Temperature-based Characterization of Process Variation

Ivan, Mattias, Petru, and Zebo
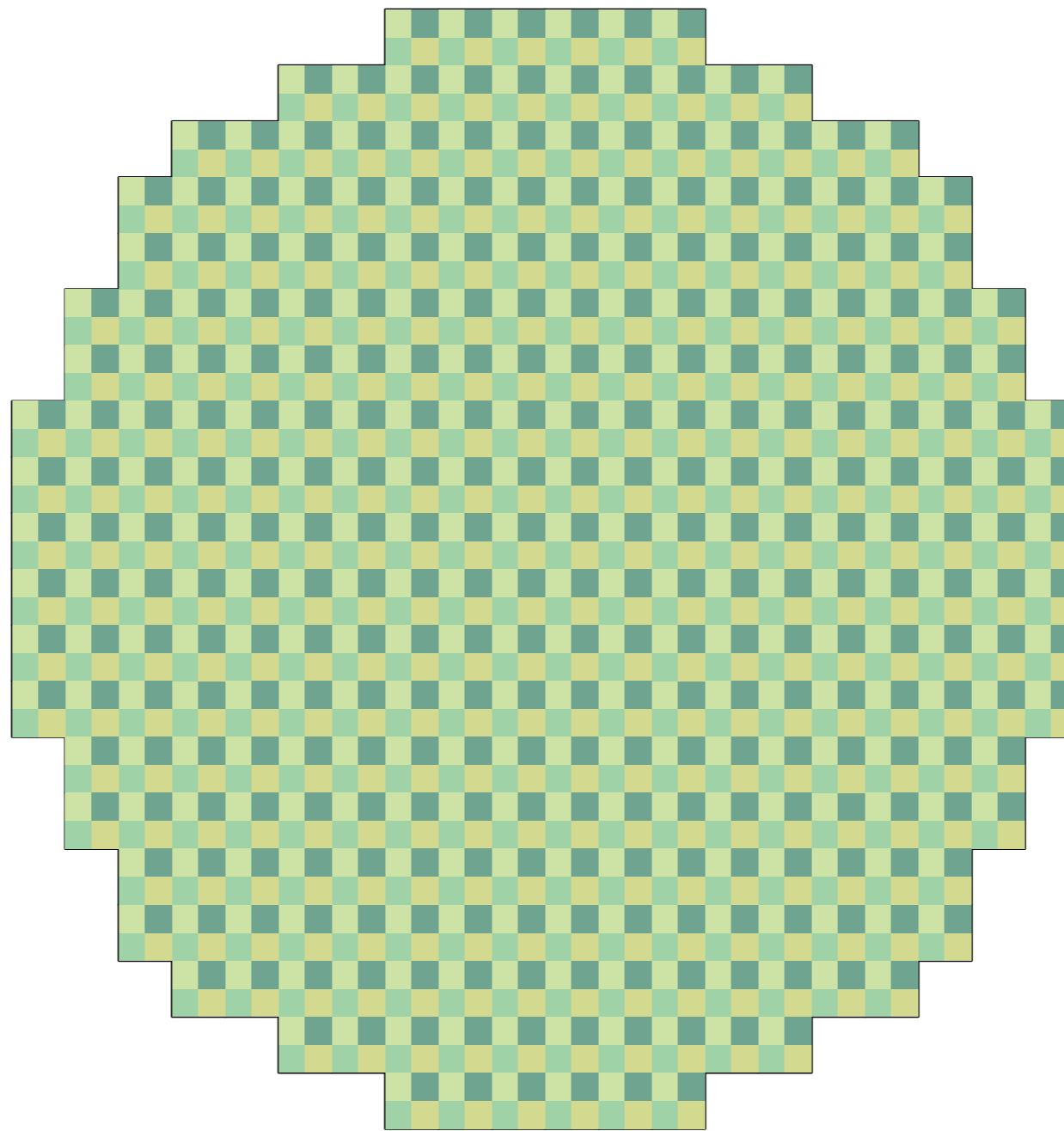
Linköping University

June 2013
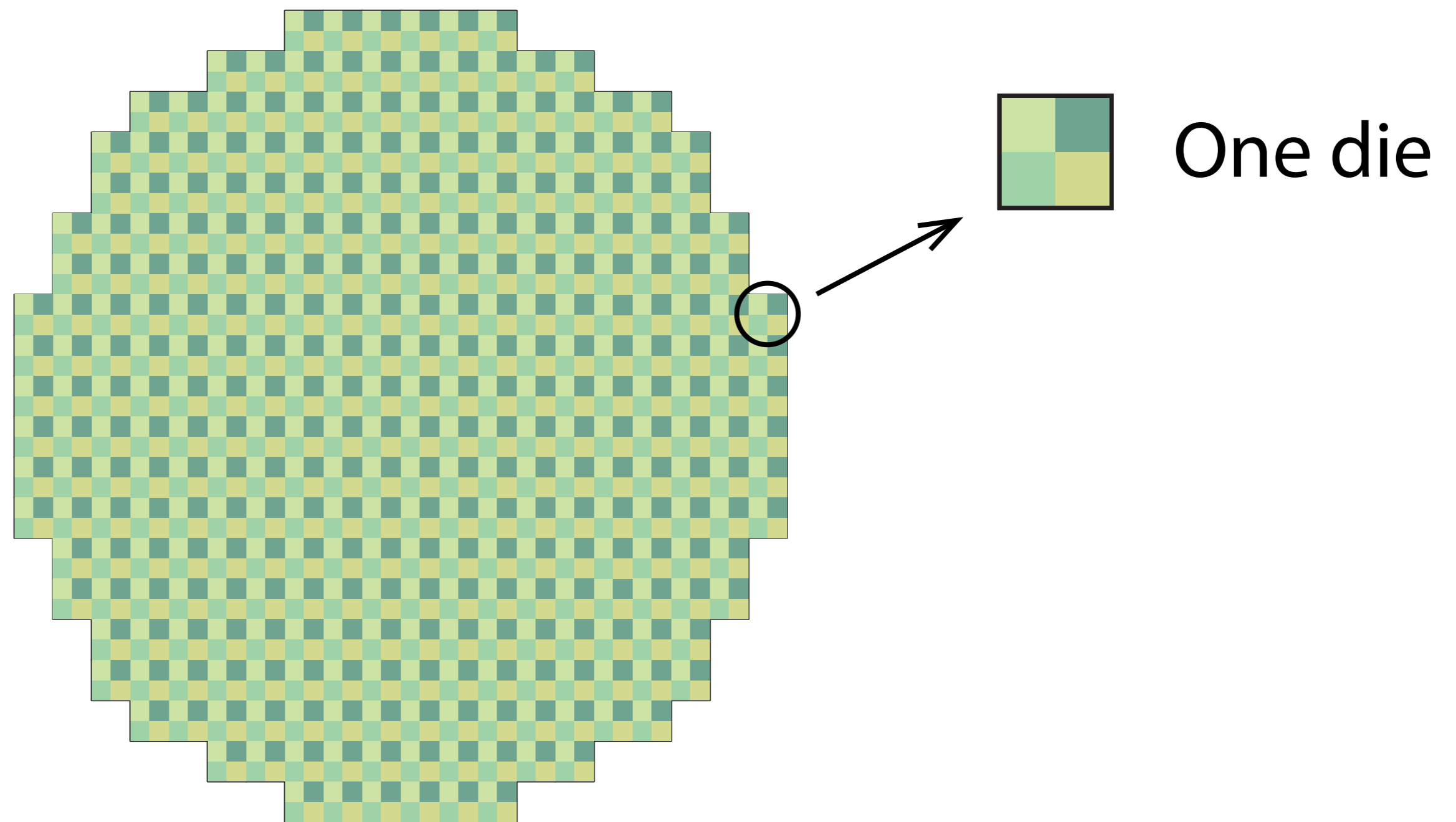
Outline

1. What?
2. Why?
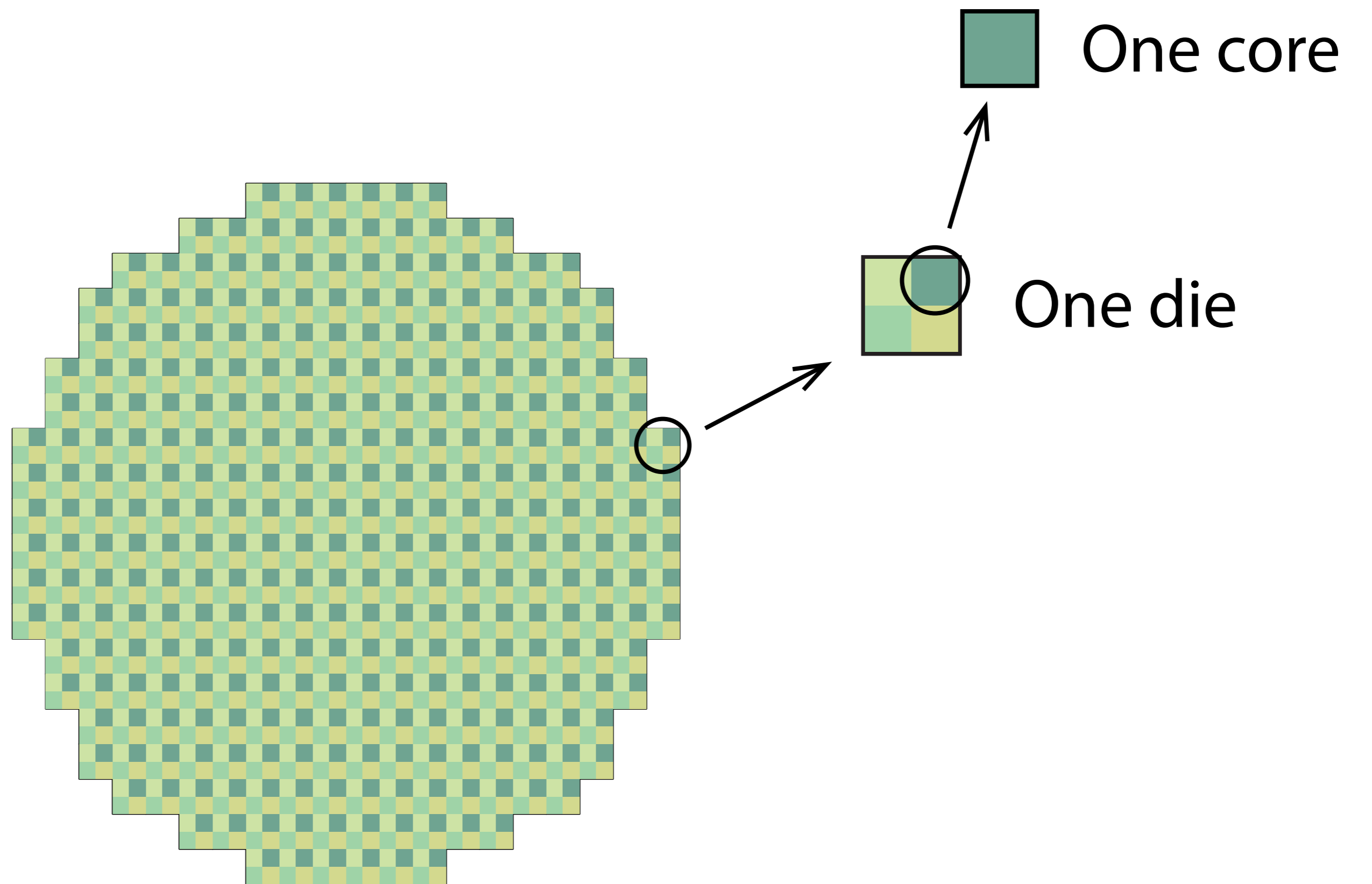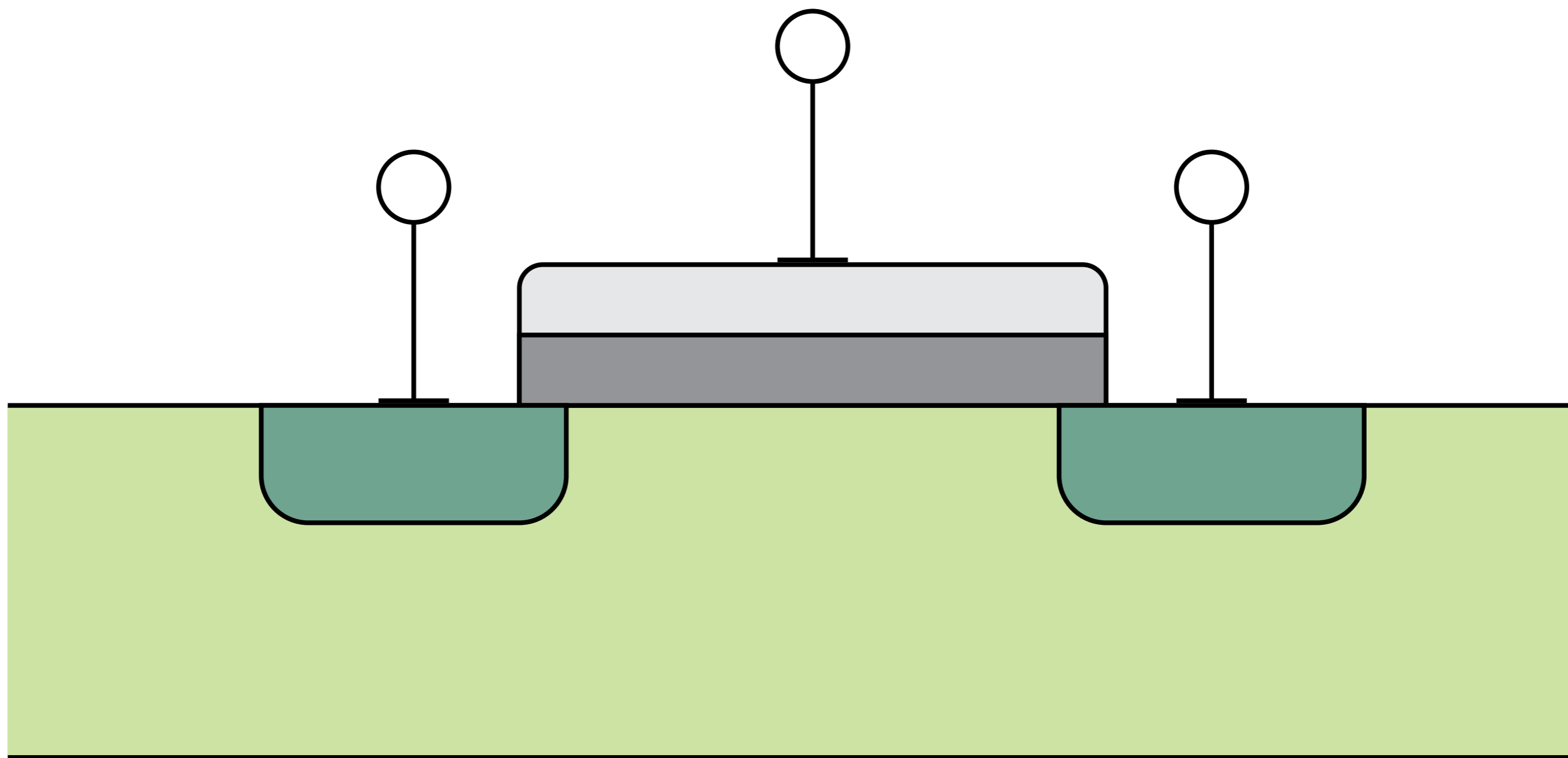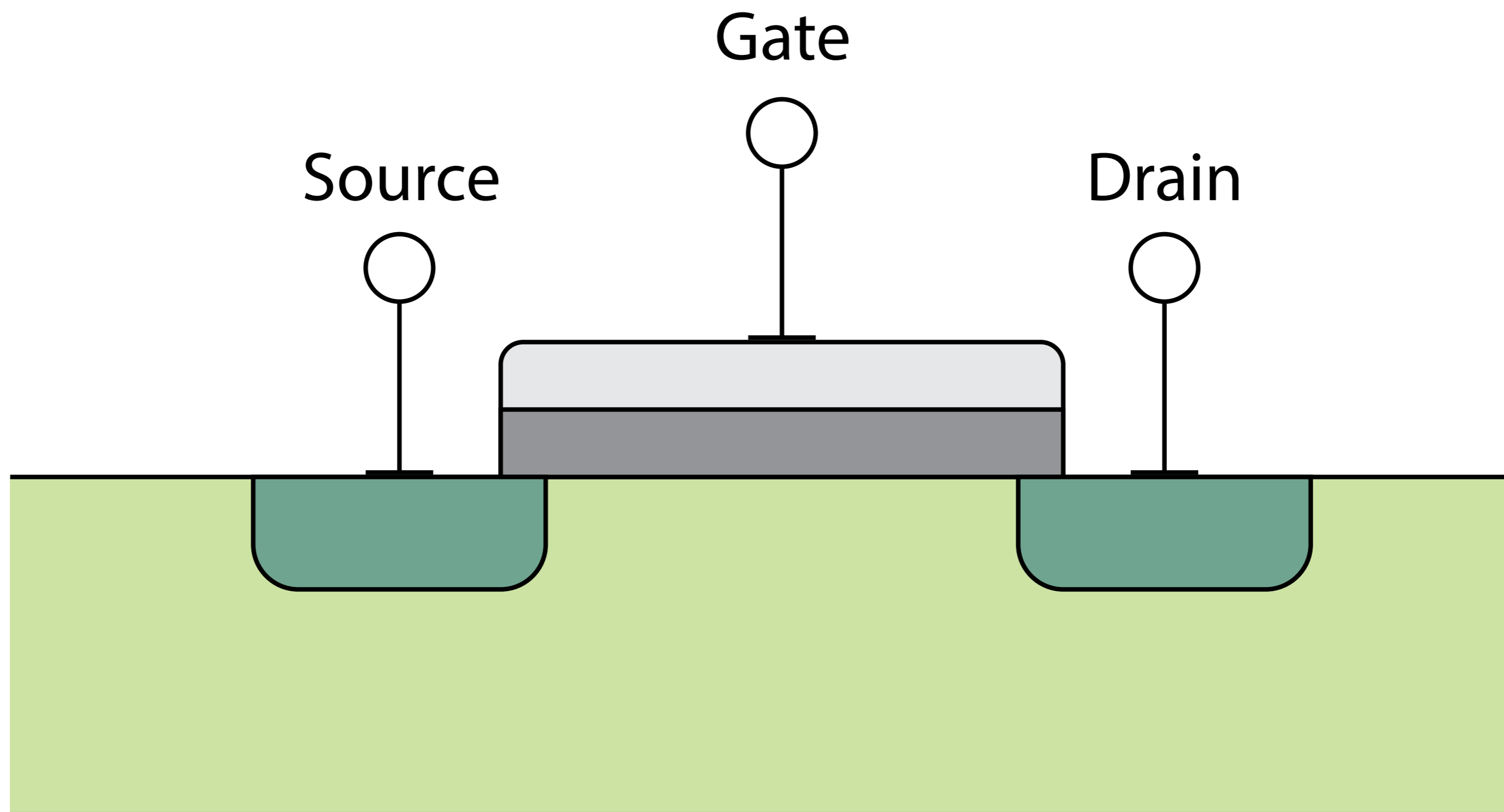3. How?

Wafer

Wafer

One die

Wafer

One core

One die

Transistor

Transistor
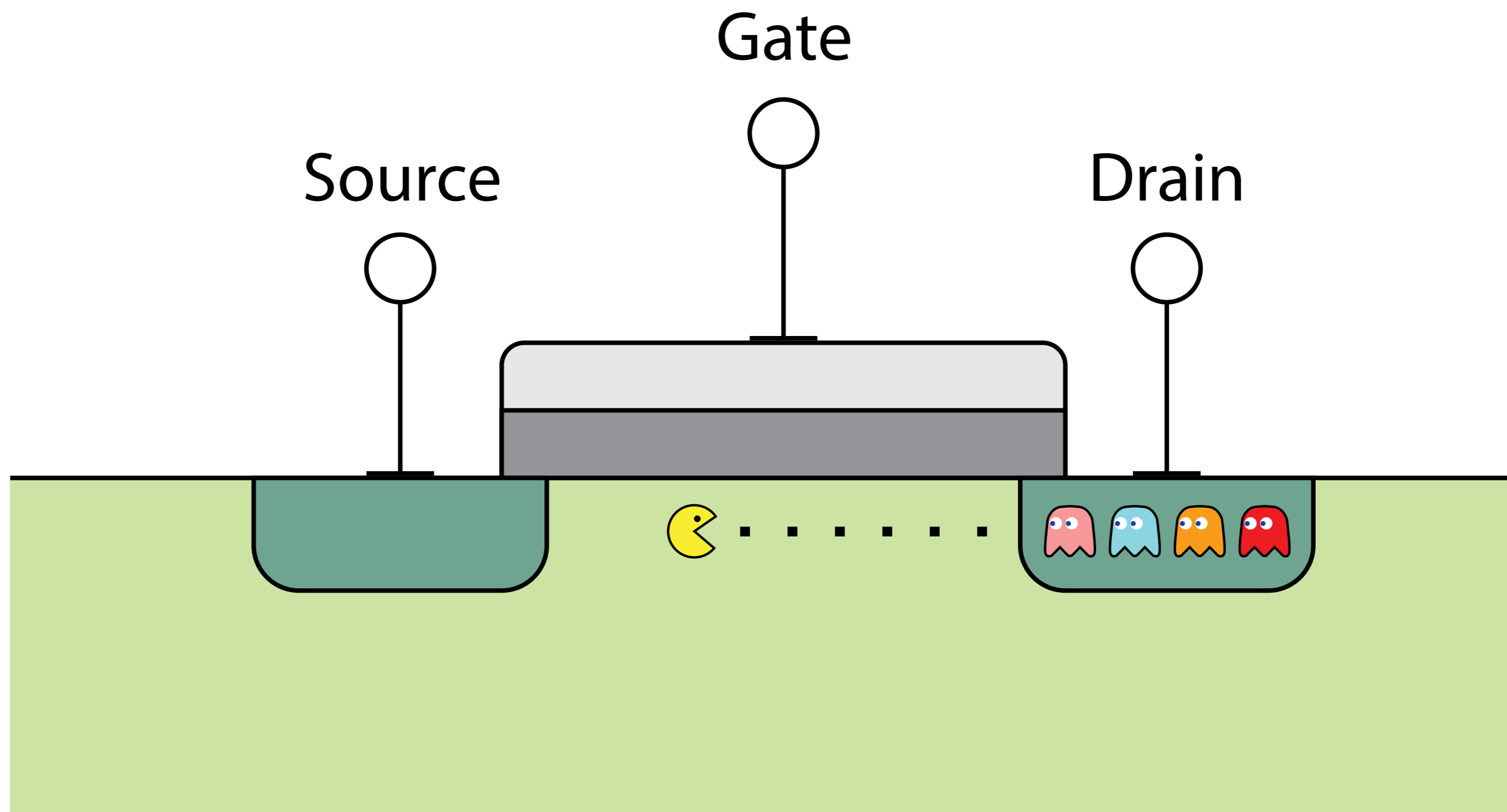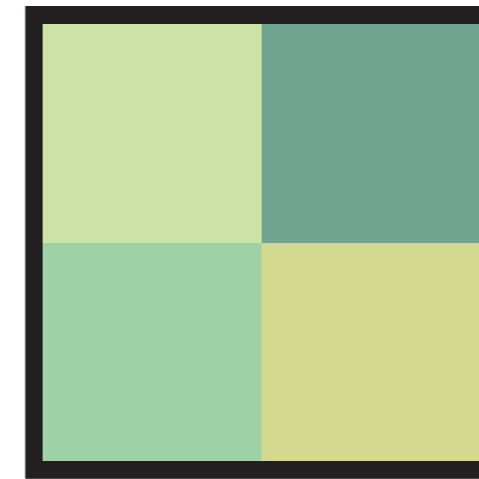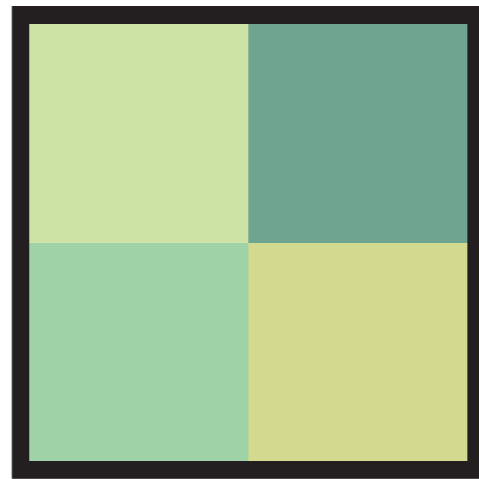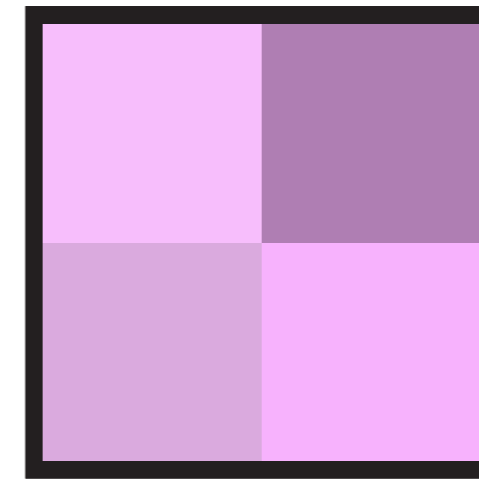
Source

Gate

Drain

3

Transistor

3

Process Variation

Process Variation

Process Variation

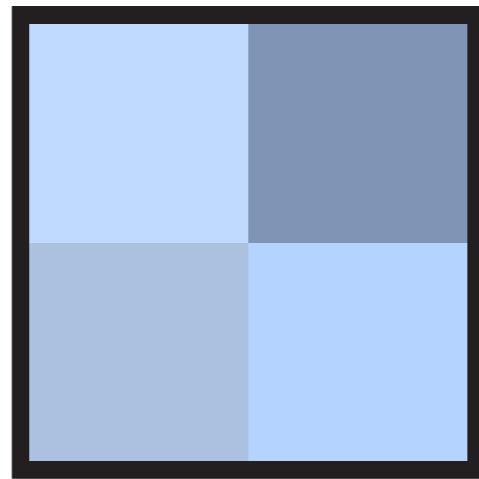# Process Variation

Process Variation

5
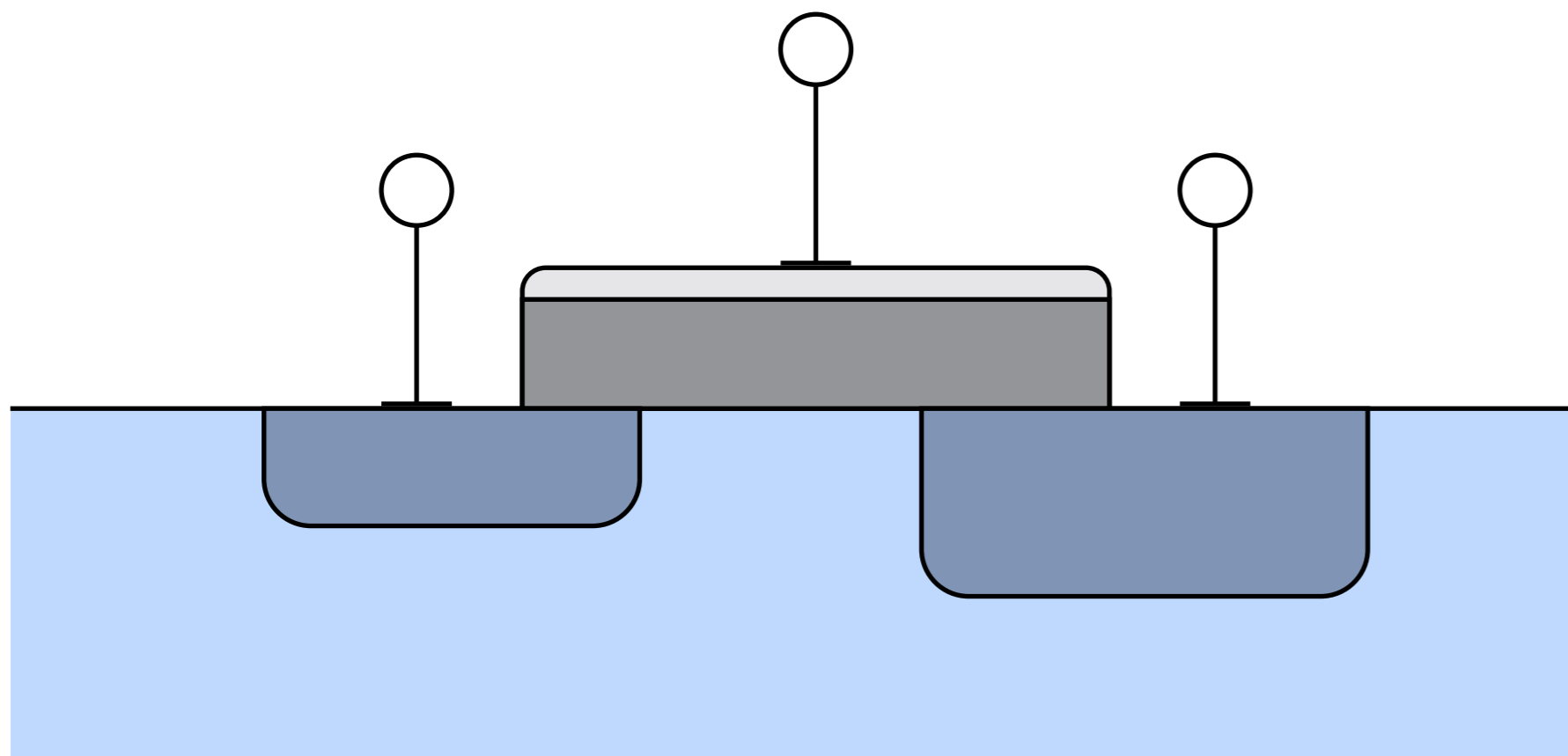
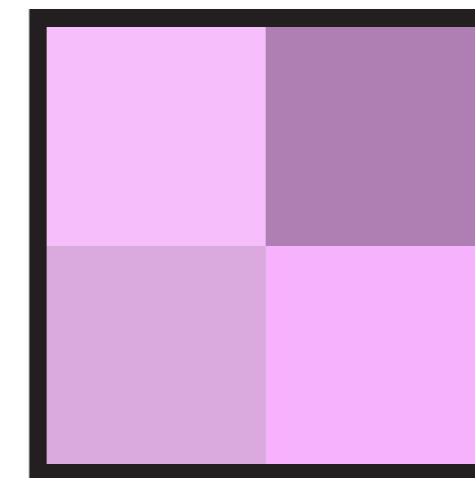# Process Variation

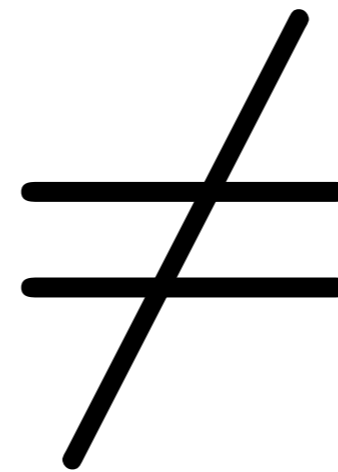# Process Variation

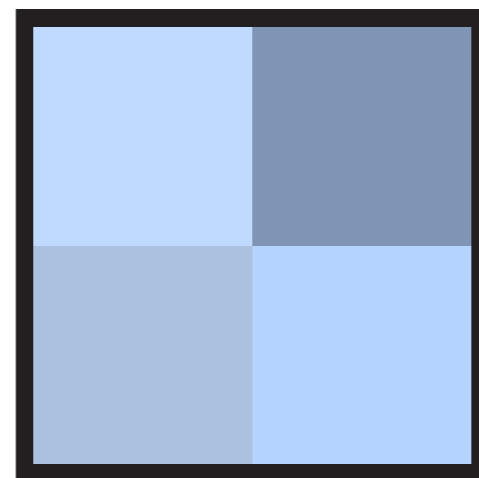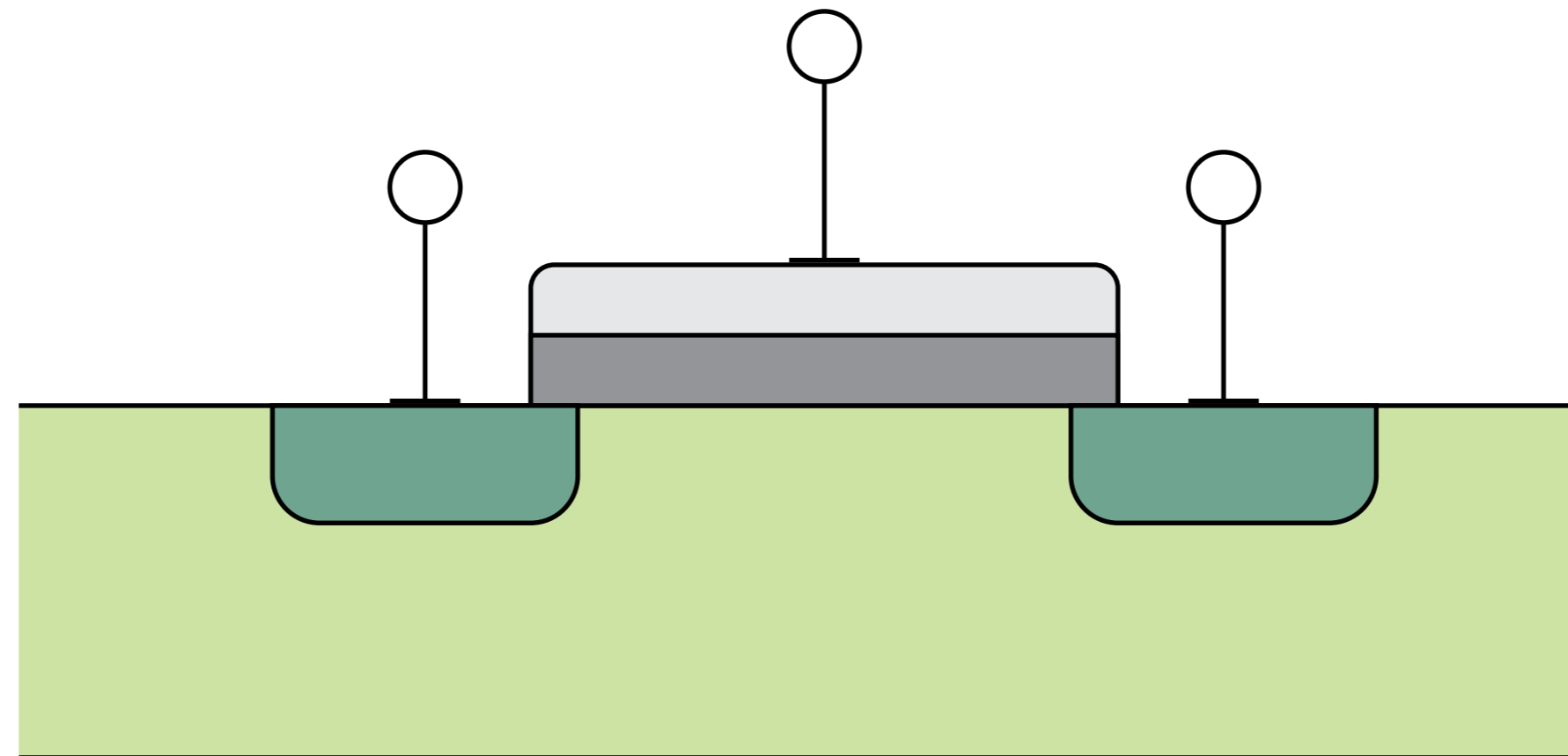# Process Variation
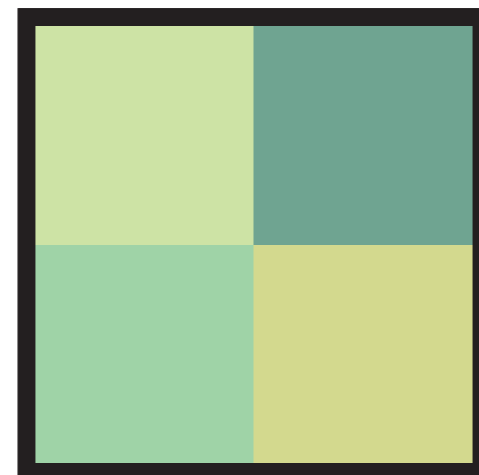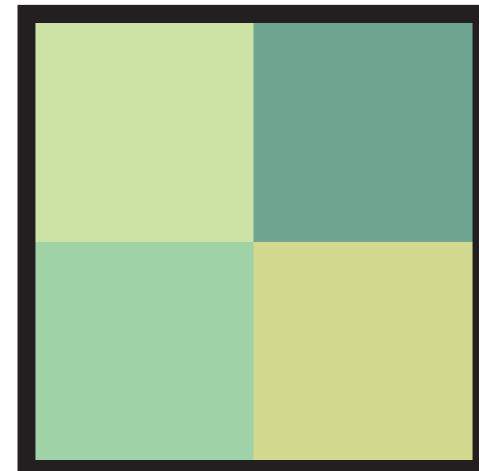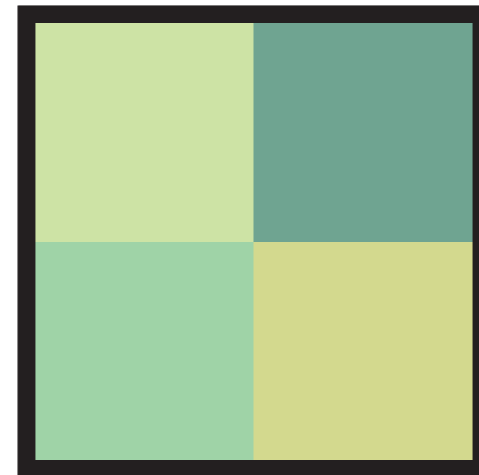
Process Variation

Process Variation
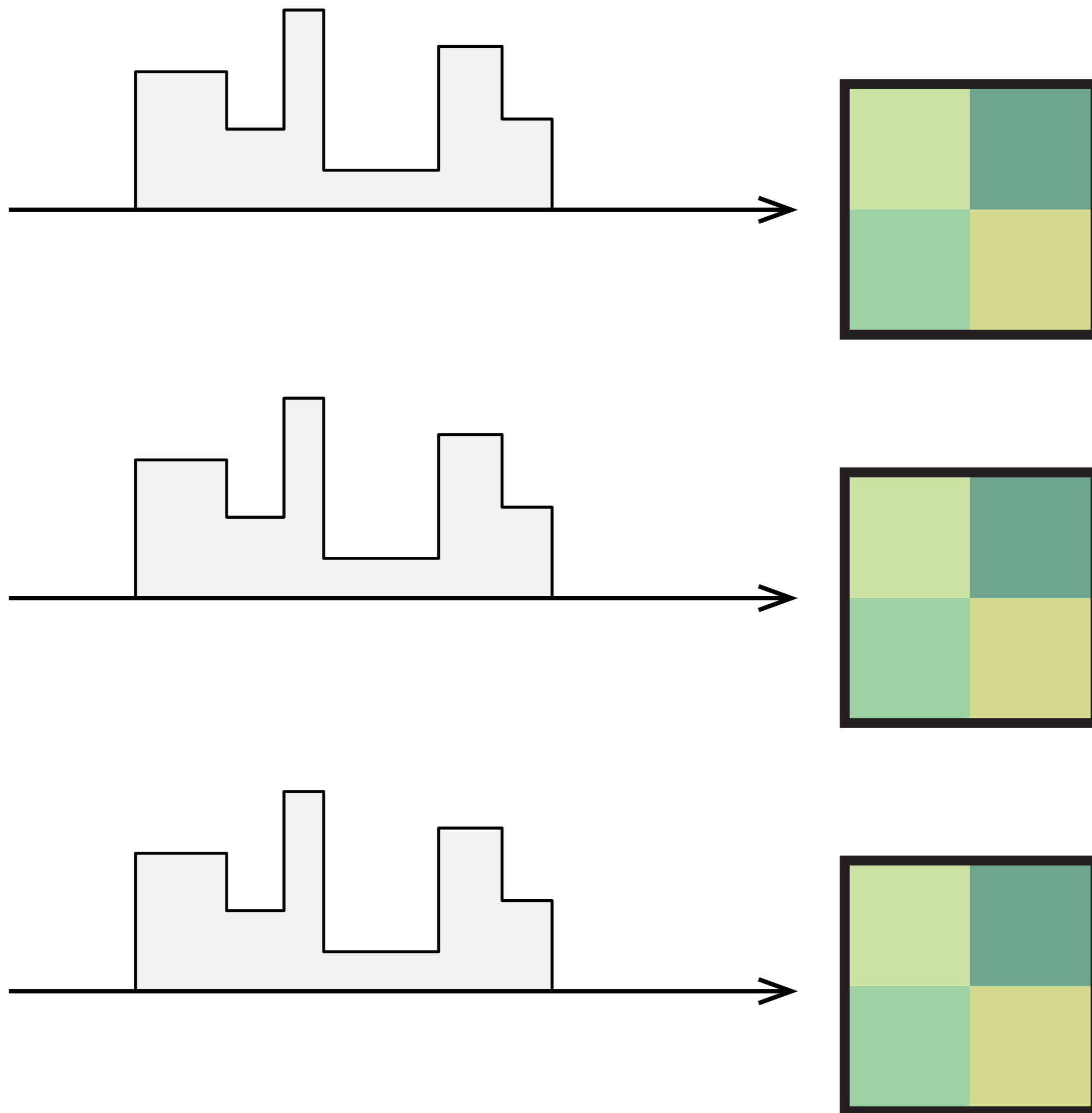
Workload

Process Variation
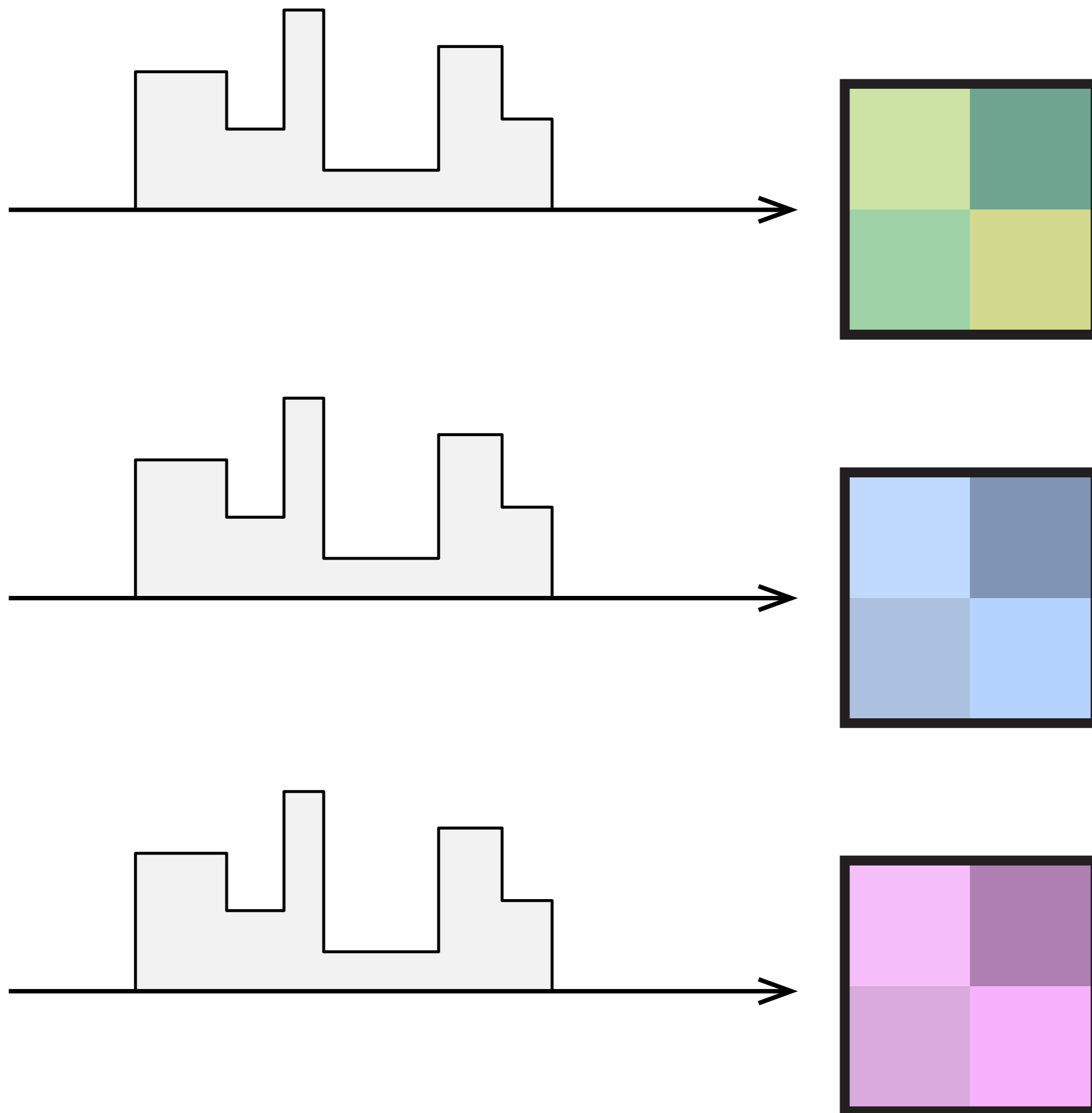
Workload

Process Variation
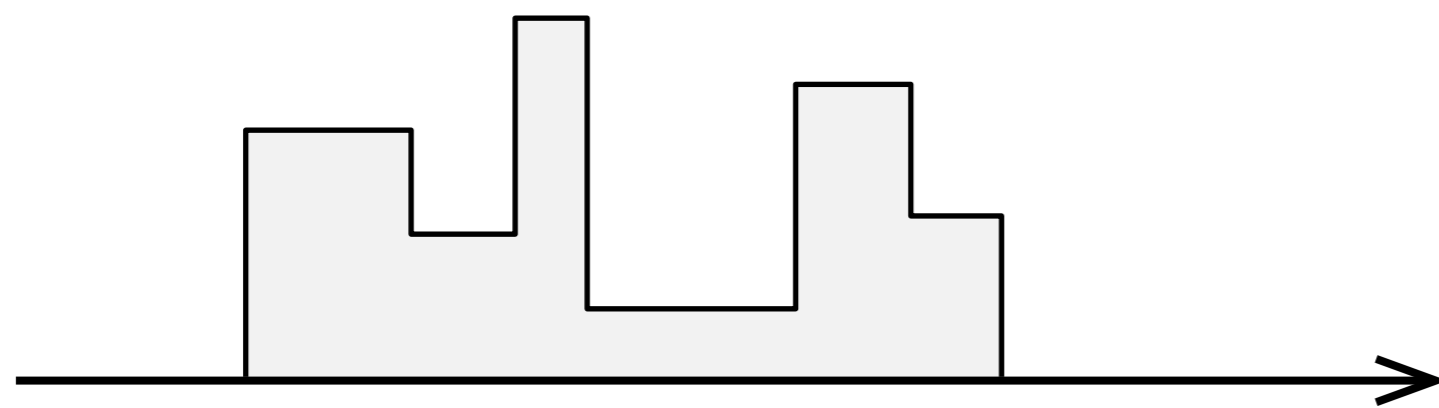
Workload

Temperature

Goal

Goal

Goal
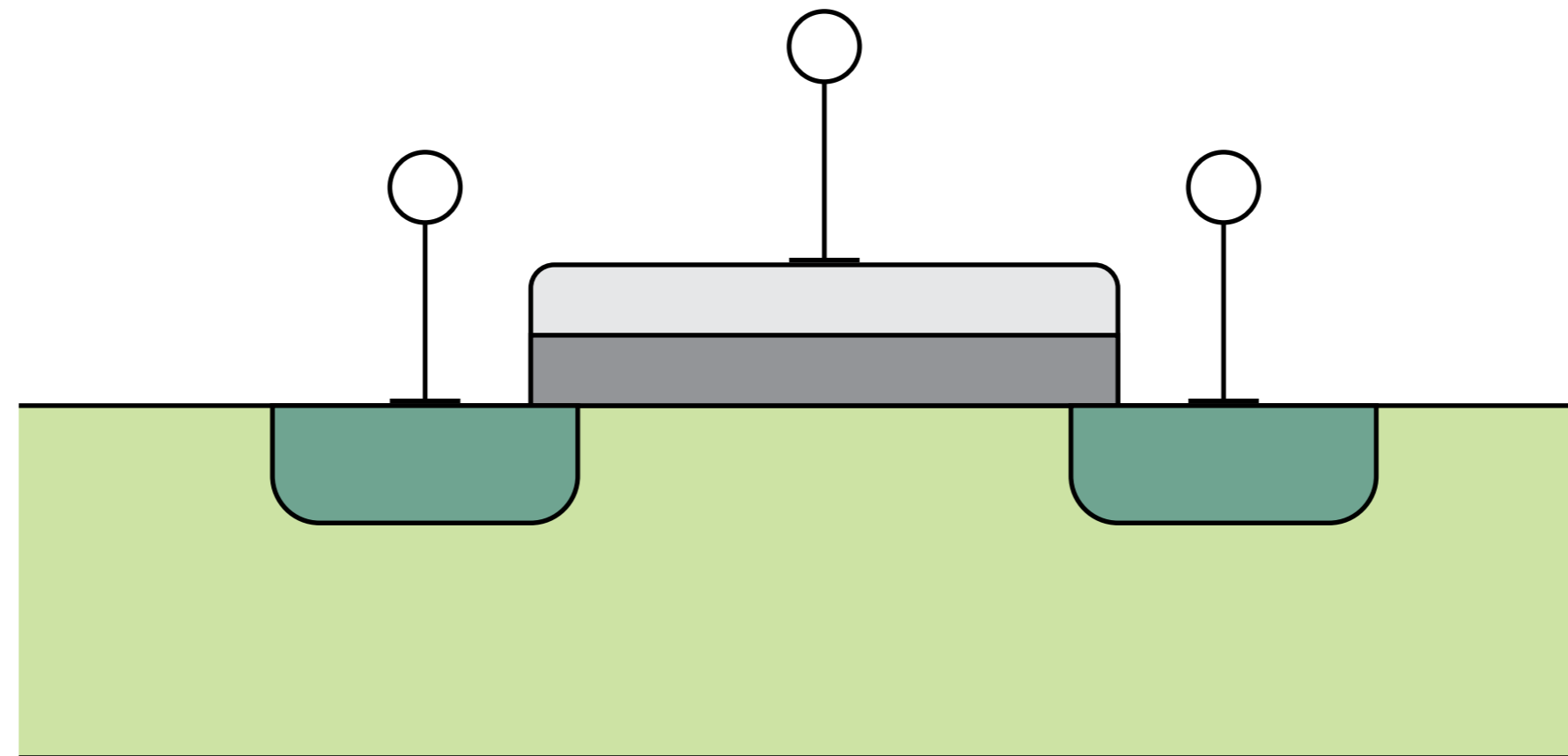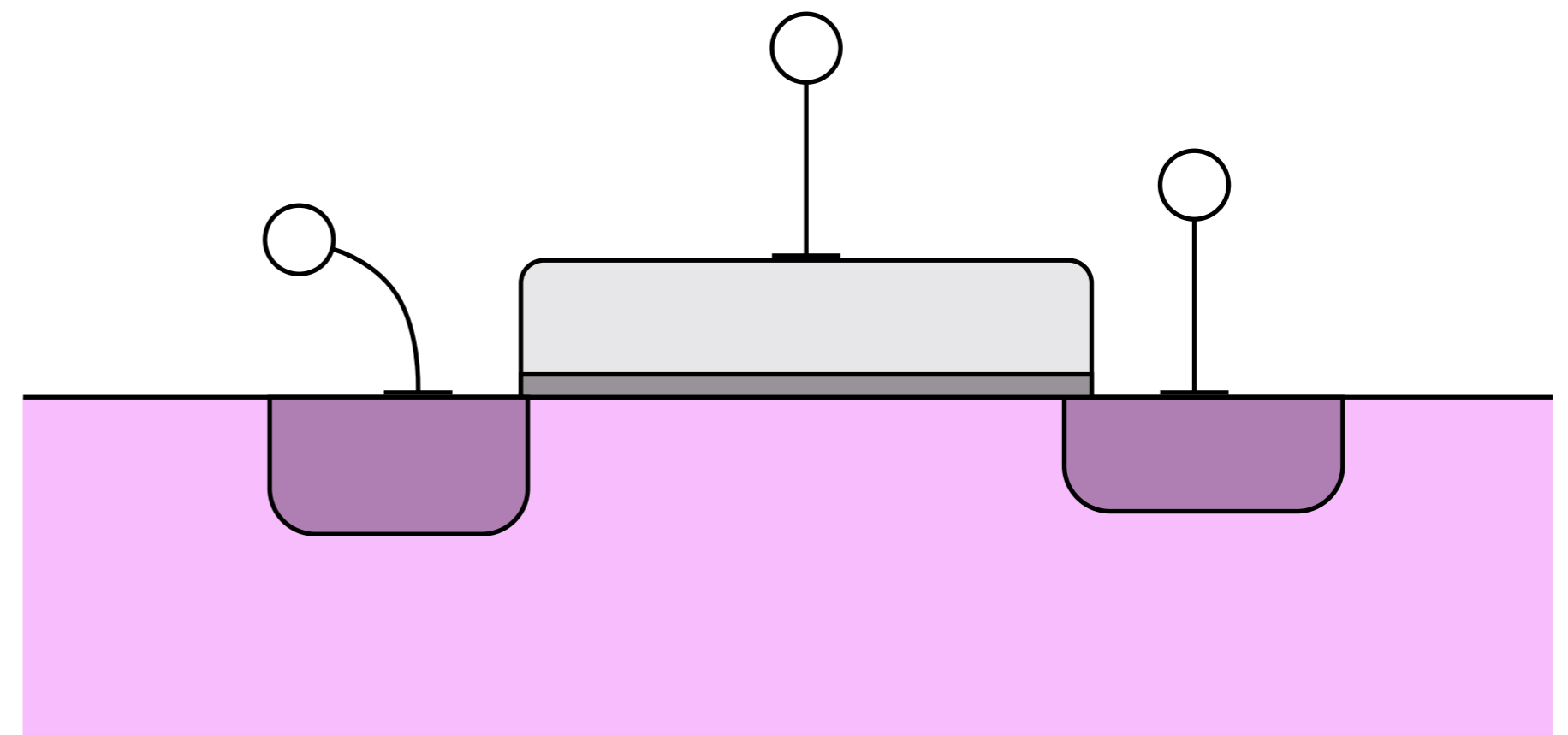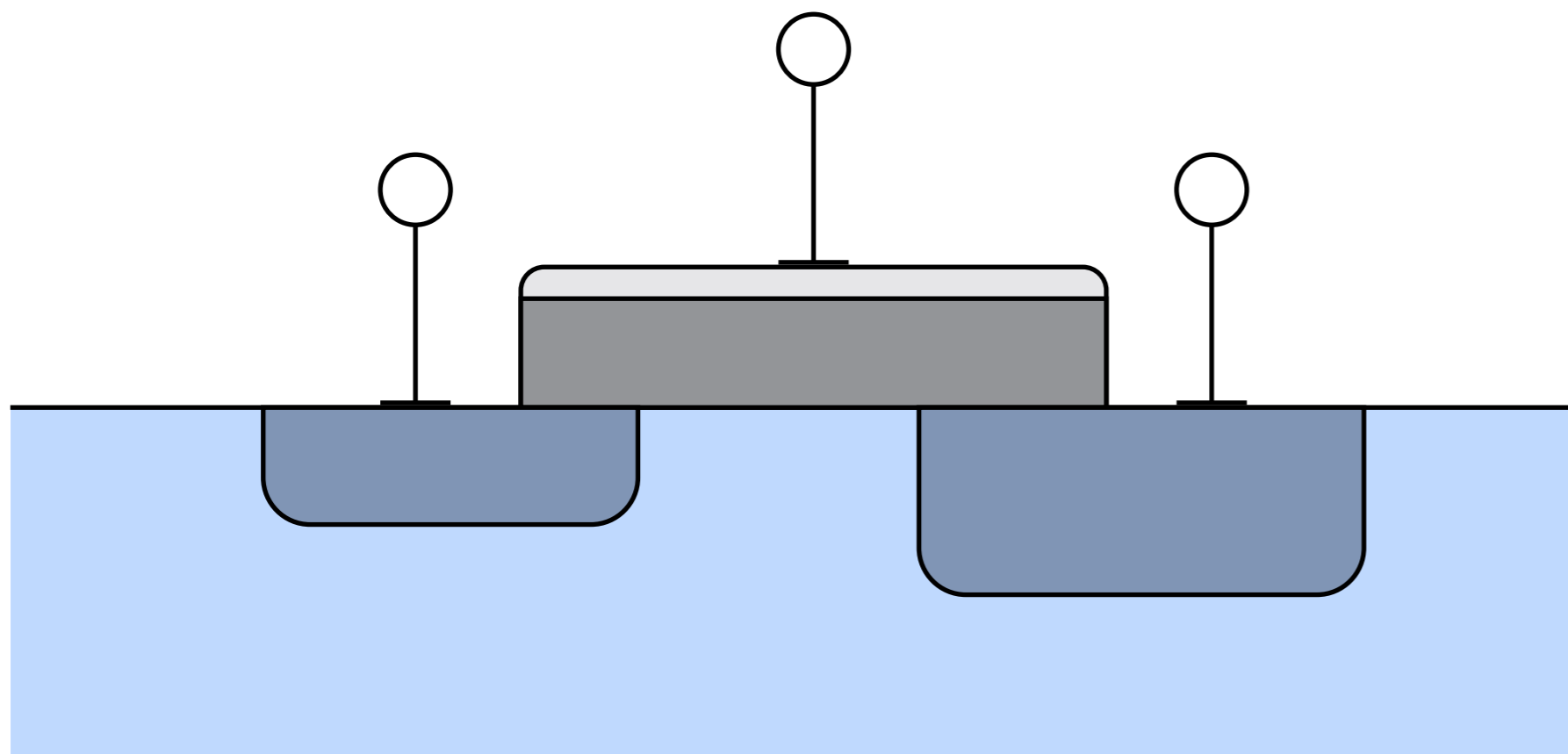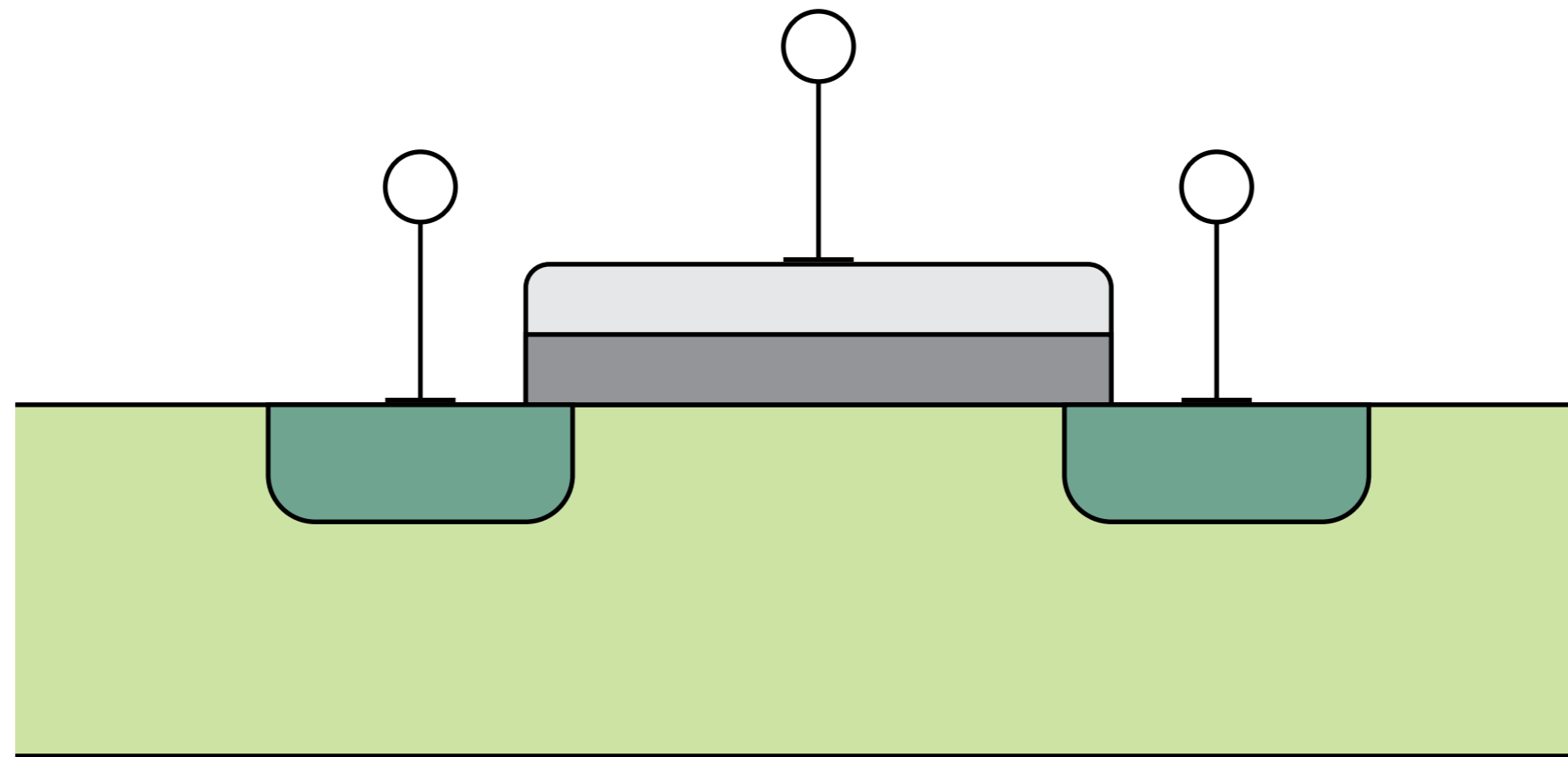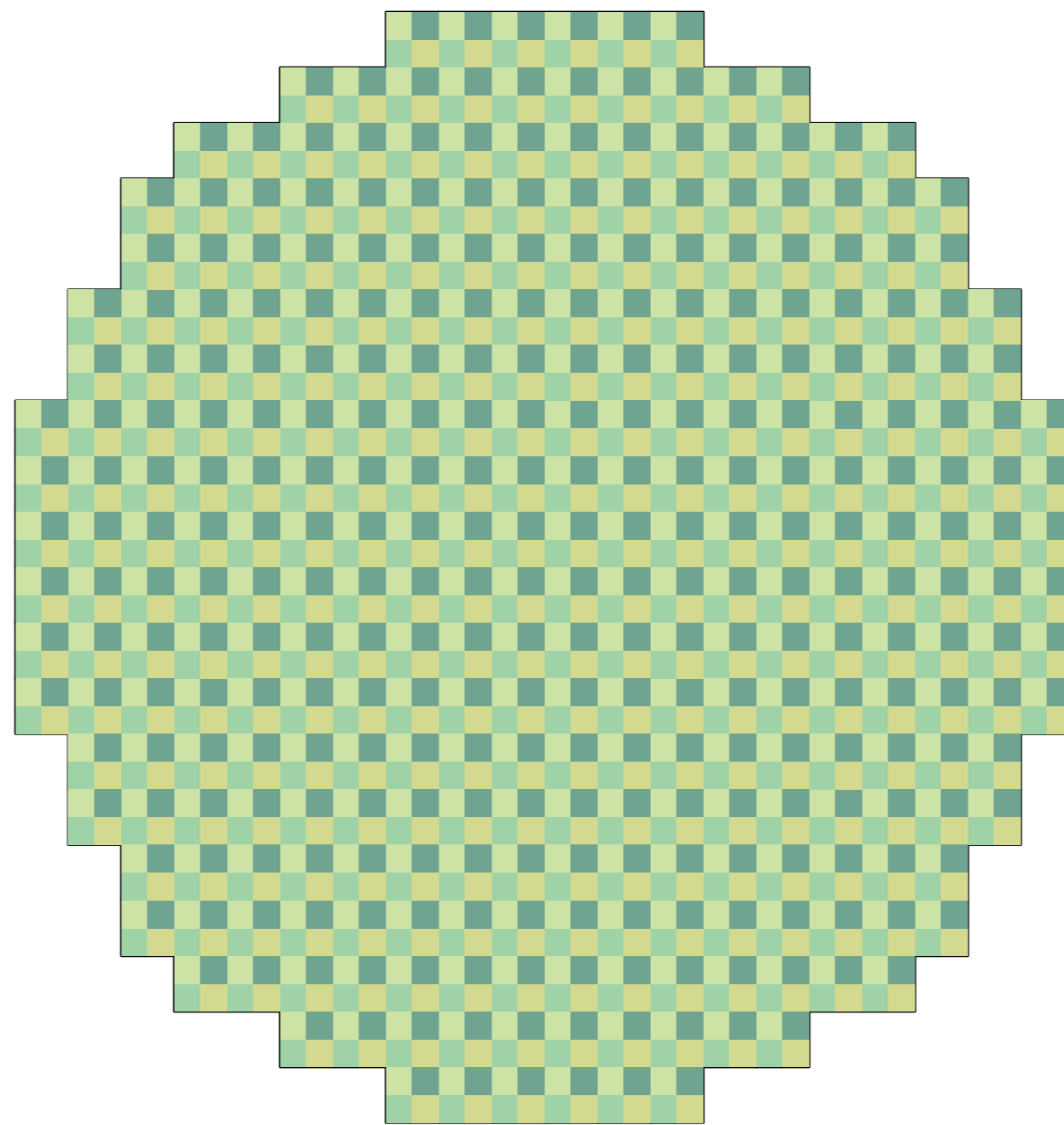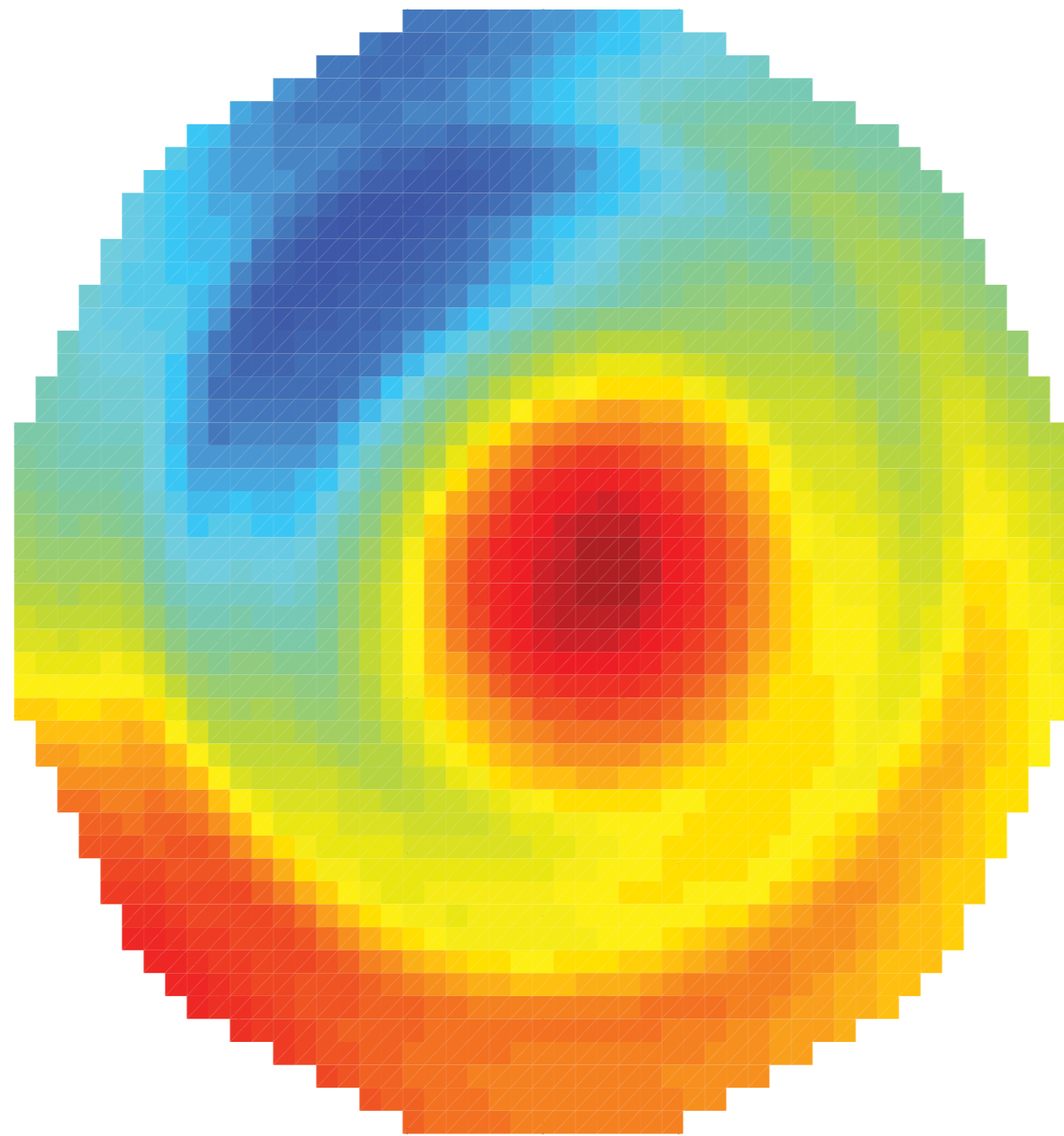

θ
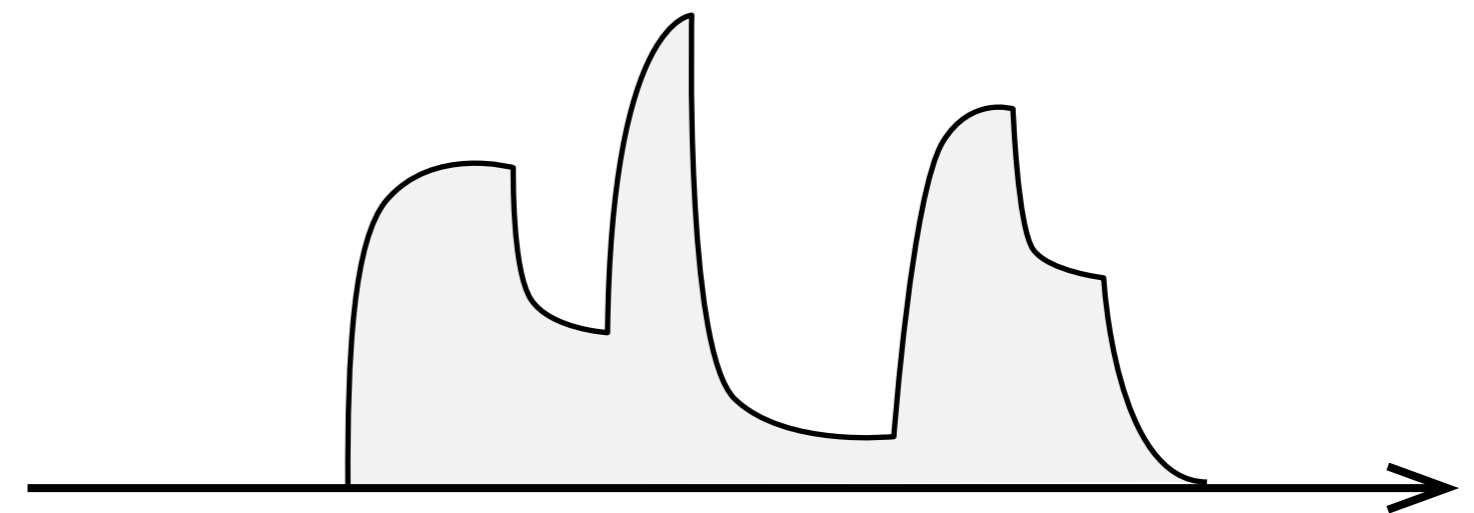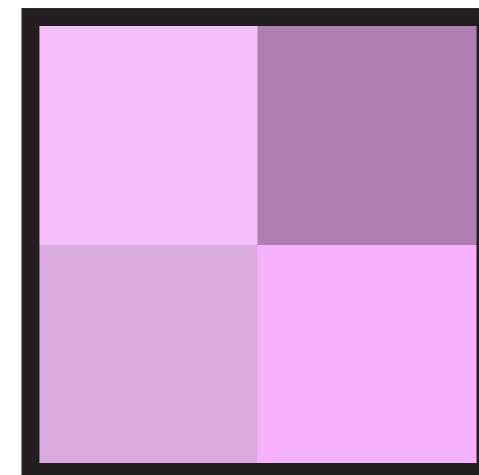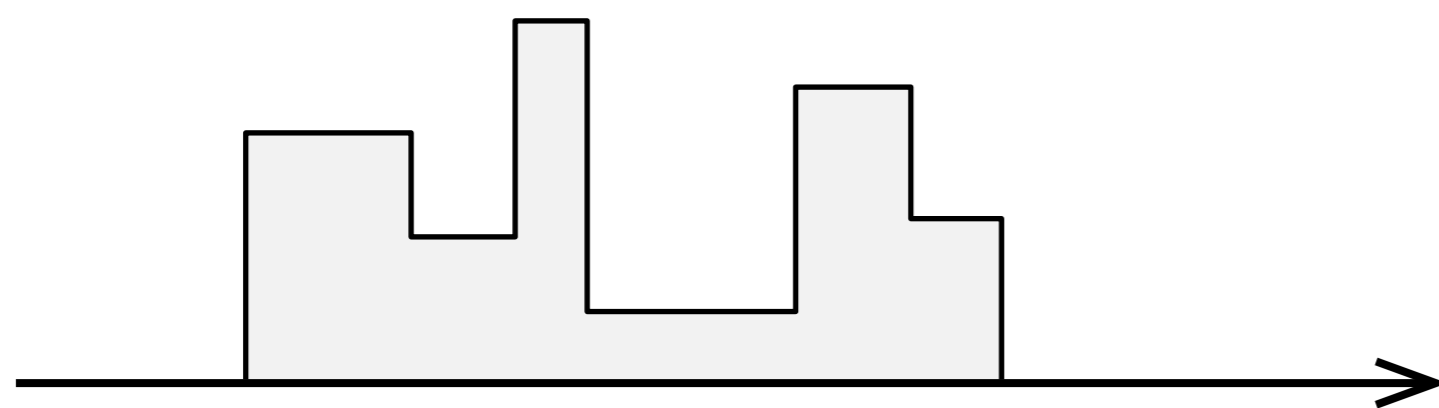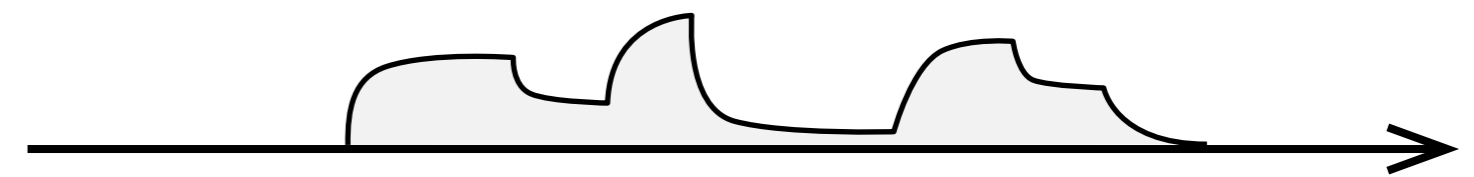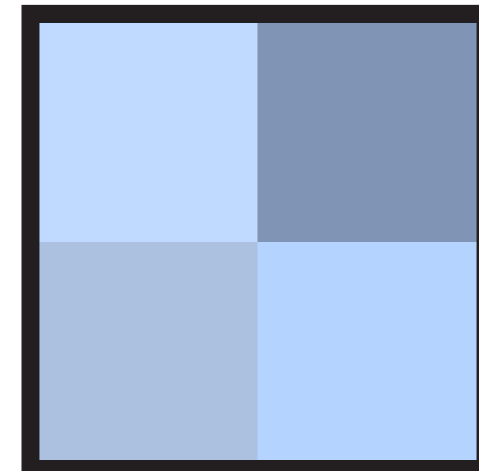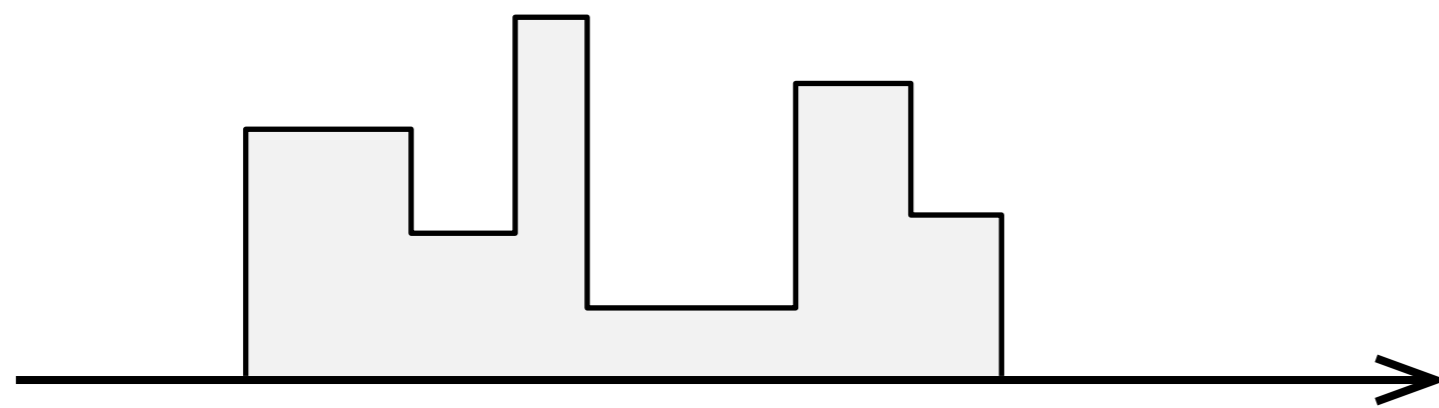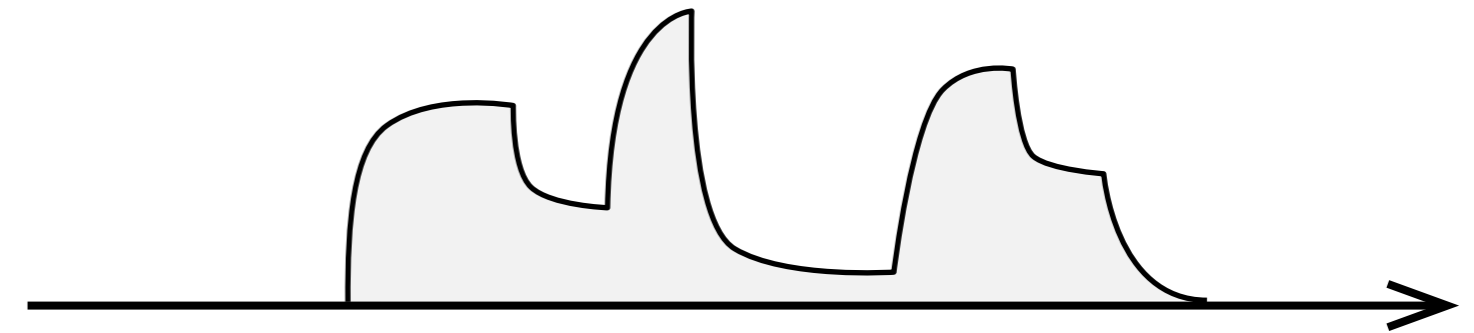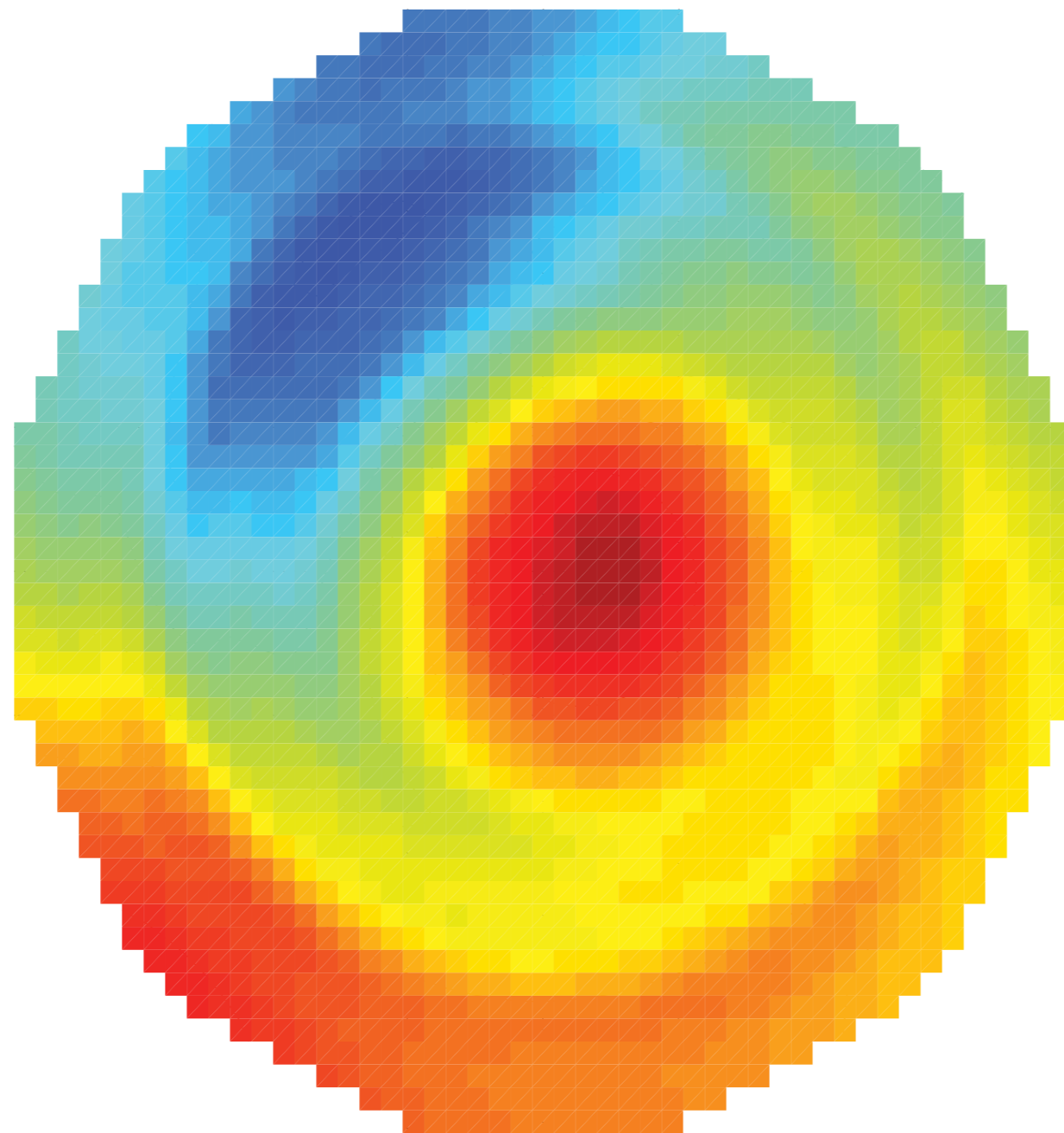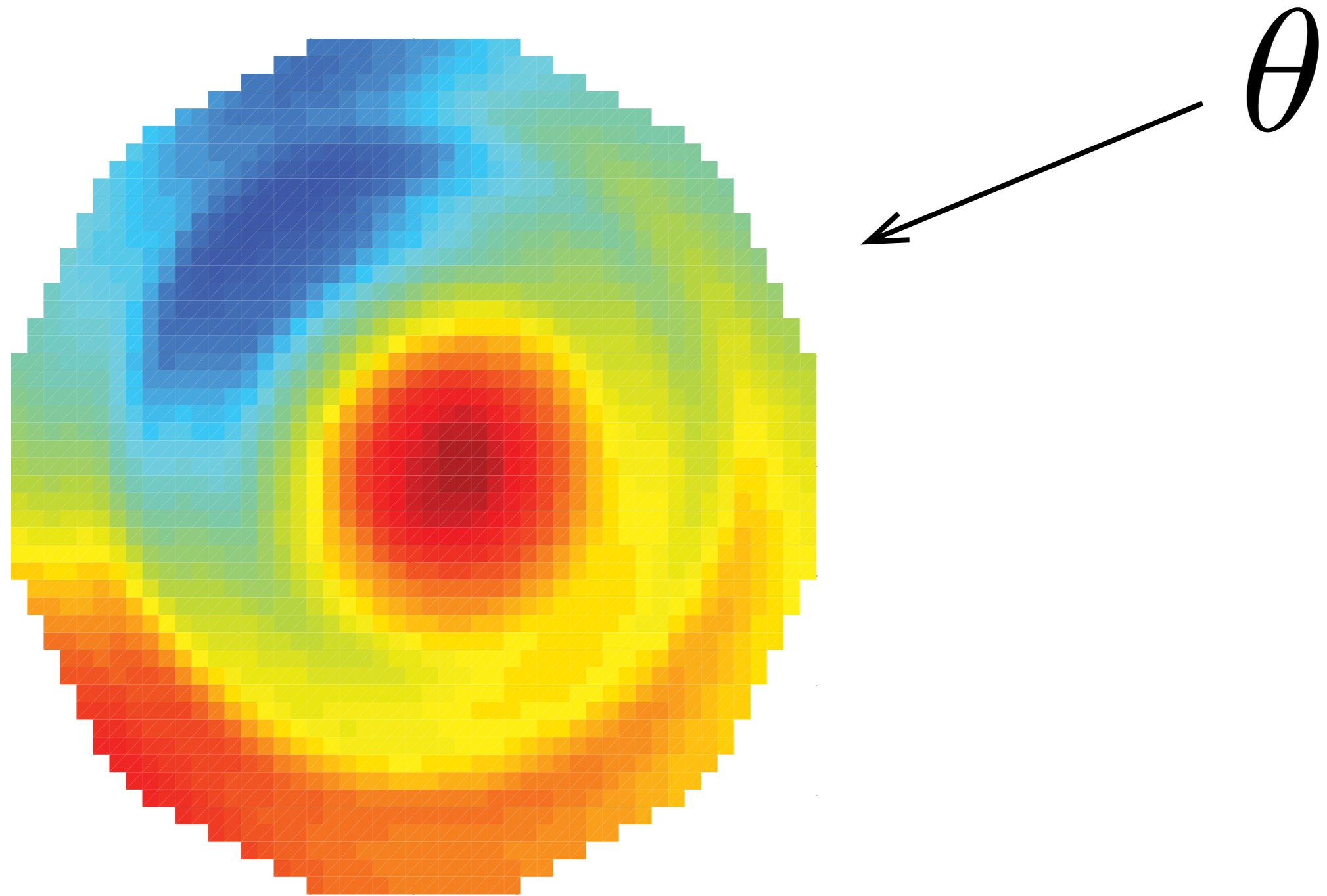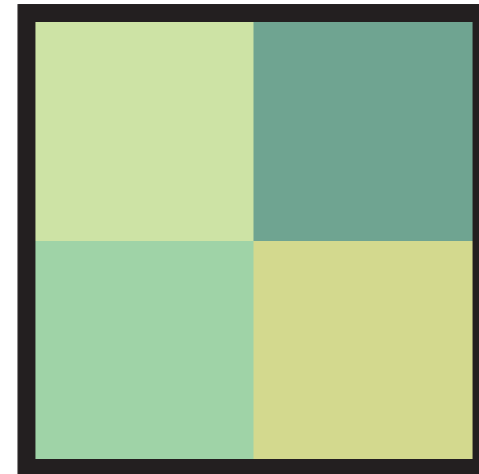
Alternatives

Alternatives

θ

Alternatives

θ

Alternatives

θ $\qquad\qquad\qquad$ $f(\theta)$

9

Alternatives

θ

$f(\theta)$

9
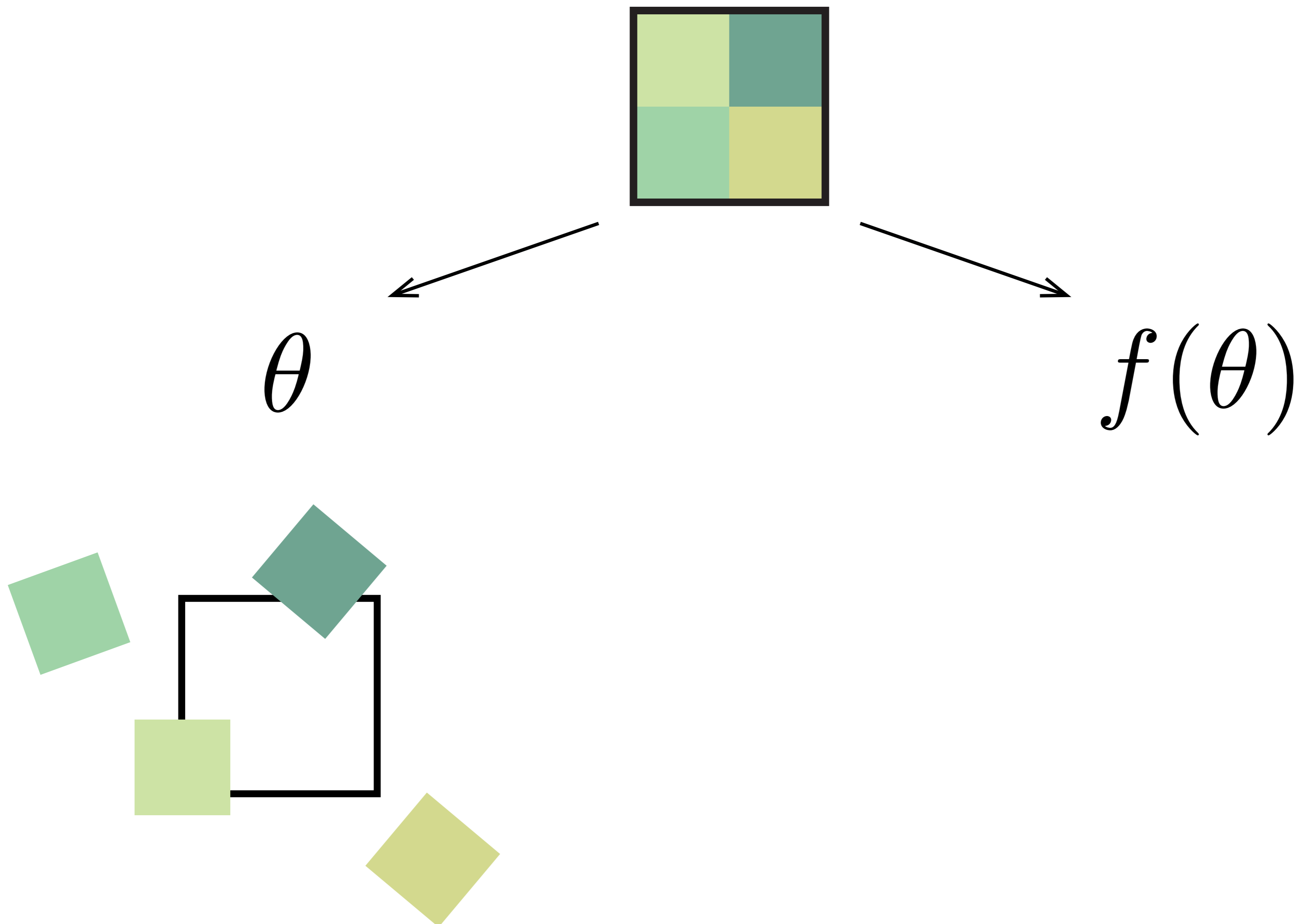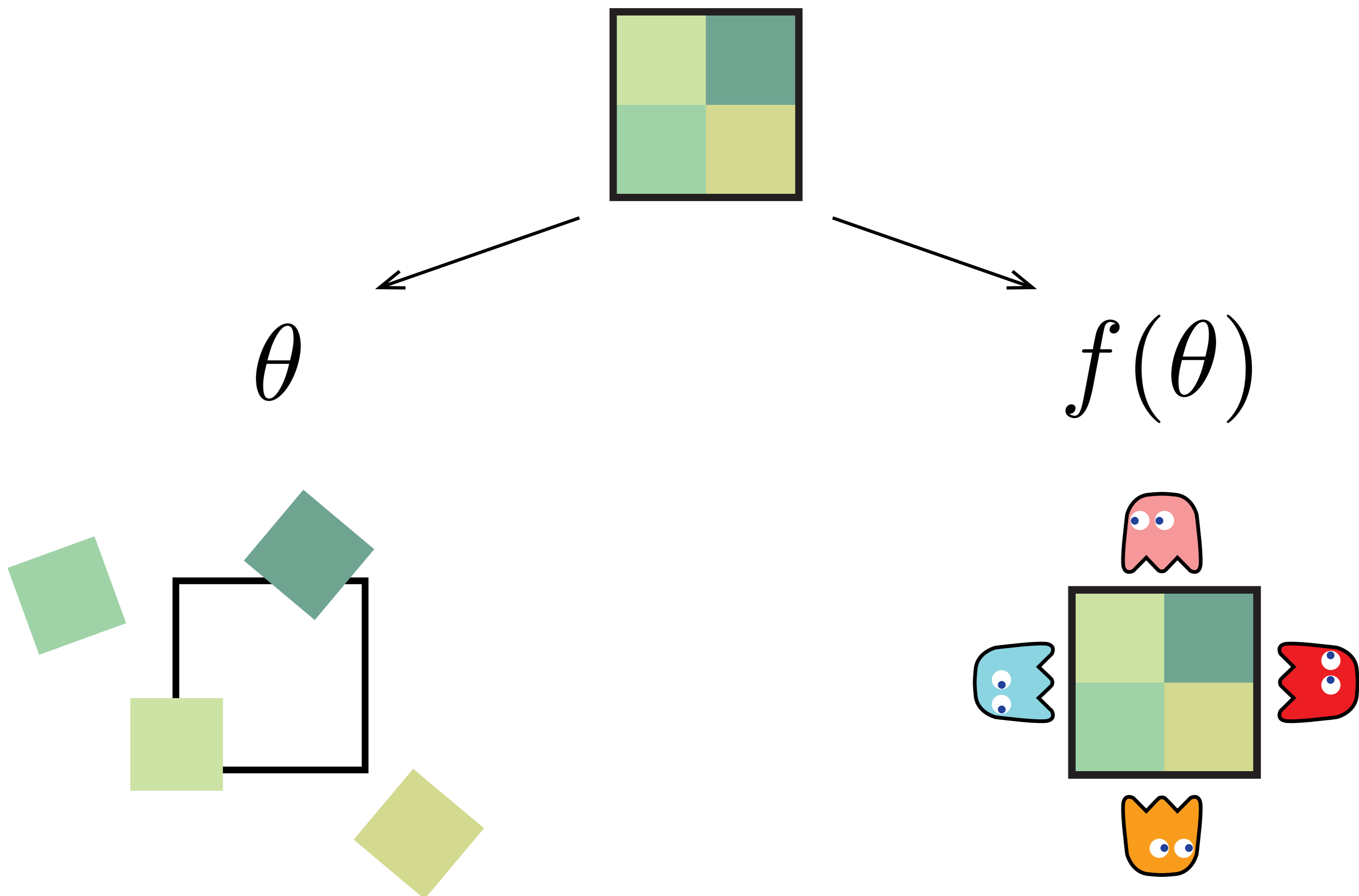
Our Solution

Our Solution

Workload

Temperature

10
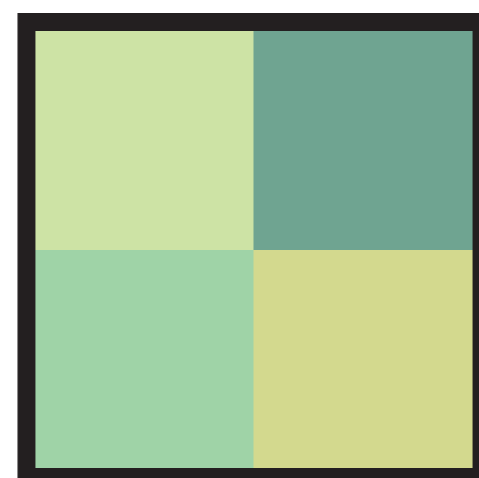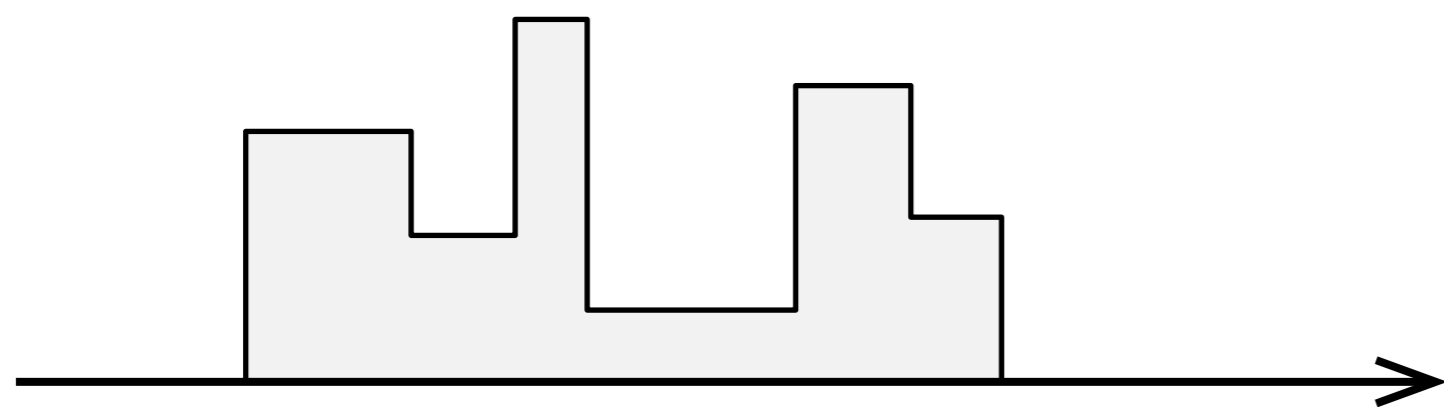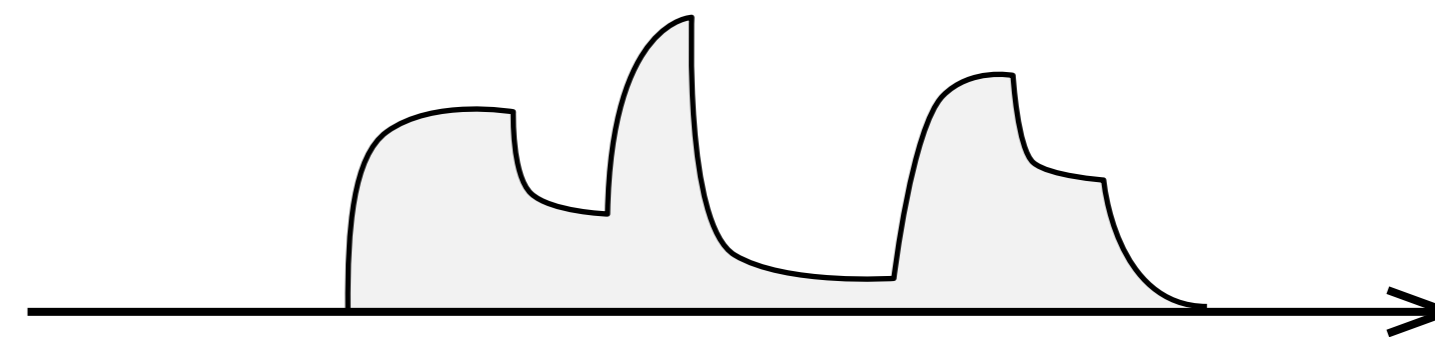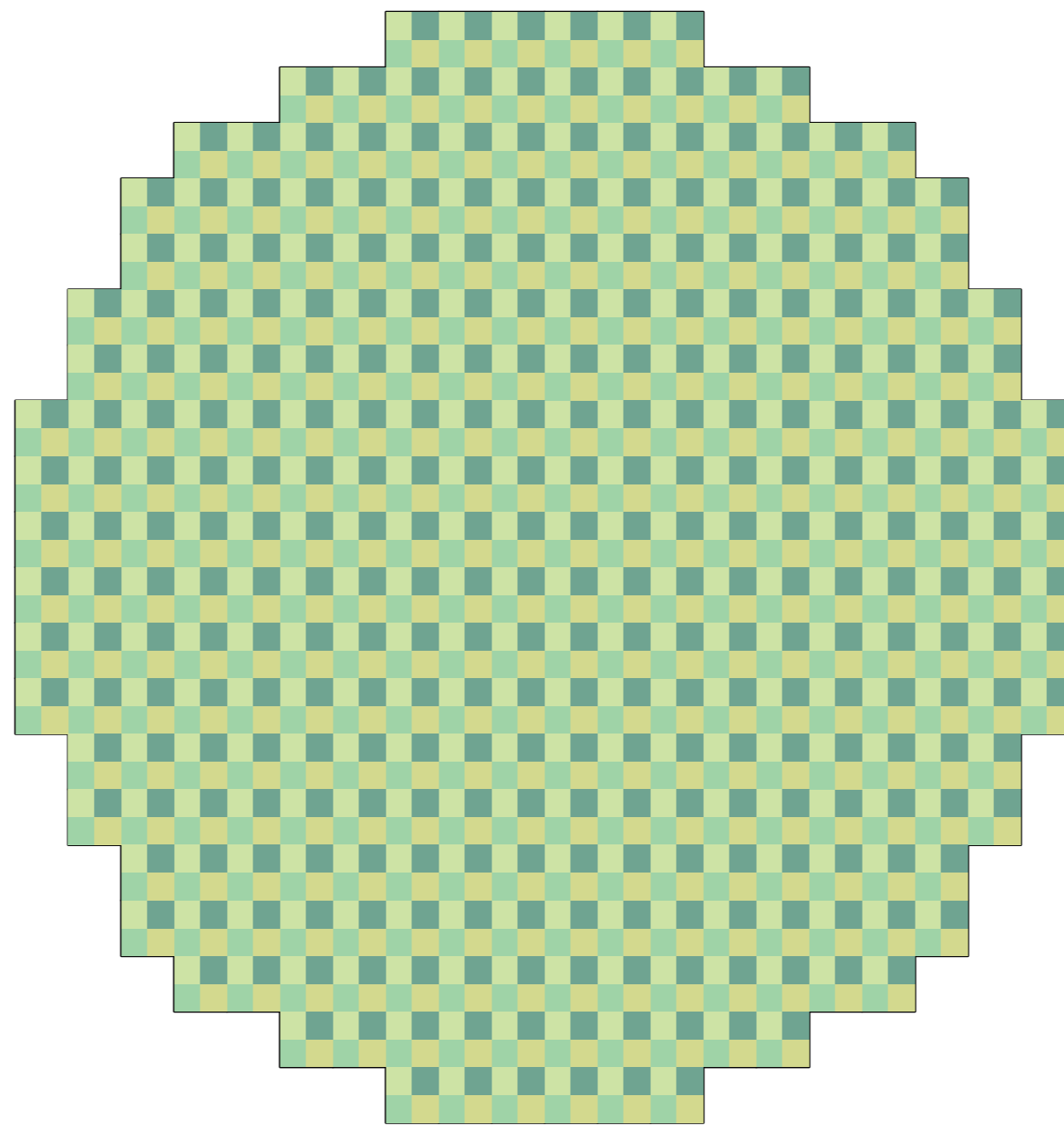
Our Solution

Our Solution

Our Solution

$\mathcal{D}$
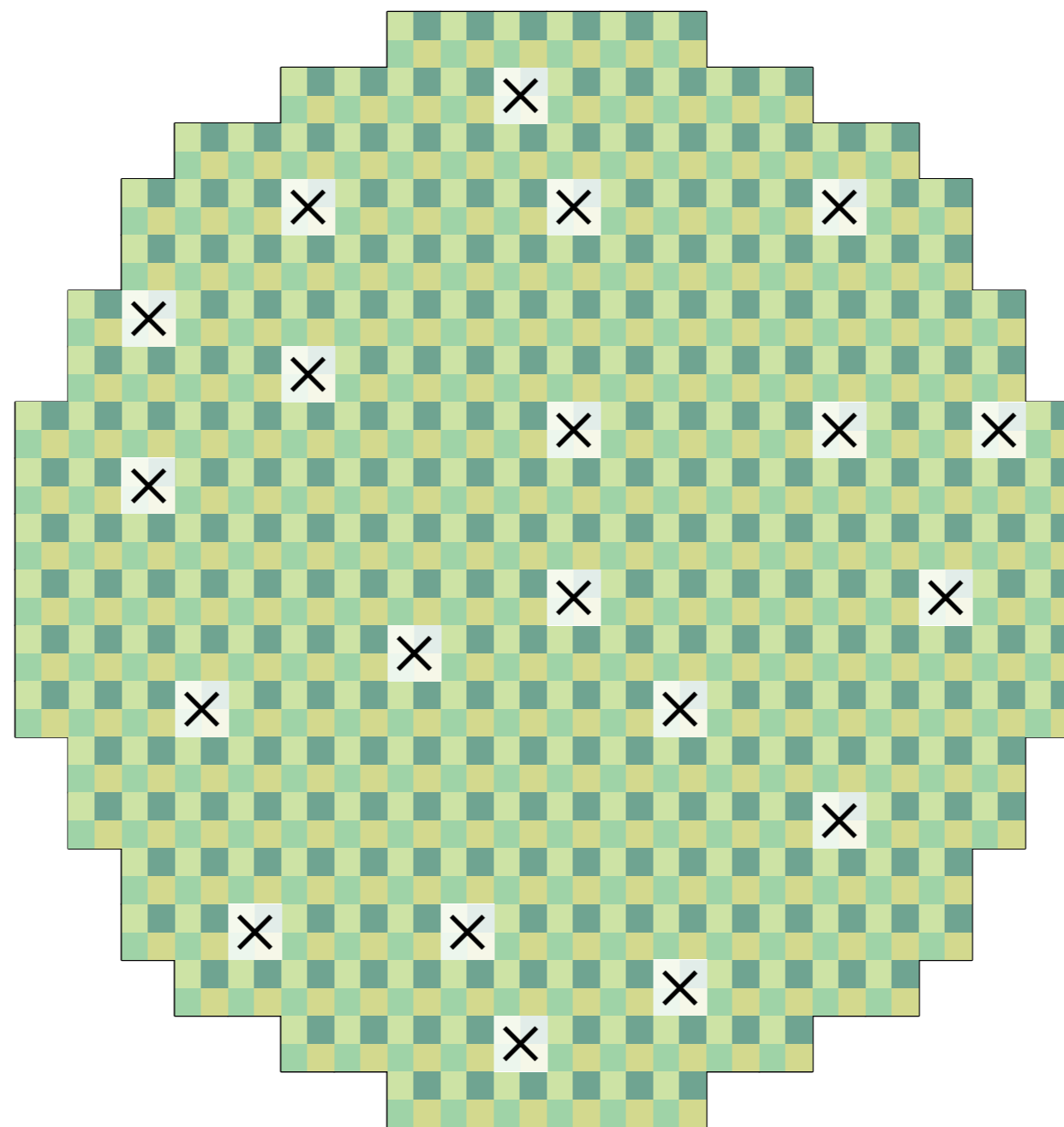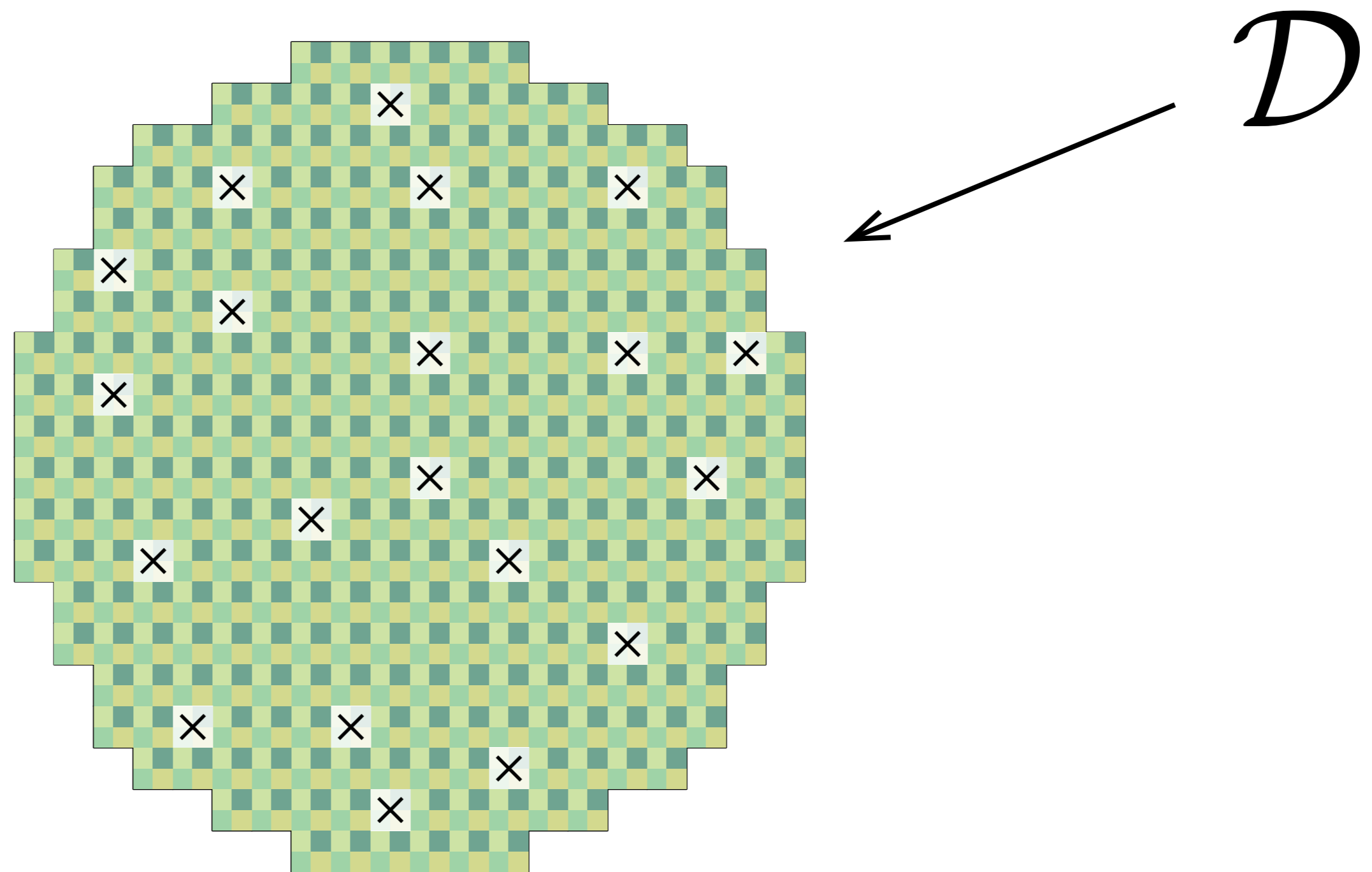
Our Solution

Our Solution

$\mathcal{D}$

Our Solution

$\mathcal{D}$

Indirect

Our Solution

$\mathcal{D}$

Indirect

Incomplete

Our Solution

$\mathcal{D}$

Indirect

Incomplete

Noisy

Our Solution

$$\mathcal{D} \longrightarrow \theta$$

Indirect

Incomplete

Noisy

Our Solution

$$\mathcal{D} \longrightarrow \theta$$

Indirect

Incomplete   Primary

Noisy

Our Solution

$$\mathcal{D} \longrightarrow \theta$$

Indirect   Primary

Incomplete   Comprehensive

Noisy

Our Solution

$$\mathcal{D} \longrightarrow \theta$$

Indirect

Incomplete

Noisy

Primary

Comprehensive

Awesome

Illustration

Illustration

True

13
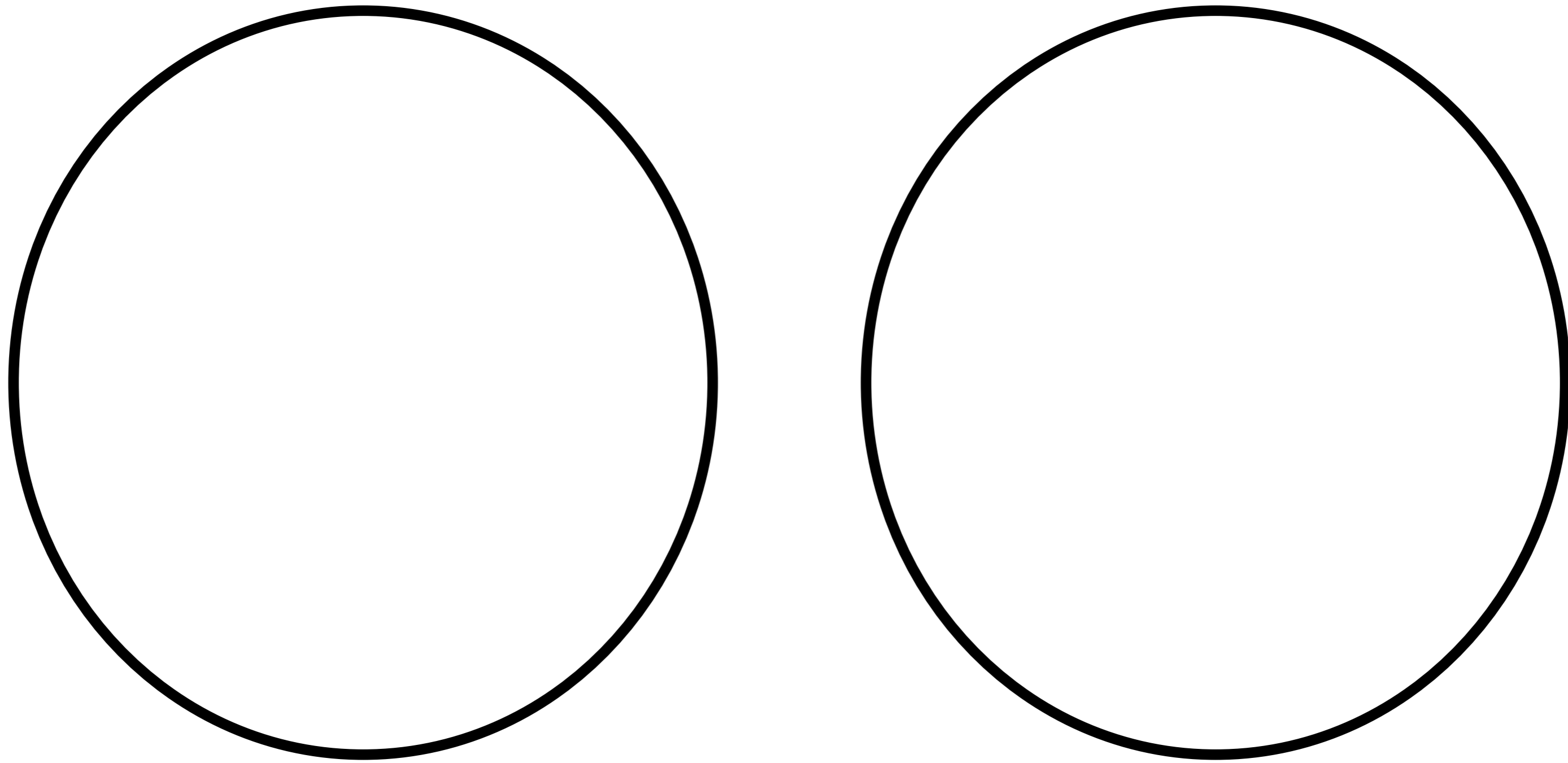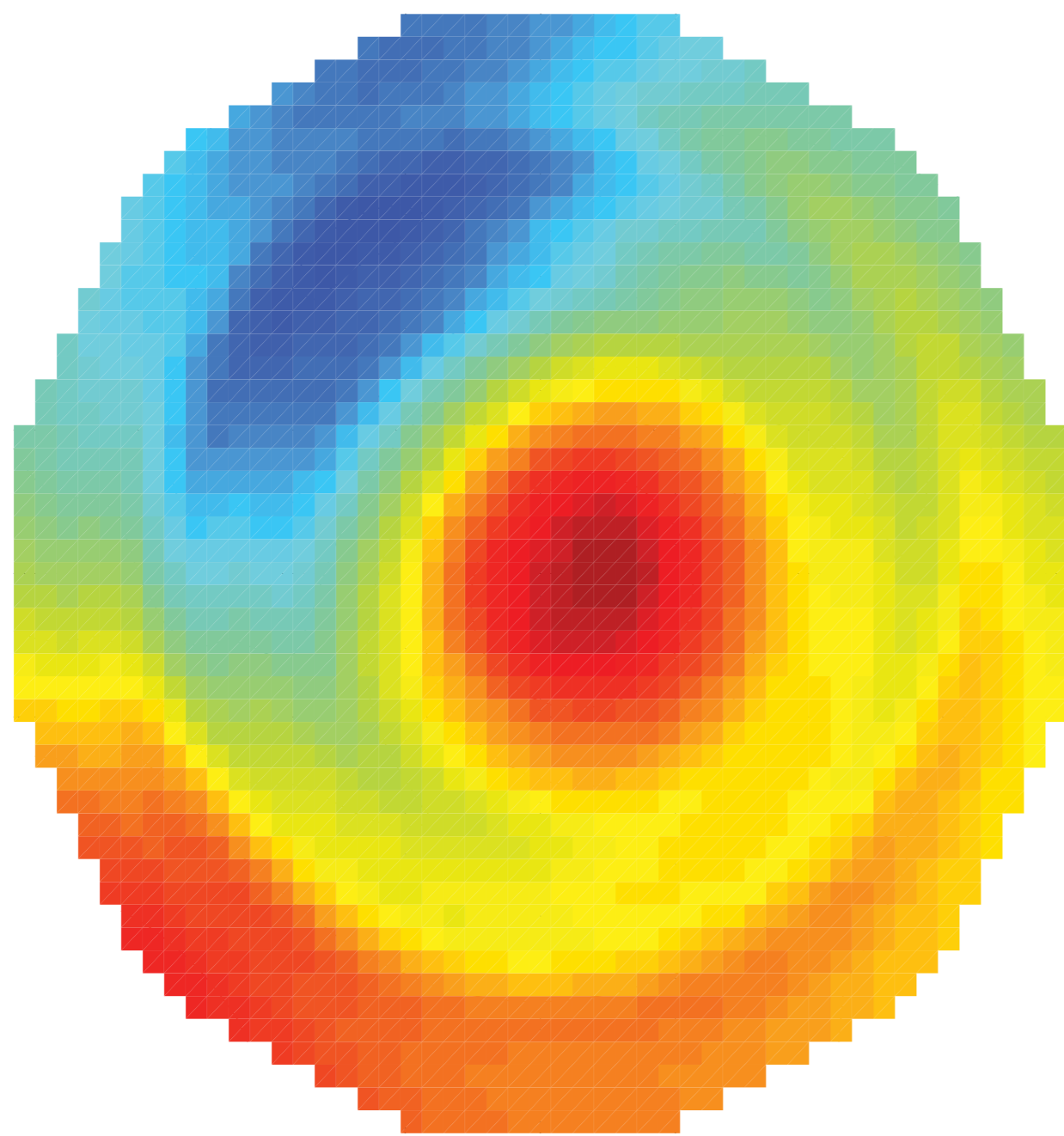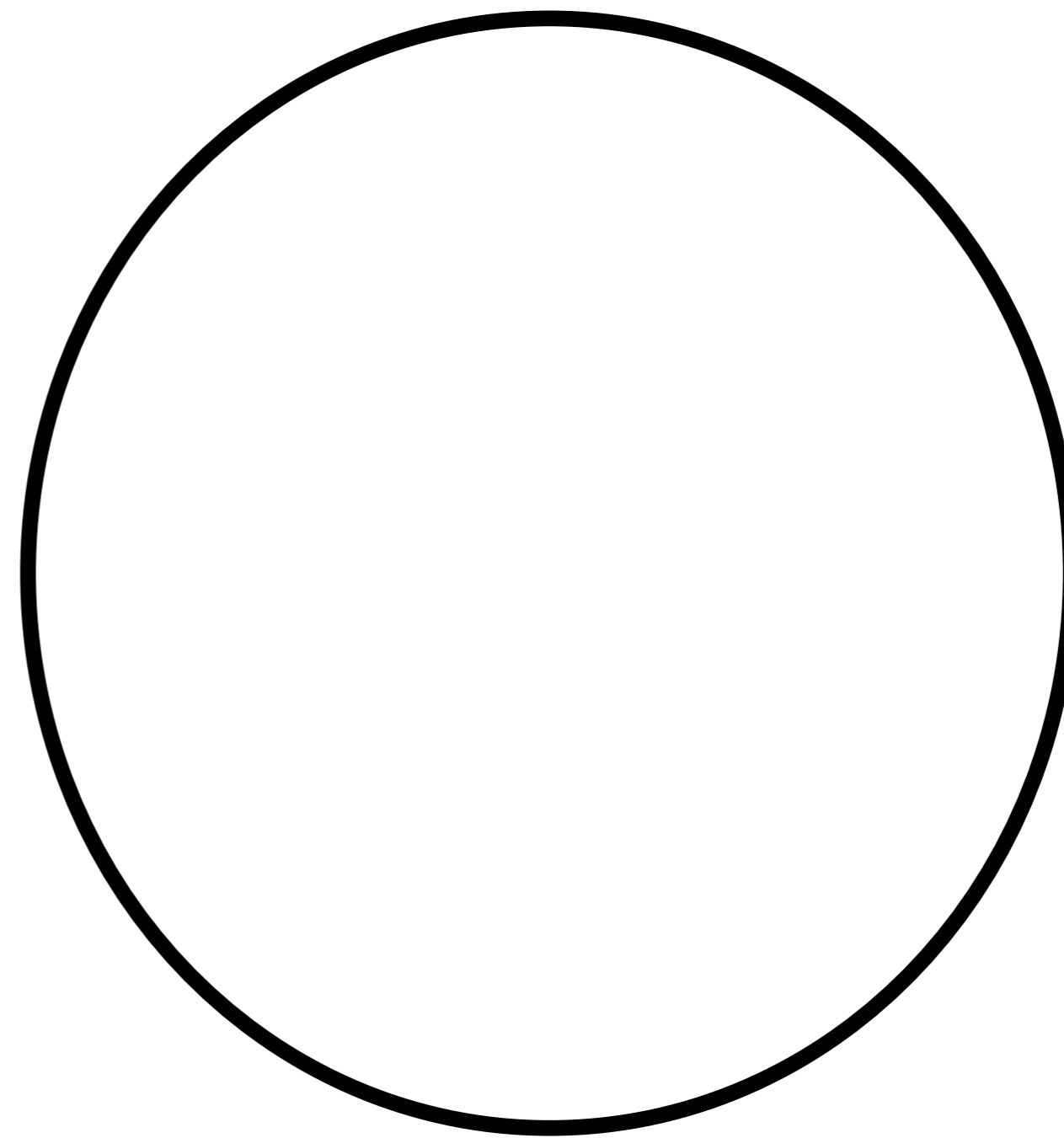
Illustration

True   Our

13

Decision Making

Decision Making

Decision Making

$$\theta < \theta_*$$
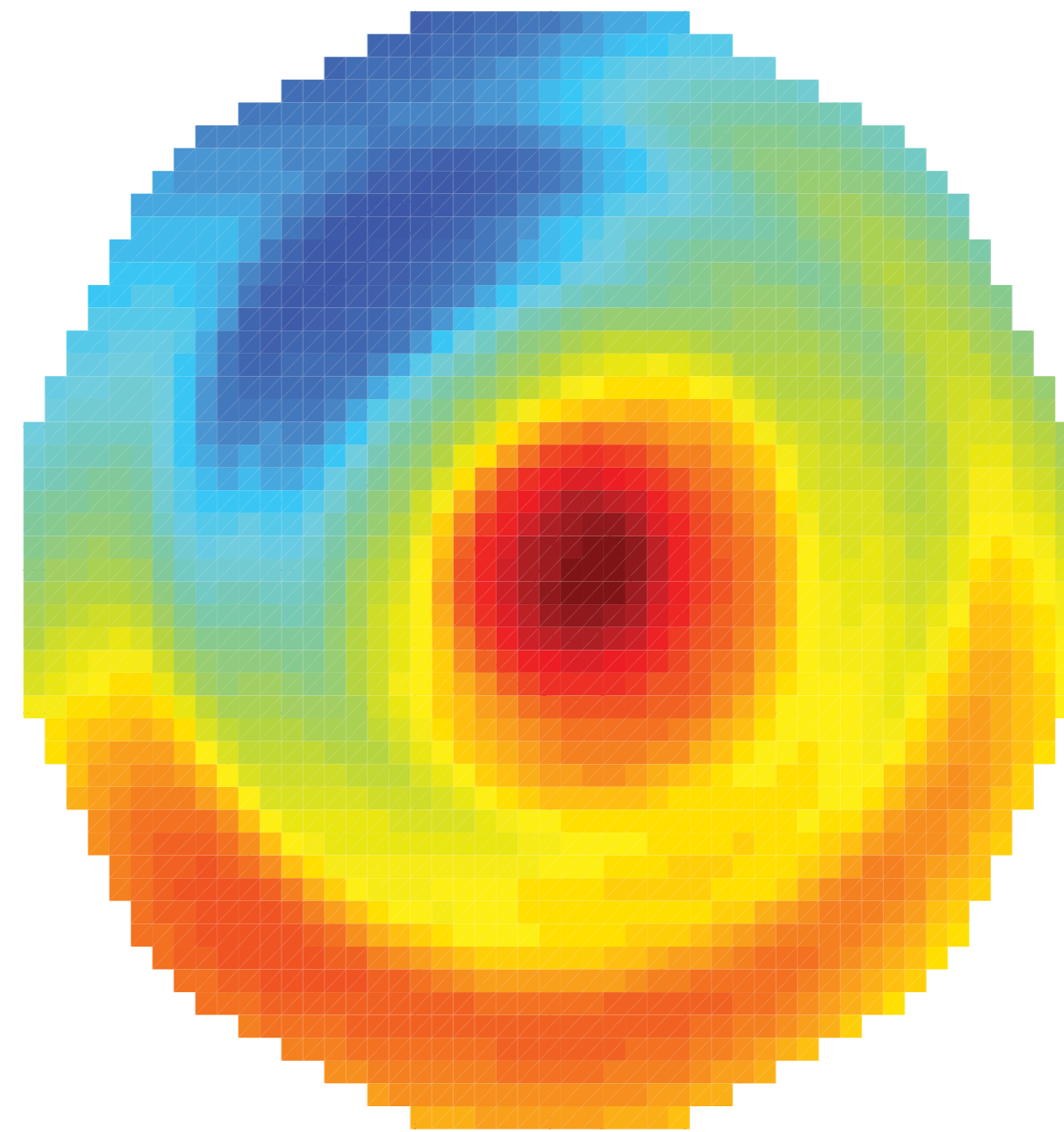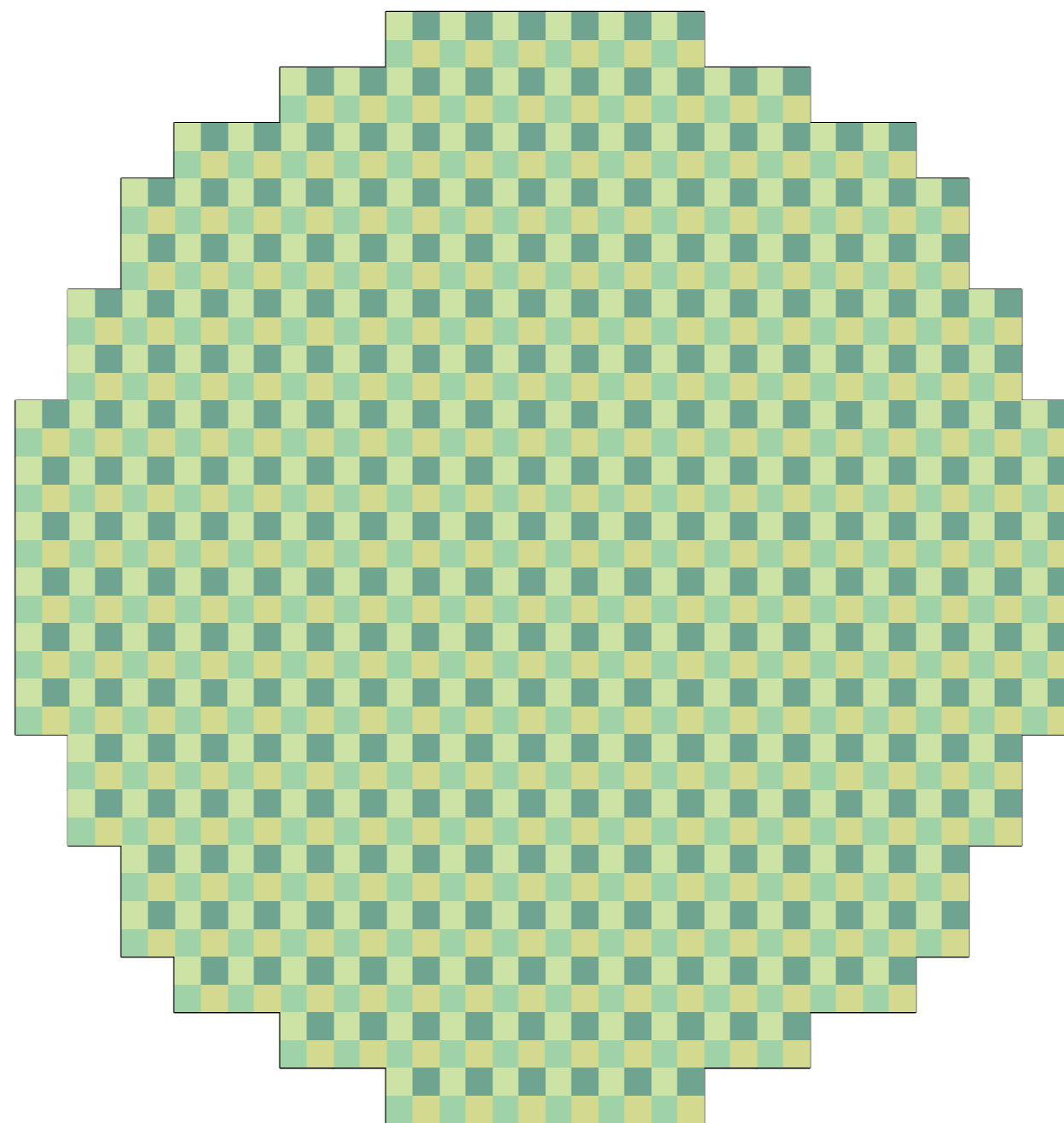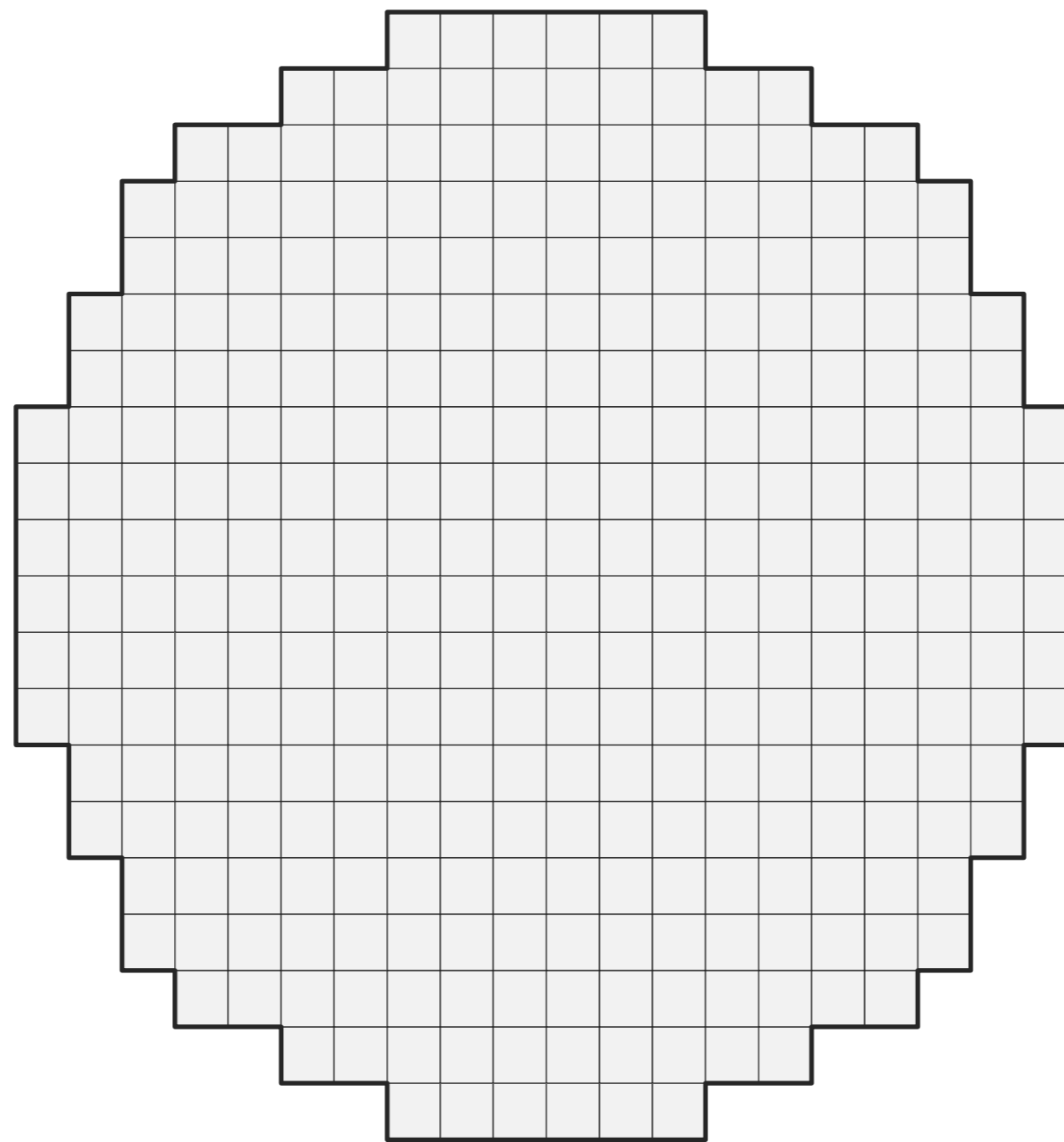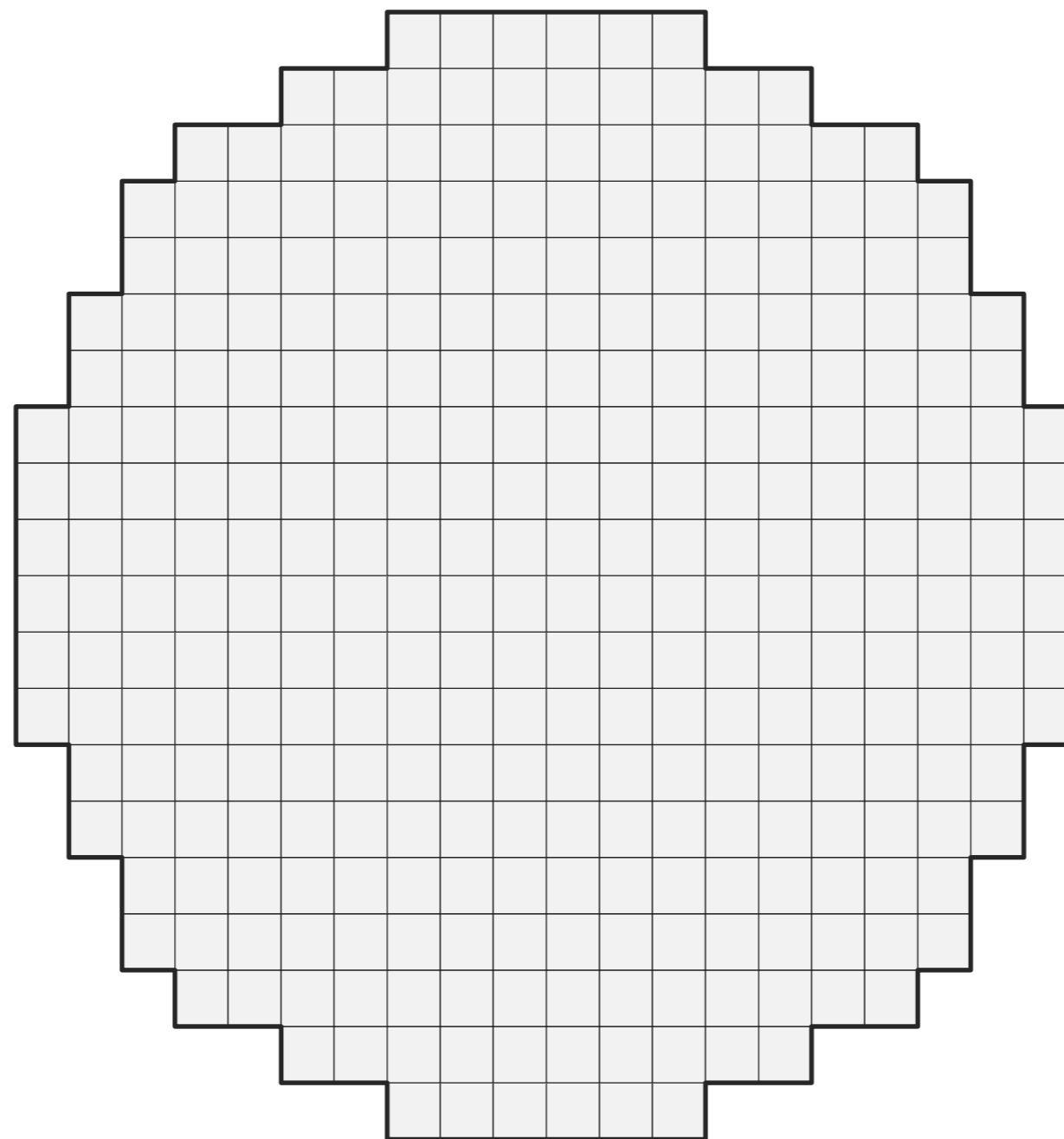
Decision Making

$$\theta < \theta_*$$
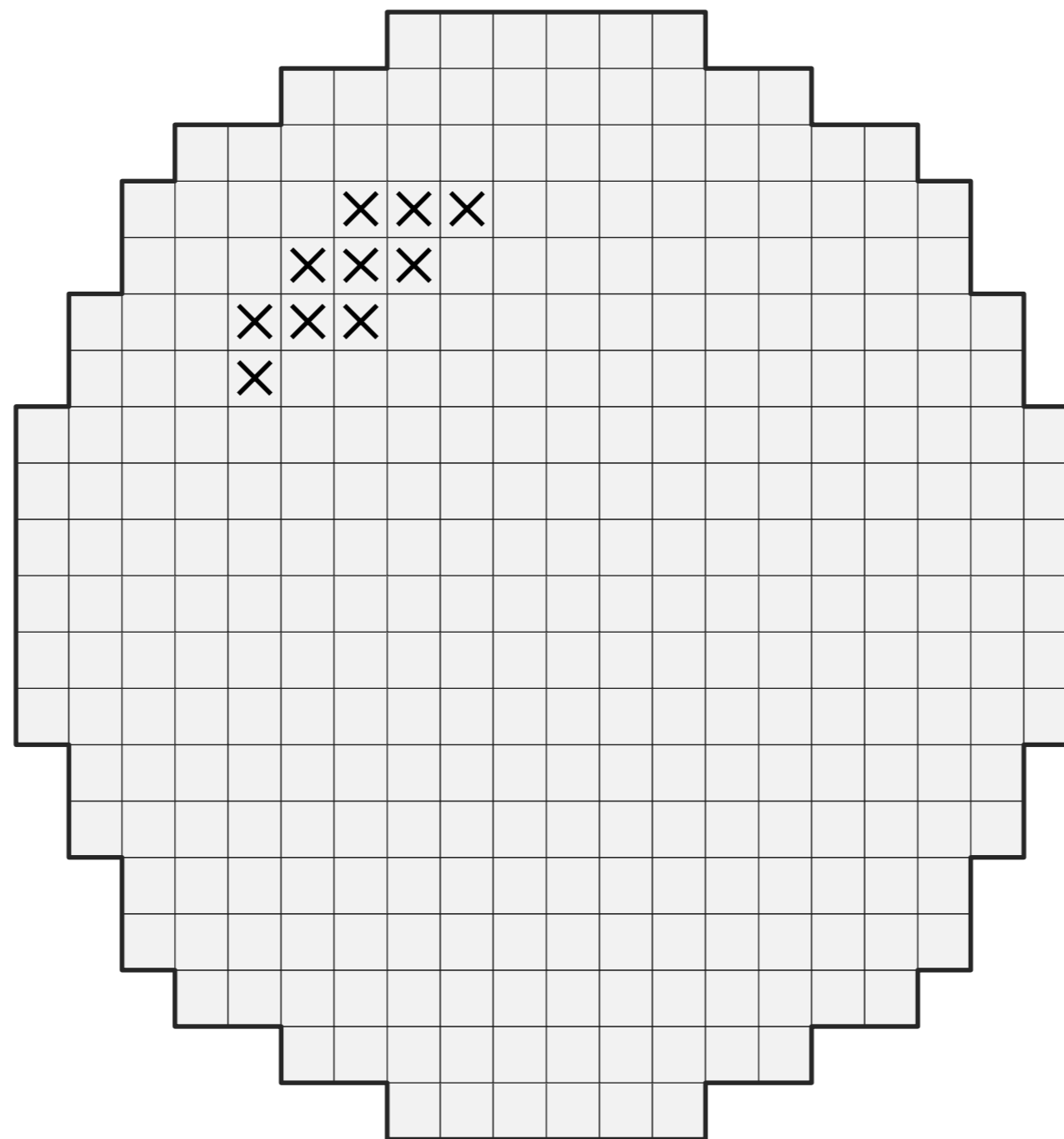
Decision Making

$$P(\theta < \theta_*) = \ ?$$
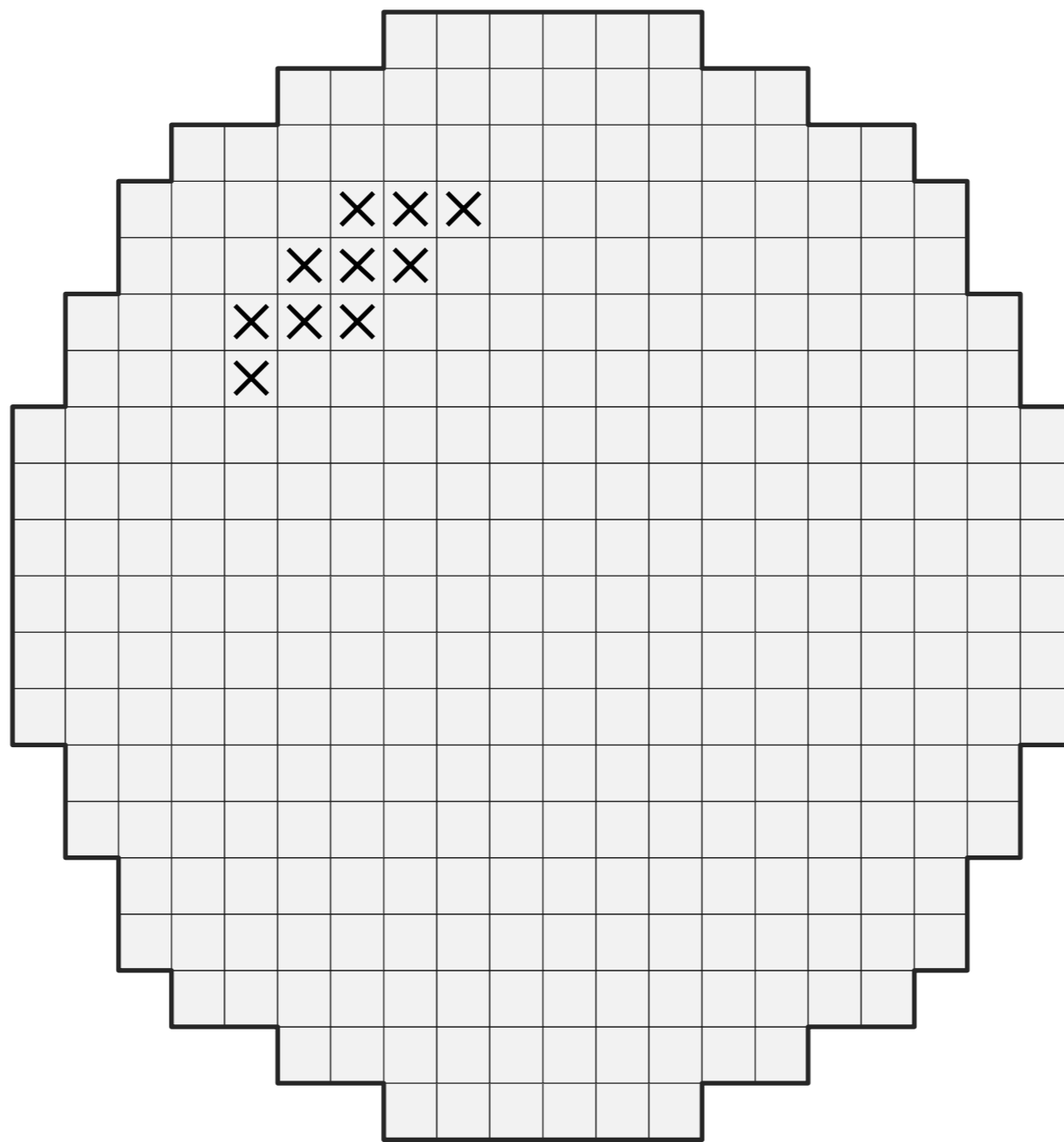
Decision Making

$$P(\theta < \theta_*) = ?$$
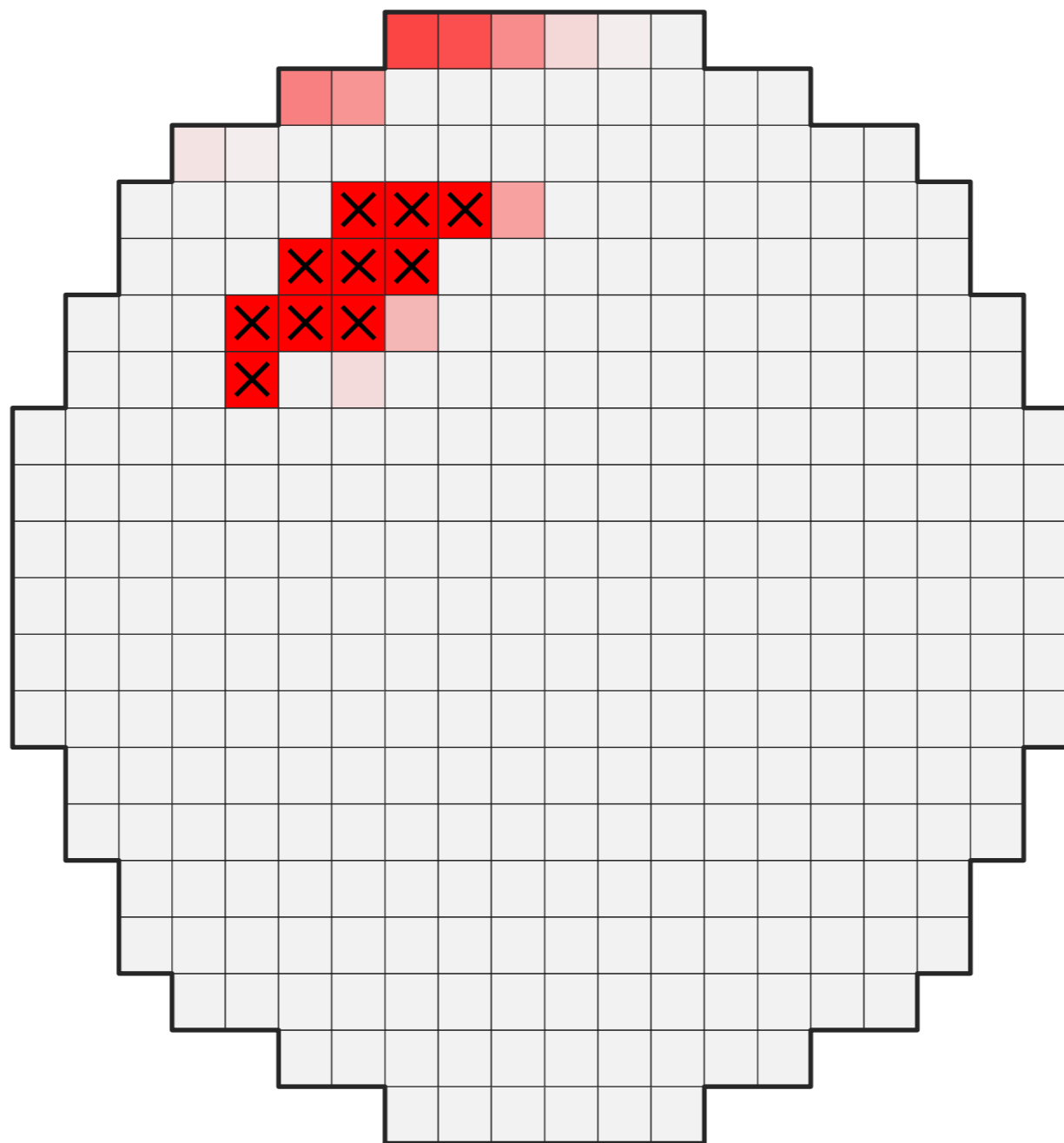
Performance

Performance

< 7%
of dies

15

Performance

<7%
of dies

<4%
of error

Performance

<7% | <4% | <4m
of dies | of error | of waiting

Performance

< 14%
of dies

Performance

<14%
of dies

<1%
of error

Performance

<14%
of dies

<1%
of error

<10m
of waiting

Bayesian Inference

Bayesian Inference

A B

Bayesian Inference

$$A \qquad\qquad B$$

$$P(A) \qquad\qquad P(B)$$

Bayesian Inference

$$P(A|B) = \ ?$$

Bayesian Inference

$$P(A|B) \propto P(B|A) \times P(A)$$

Bayesian Inference

Posterior   Likelihood   Prior

$$P(A|B) \propto P(B|A) \times P(A)$$

Bayesian Inference

Posterior   Likelihood   Prior

$$P(\theta|\mathcal{D}) \propto P(\mathcal{D}|\theta) \times P(\theta)$$

Bayesian Inference

Likelihood

$$P(\mathcal{D}|\theta)$$

Prior

$$P(\theta)$$

16

Markov Chain Monte Carlo

Thank you!