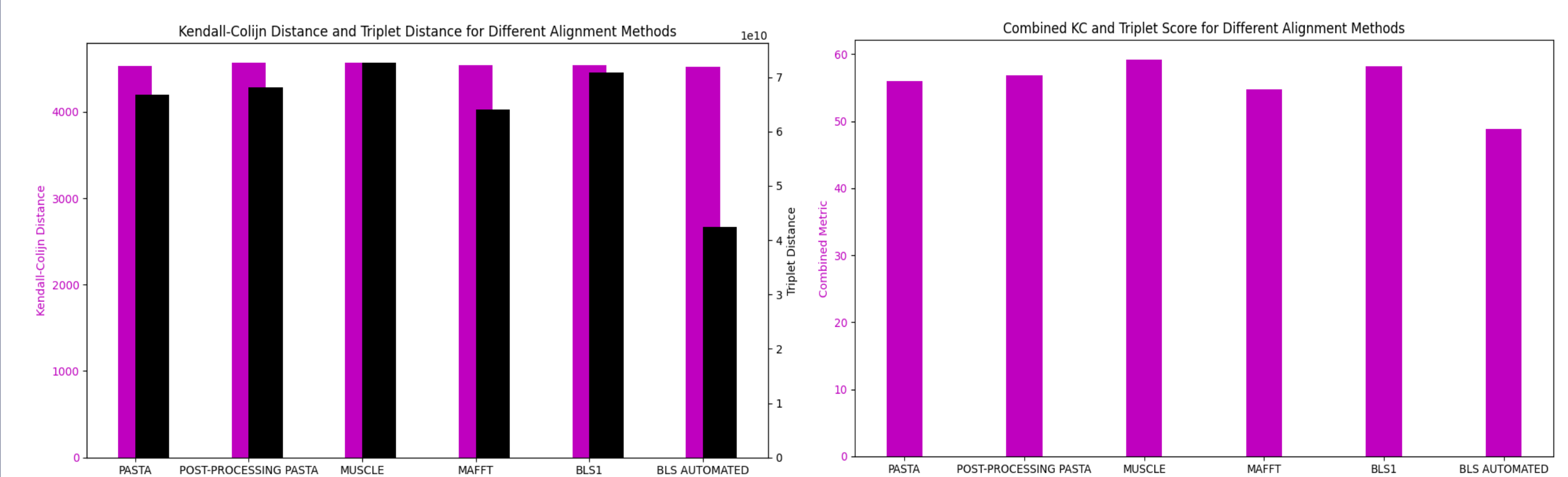Number of users in the first 3 years for notable citizen science games
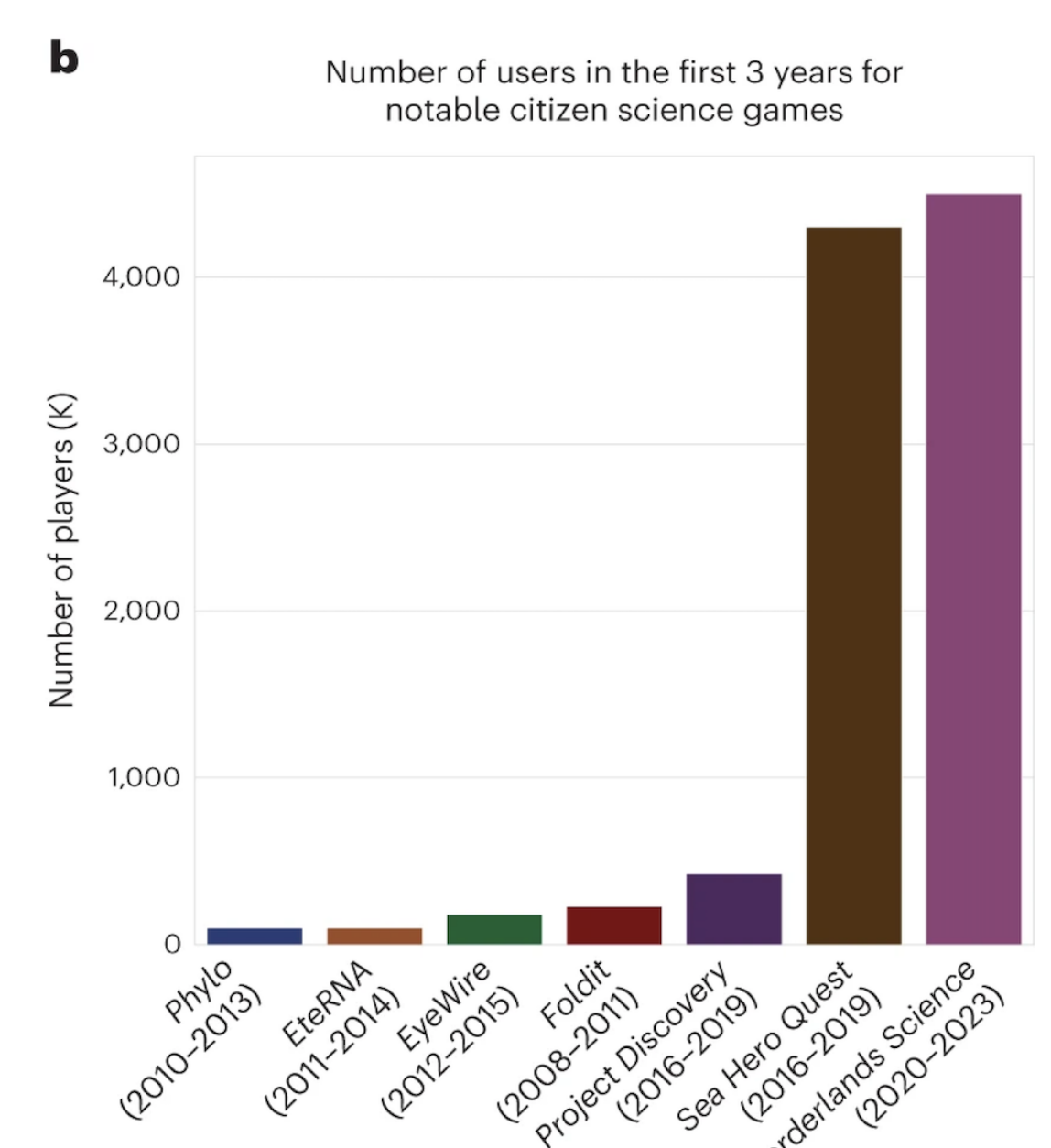
PIPELINE, NOW AUTOMATED!

Below is the pipeline used in Borderlands Science. As our next step, we are aiming to use the AI that we trained on the players to automate the use of the pipeline. This will allow us to increase the quality of previous experiments, as well as enabling the pipeline to solve MSA on **new sequences**!

THE MICROSETTA INITIATIVE
INPUT SEQUENCES

AI AGENT

PRE-ALIGNMENT GENERATING PUZZLES SOLVING PUZZLES FILTERING AND AGGREGATION

CREATING FULL ALIGN. KC AND TRIPLET CALCULATIONS DE-NOVO TREE GENERATION REALIGNMET

EFFECT SIZES CALCULATIONS RESULTS!

We have trained our AI agent on the highest quality solutions from the game!

Results:
Our automated pipeline using the AI agent trained on high-quality player solutions from Borderlands Science beats the performance of Borderlands Science players and state-of-the-art alignment algorithms on the Borderlands Science dataset.

Kendall-Colijn Distance and Triplet Distance for Different Alignment Methods

Combined KC and Triplet Score for Different Alignment Methods

A new citizen science paradigm!
Borderlands Science and Eve Online (or Project Discovery) demonstrate the potential of embedding scientific discovery games within popular commercial titles. Pre-existing player bases unlock new opportunities, with **millions of players,** problems that were previously unsolvable can now become viable research targets through citizen science!

In 4 years, over 4 million players have submitted over 120 million solutions to more than a million puzzles. This amounts to more than 700 work-years!

PASSED   64%
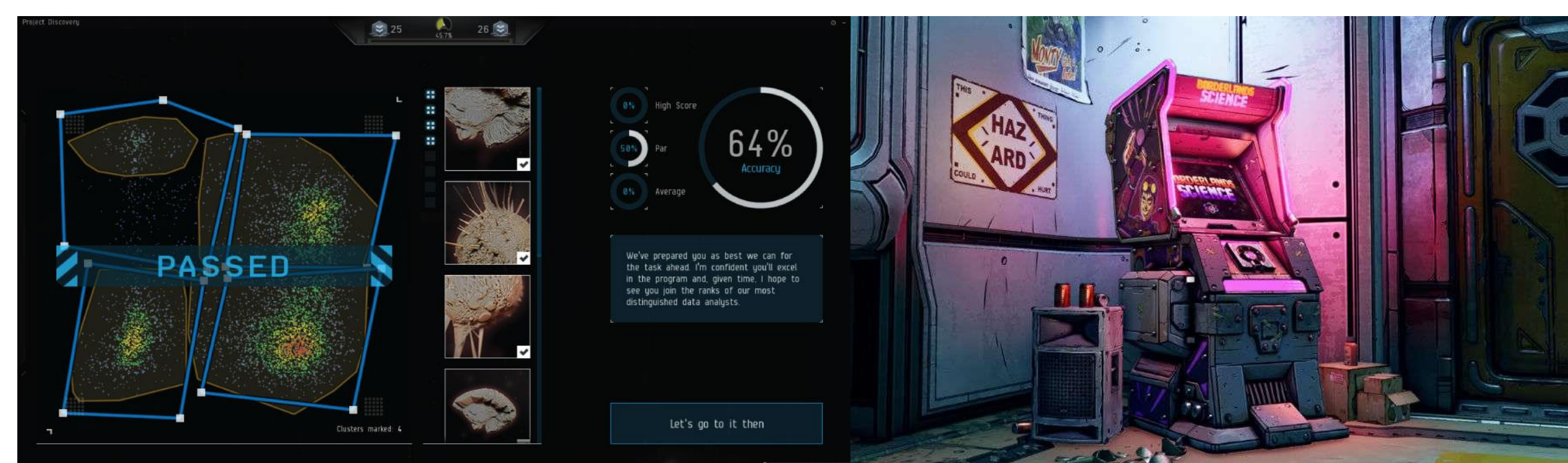
Our mission:
We develop new ways to use popular games to solve scientific problems and make valuable research progress. The video game of tomorrow becomes a responsible way to participate in resolving scientific and social problems. They connect and build trust of society in science and game industry.

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