

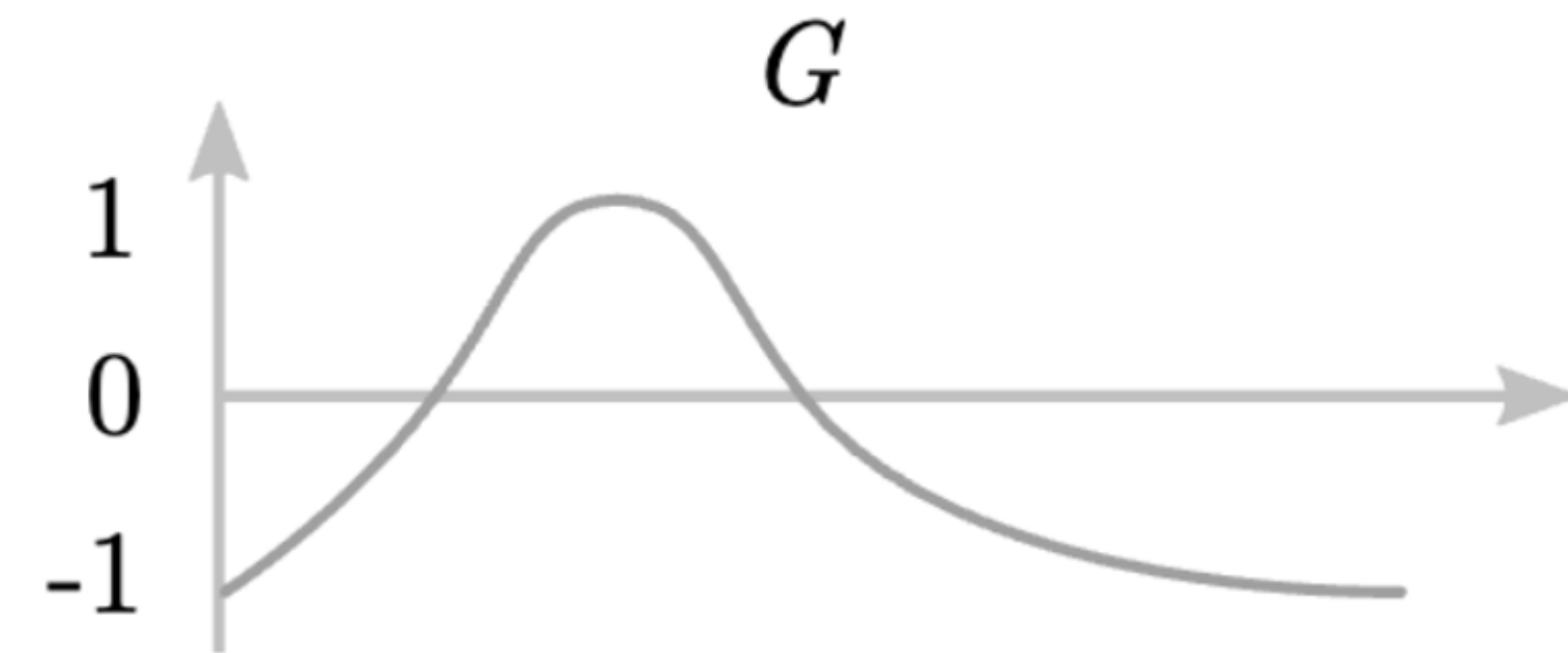
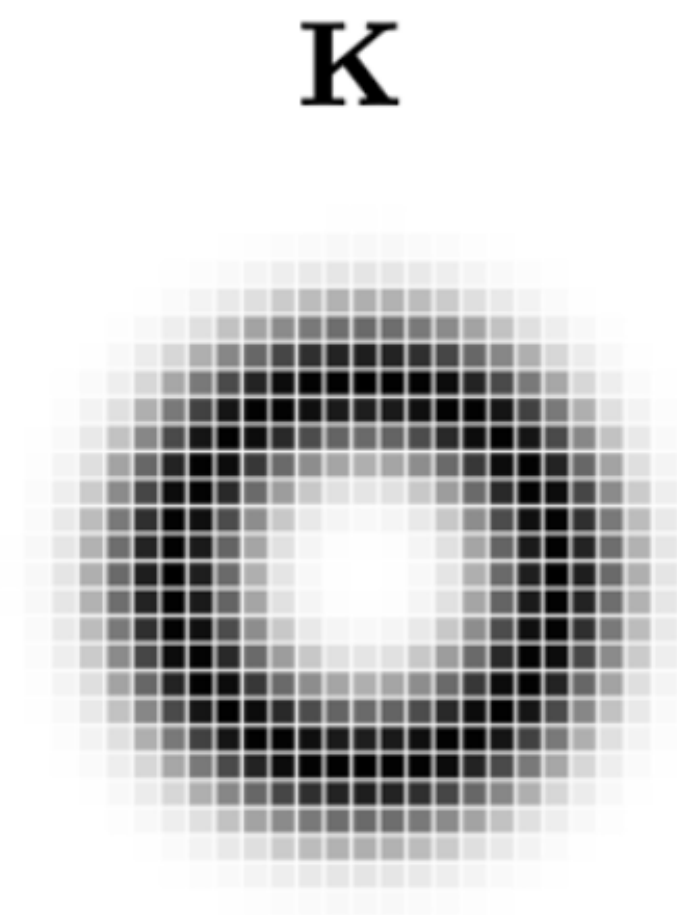
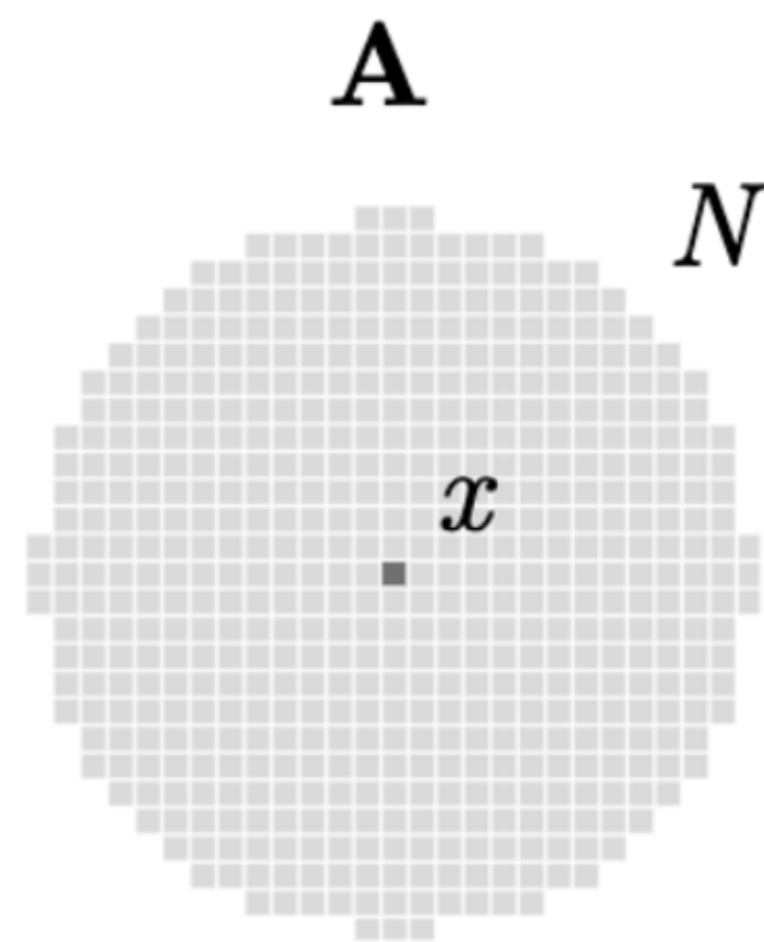
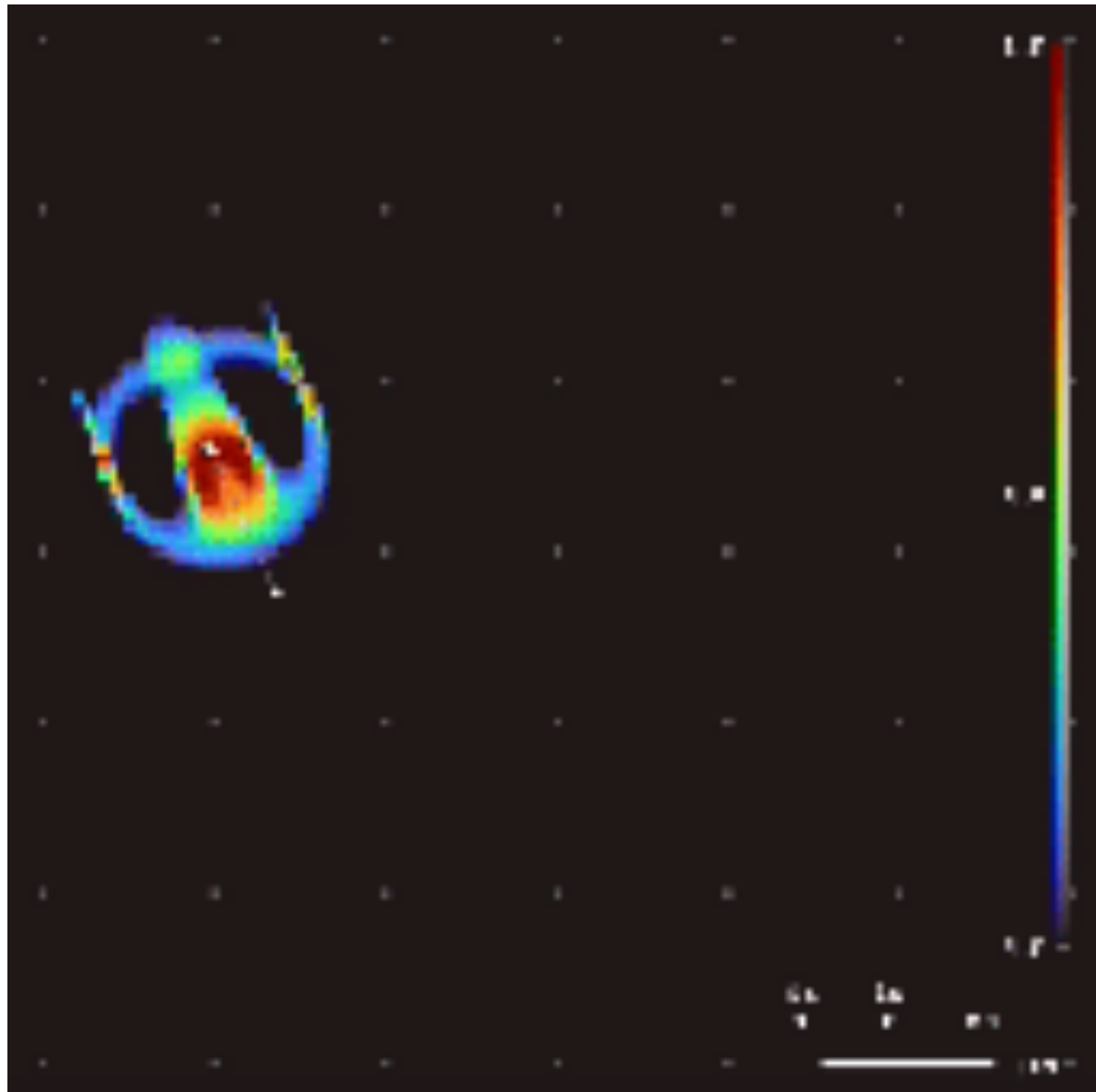
Toward Artificial Open-Ended Evolution within Lenia using Quality-Diversity

Maxence Faldor, Antoine Cully

Imperial College London

Lenia

Updating cells based on neighbors



“Open-ended”

= Endless Evolution

Quality-Diversity algorithm

Find diverse, high-performing solutions across niches,
unlike traditional optimization which seeks one best solution.

Training steps

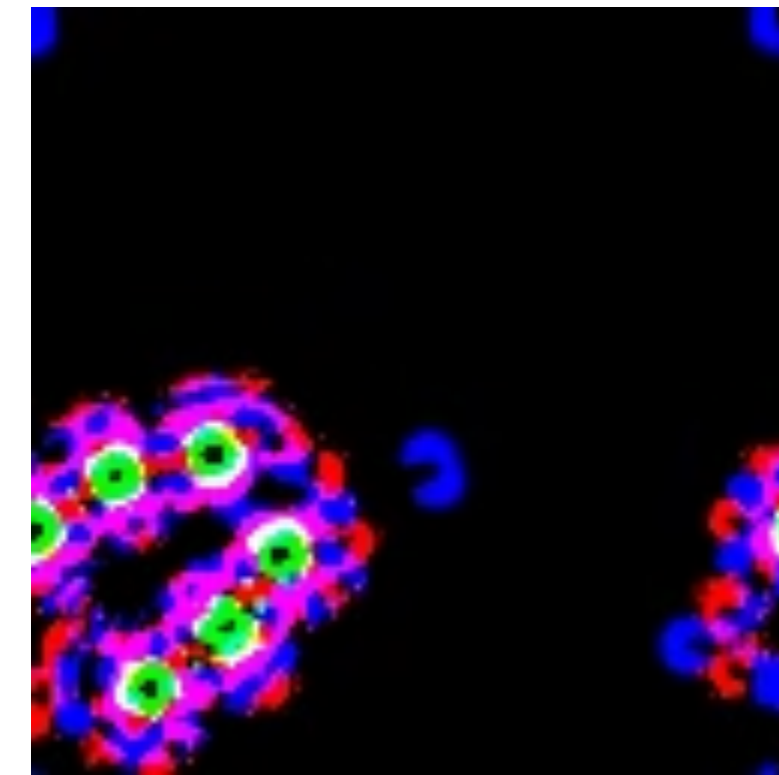
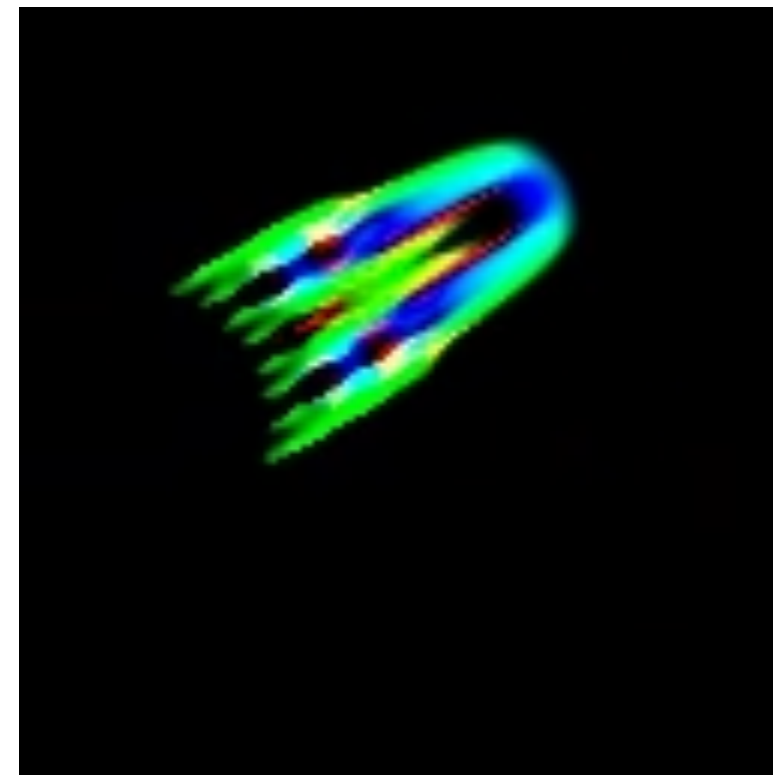
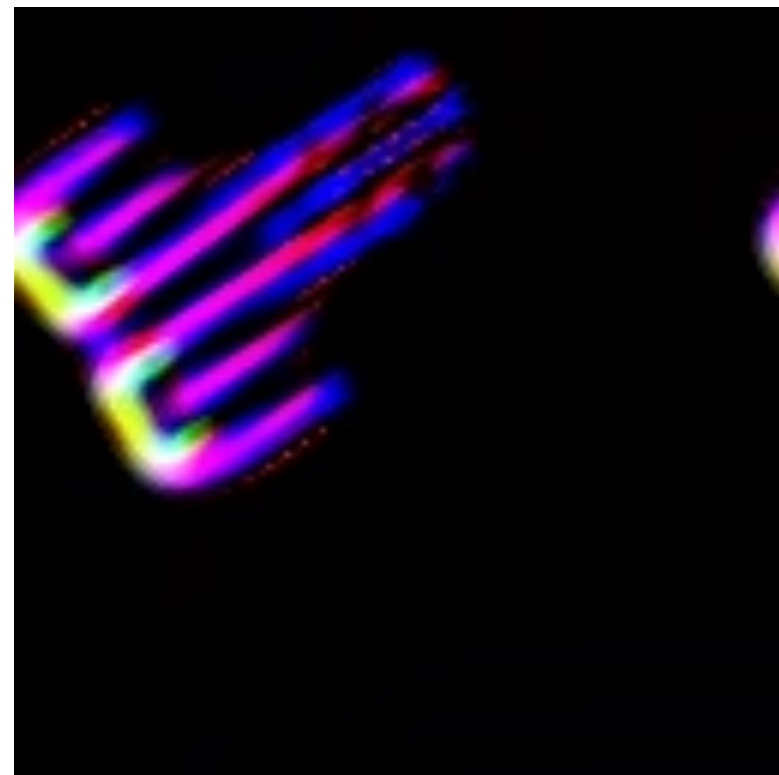
1. Generate initial random solutions.
2. Select high-fitness parents and generate offspring.
3. Evaluate and insert offspring if fitness is better.
4. Repeat.

Producing offspring

Set of kernel parameters

$$\mathbf{x} = \mathbf{x}_1 + \sigma_1 \mathcal{N}(0, I) + \sigma_2 (\mathbf{x}_2 - \mathbf{x}_1) \mathcal{N}(0, 1)$$

$$[0.2, 0.4, 0.6] + [0.5, 0.7, 0.9] = [0.246, 0.443, 0.648]$$

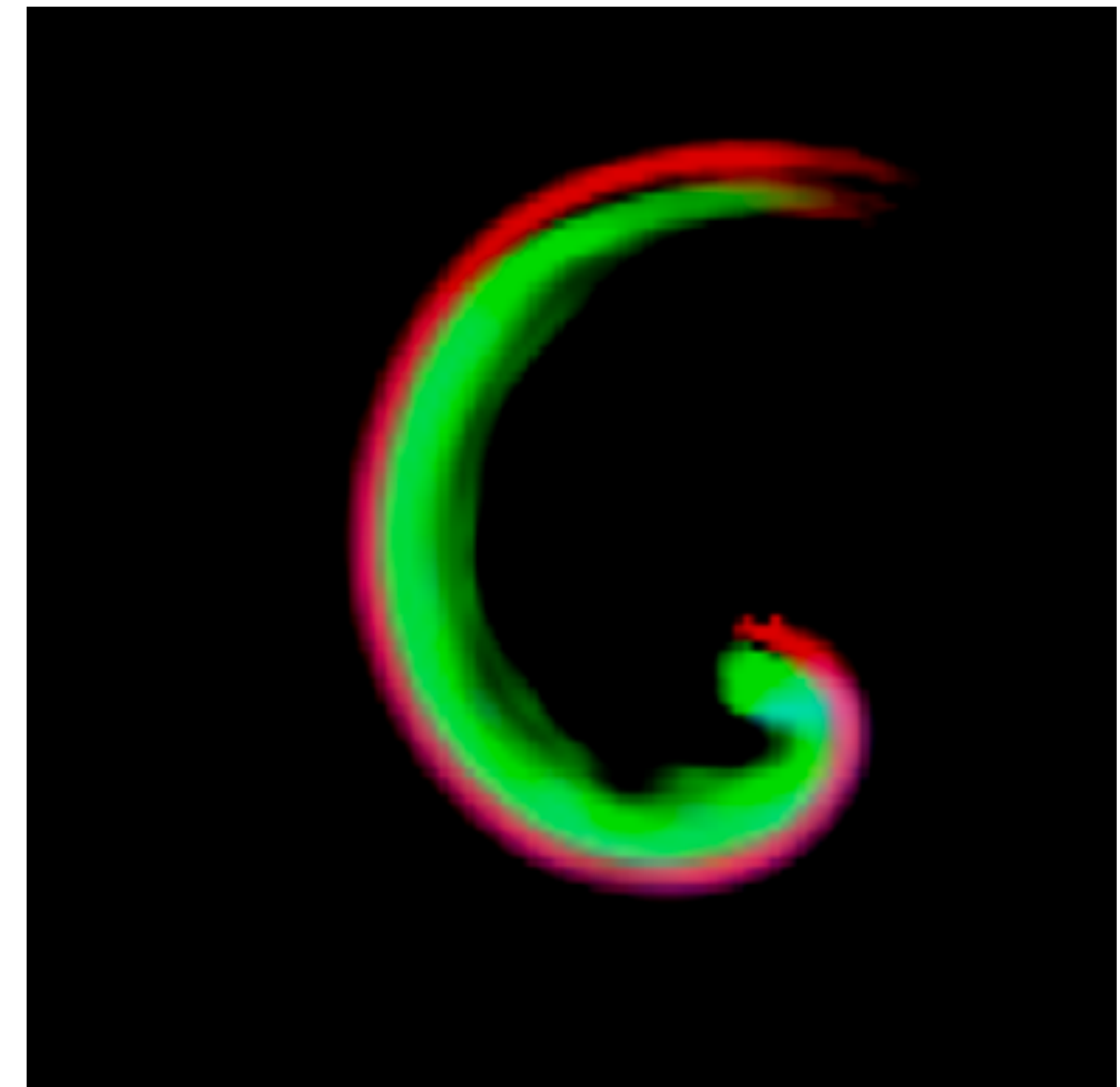


Constraints

- Maximum mass
- Minimum mass
- Mass spread

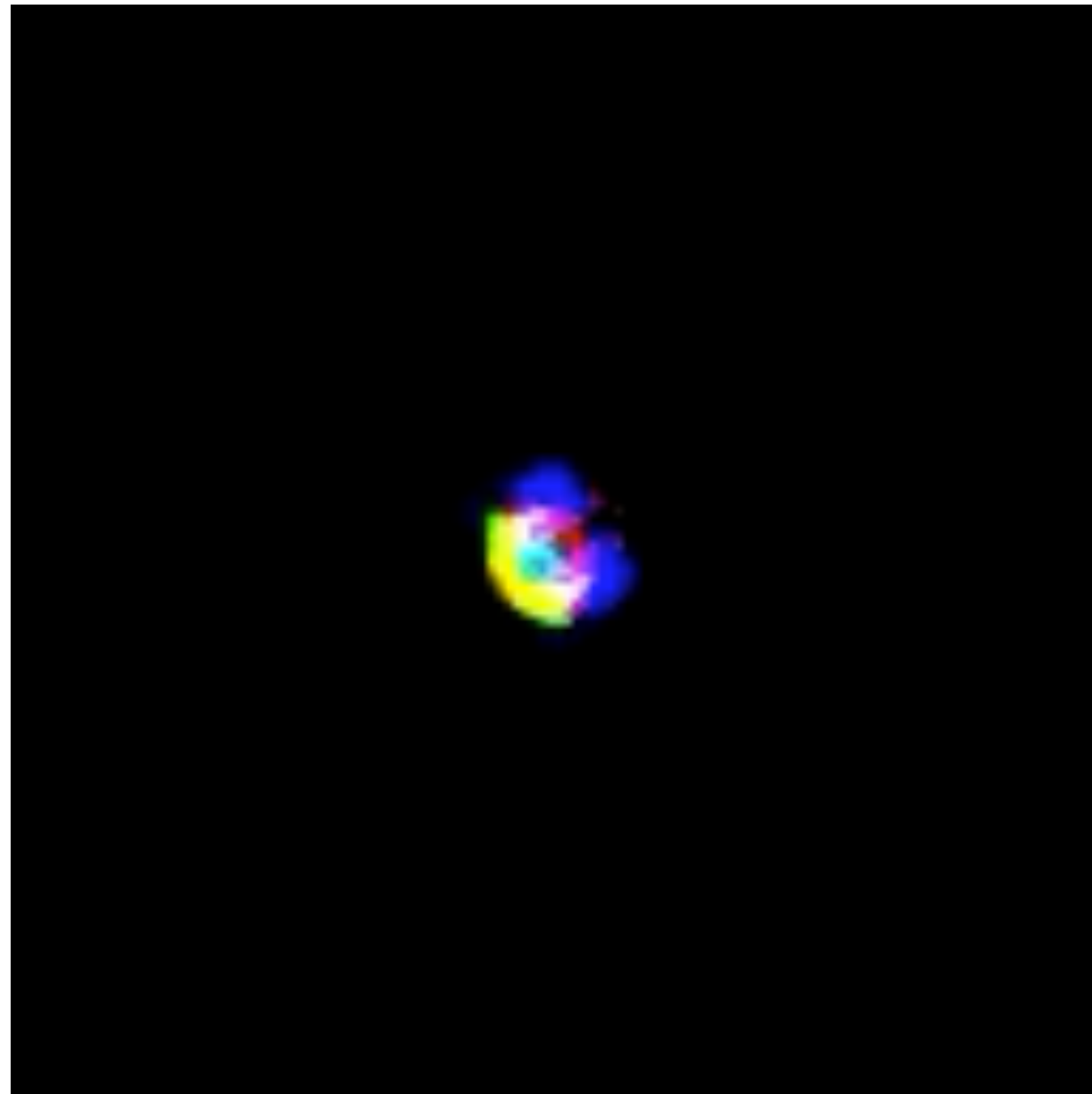
Manual diversity

- **Mass**
sum of all pixel values in the phenotype
- **Velocity**
change in the center of mass
- **Color**
channel proportions
- **Angle**
direction of movement of the center of mass

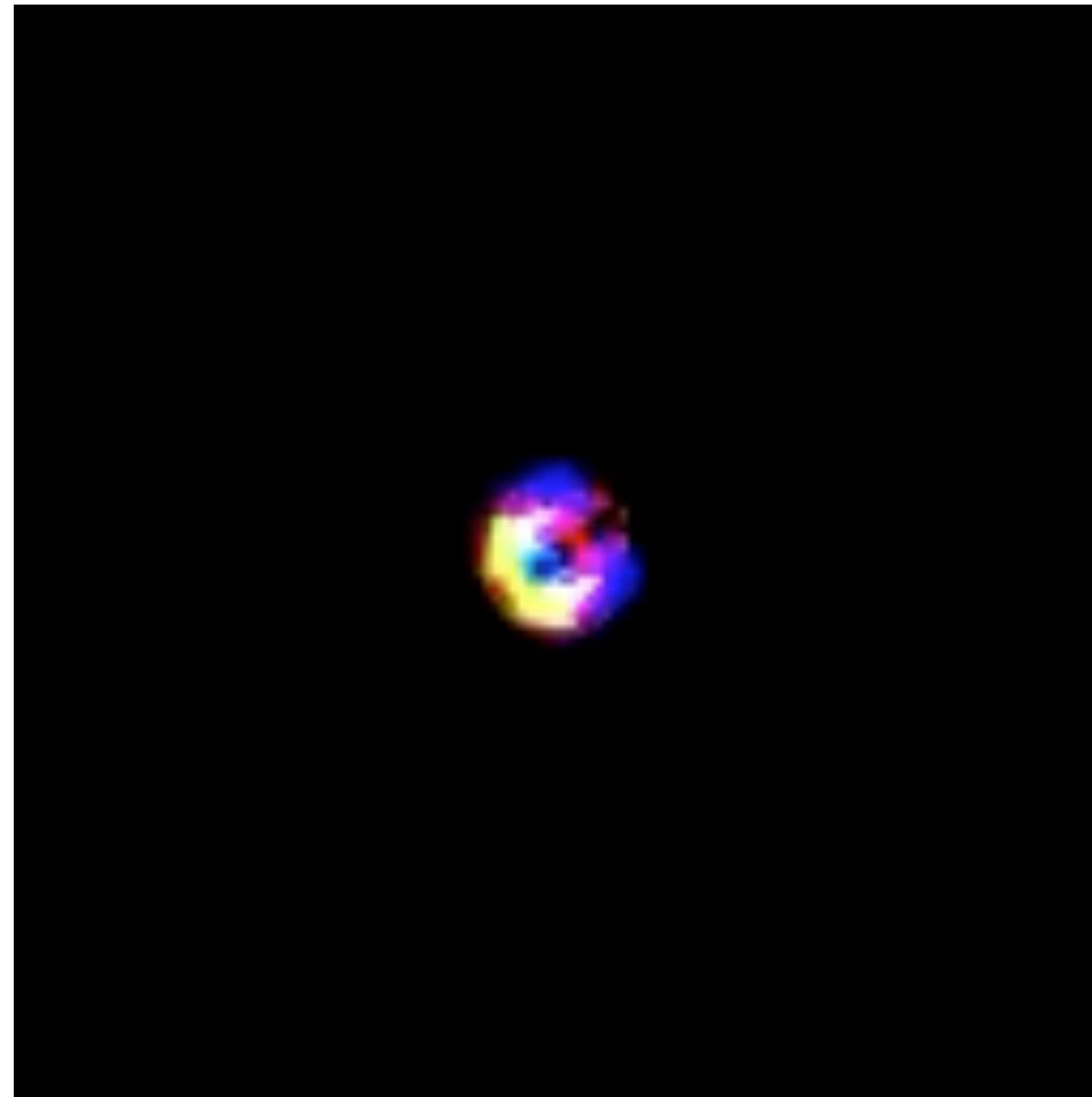


Fitness example

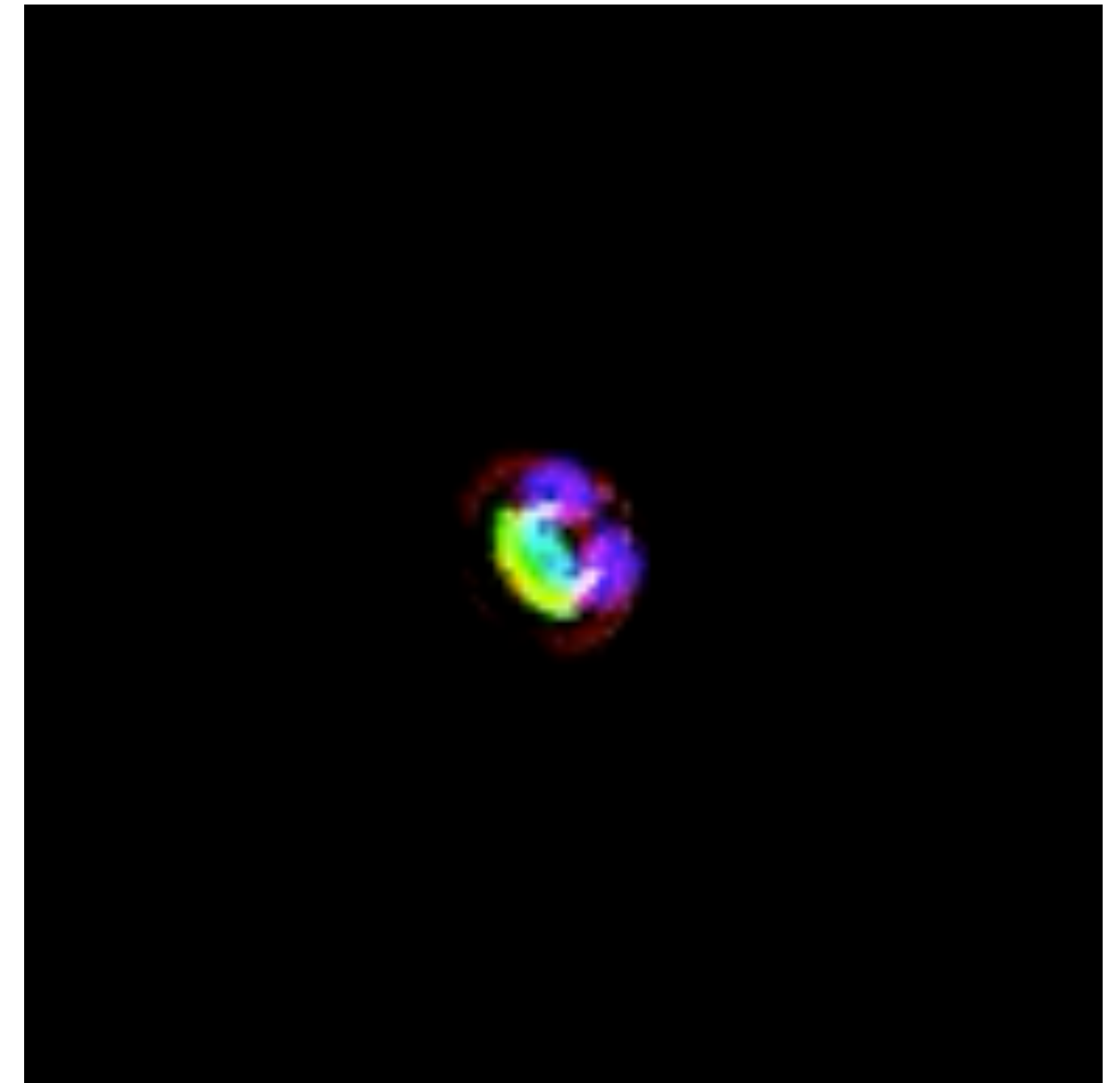
Positive
Mass Variance



Positive
Velocity Average



Negative
Mass Average

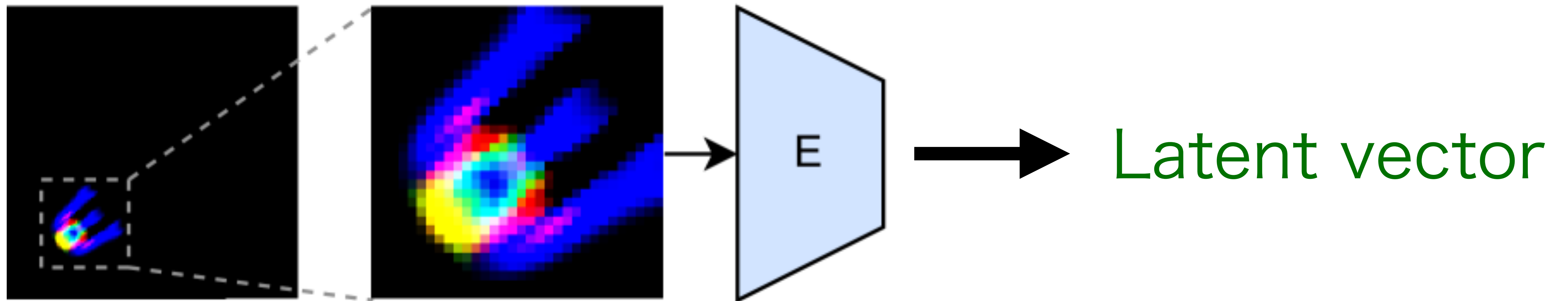


Unsupervised diversity

- Manually specified diversity restricts the breadth of discoverable self-organizing patterns.
- Use QT algorithm to measure diversity, and discover patterns without the need for predefined diversity criteria

Evaluate diversity

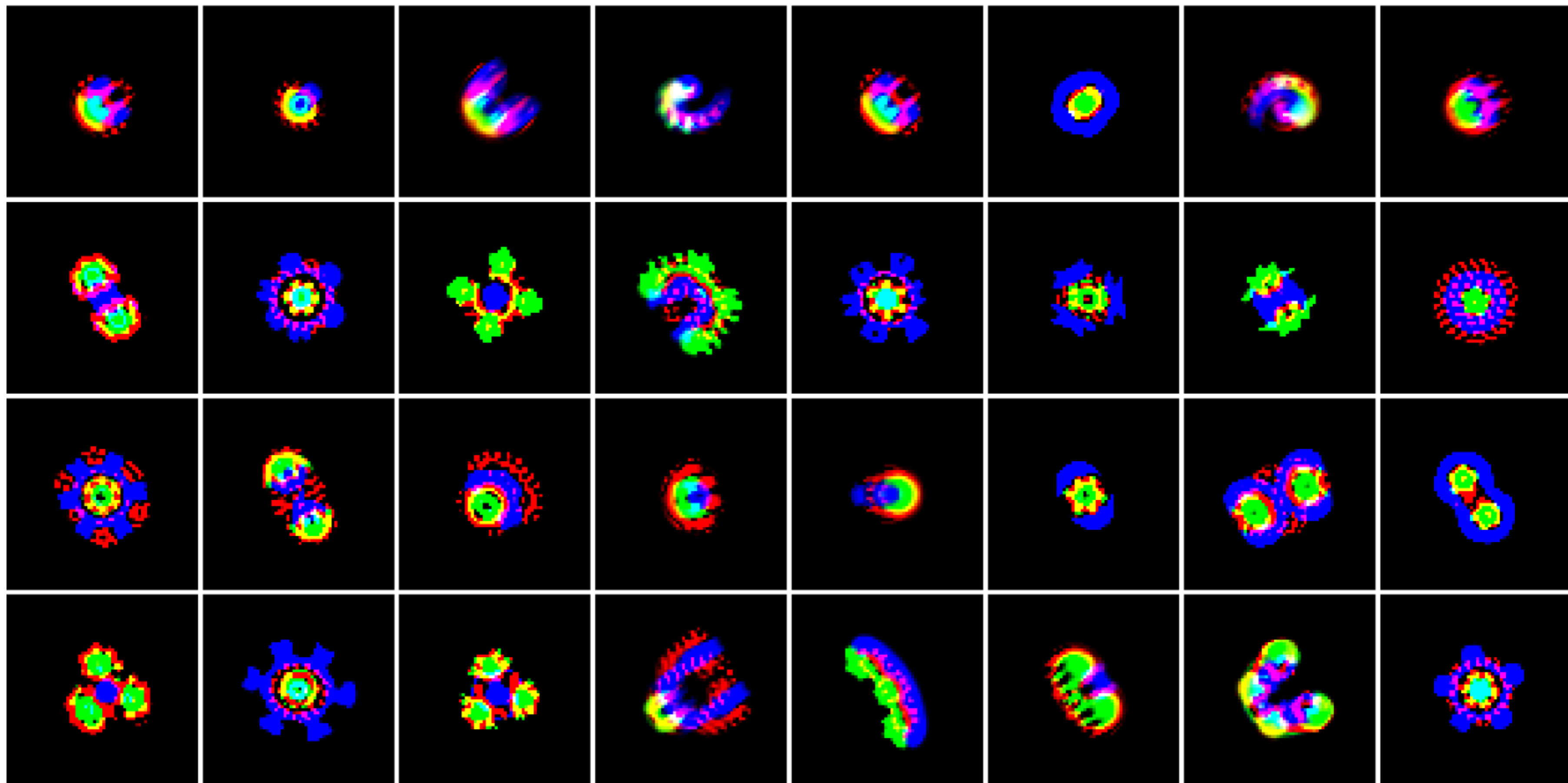
Variational AutoEncoder (VAE)



How to evaluate in unsupervised

- This stability indicates consistent and self-organized patterns.
- Lower variance in the latent space means higher fitness, reflecting stable and organized behavior.

Unsupervised diversity



Thank you for your attention.