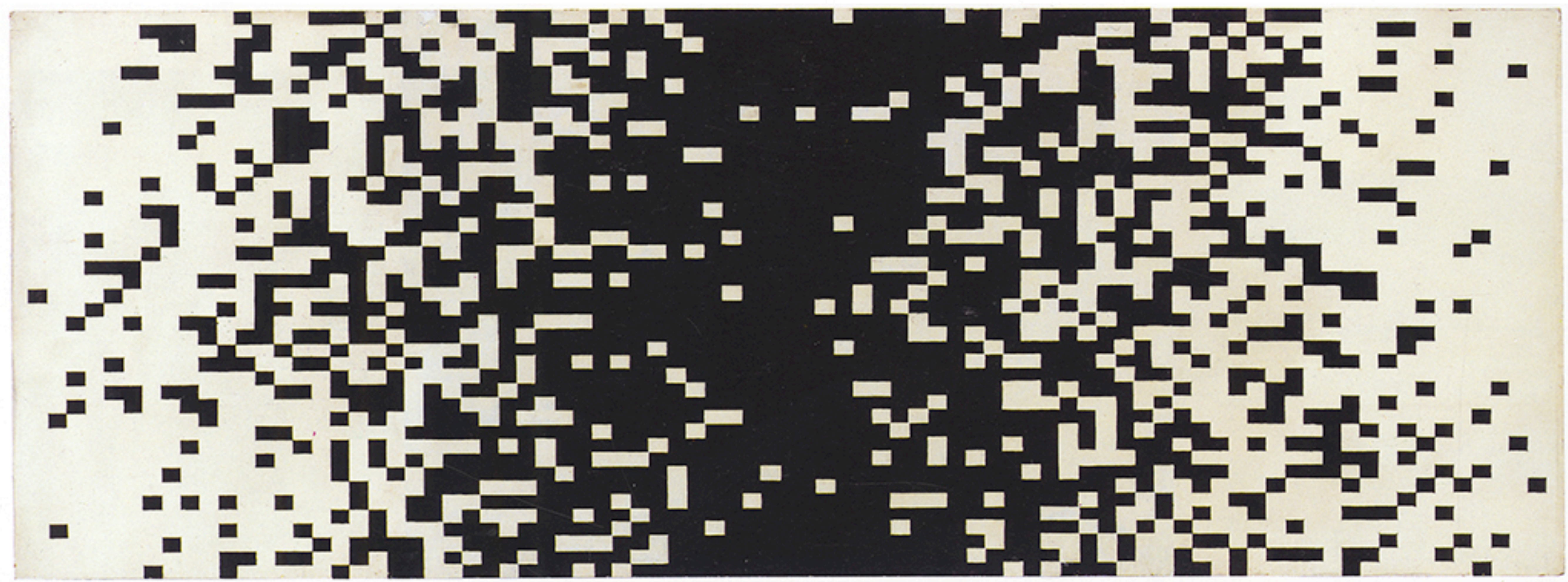
The river banks of Ellsworth Kelly's *Seine*

Bryan Gin-ge Chen
Department of Physics and Astronomy



Ellsworth Kelly (1923–)

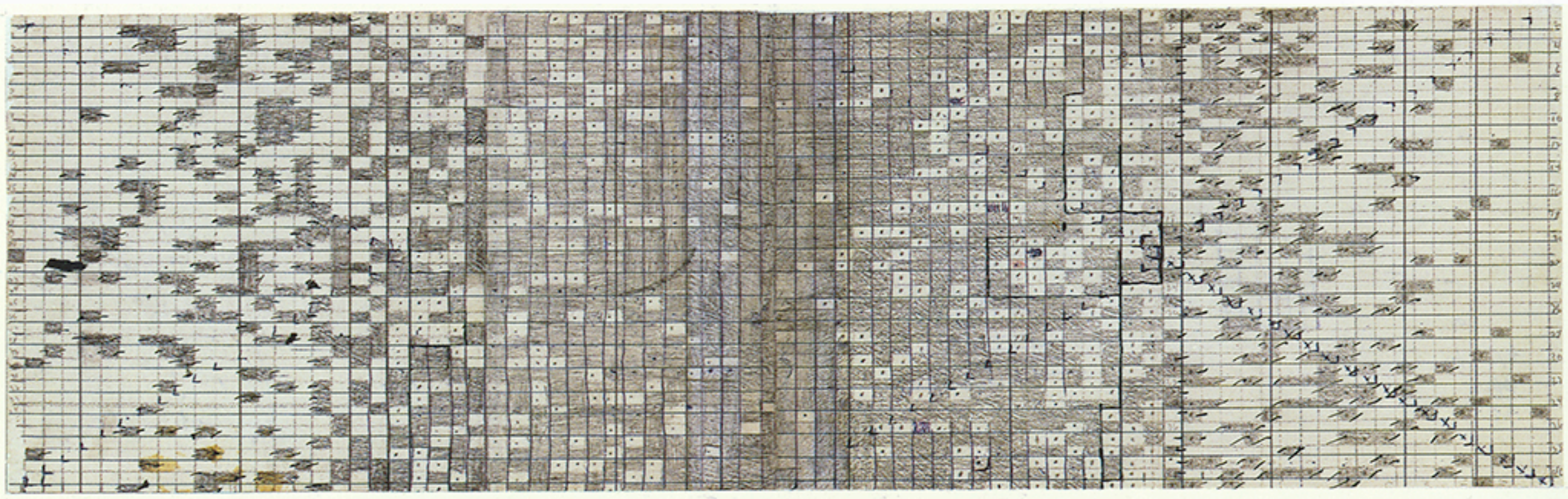
Drafted in 1943, went to Boston Museum School in 1946.

Spent 1948-1954 in France.

In 1951, worked on capturing the **reflections of light on water** in a grid.

Also began to cut up brushstrokes and **arrange them randomly**.

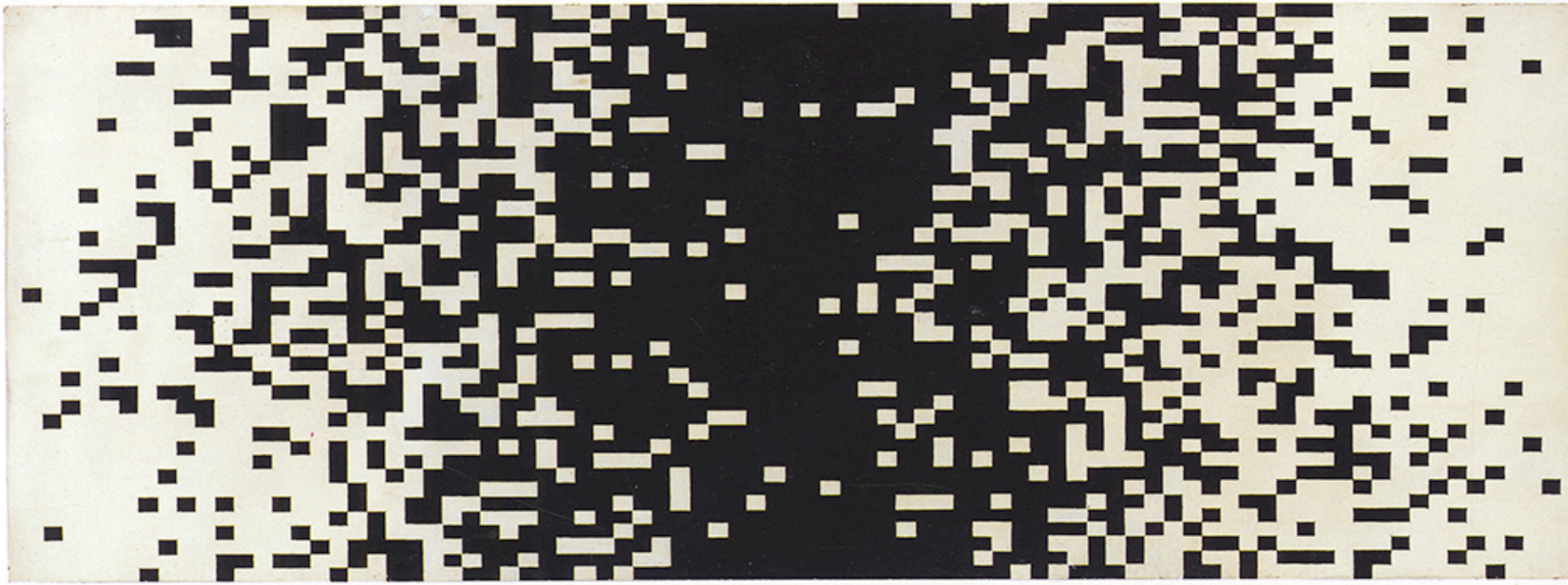
Seine **unified** these ideas:

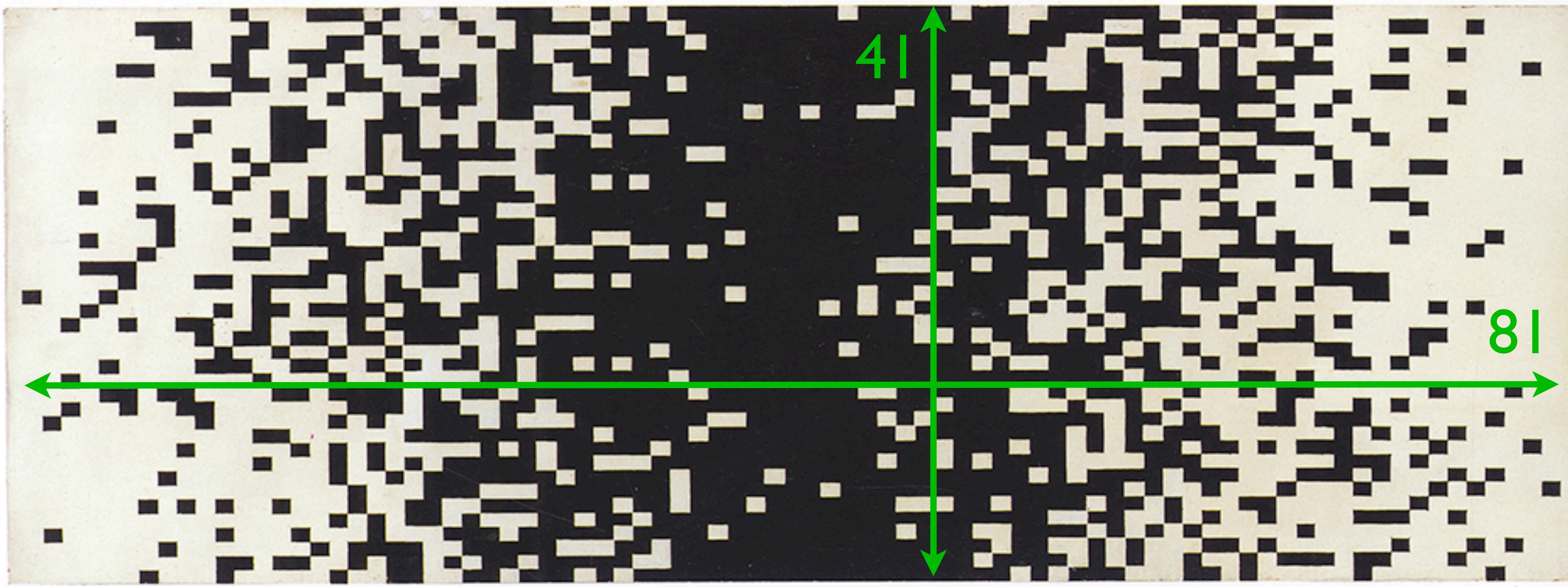


Study for *Seine*, 1951

Diane Upright, Ellsworth Kelly: Works on Paper. Fort Worth Art Museum, 1987.

Yve-Alain Bois, Jack Cowart, and Alfred Pacquement. Ellsworth Kelly: The Years in France, 1948-1954. Washington, DC: National Gallery of Art, 1992.

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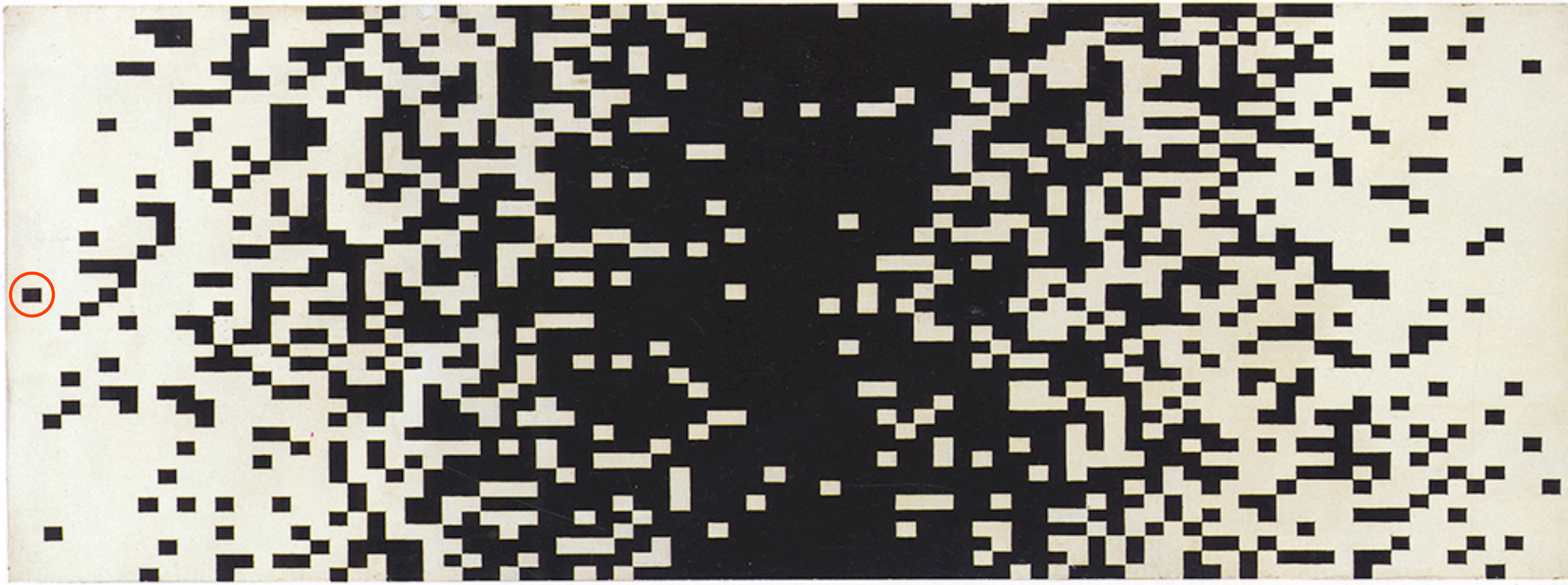
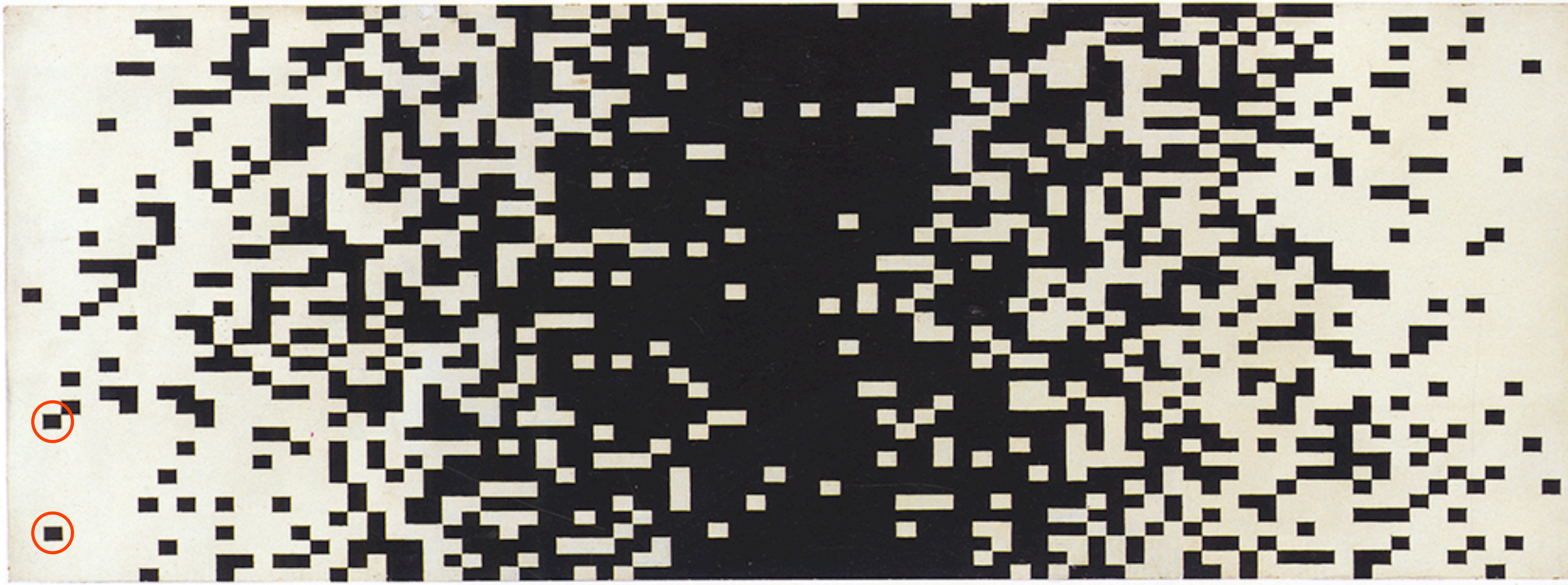
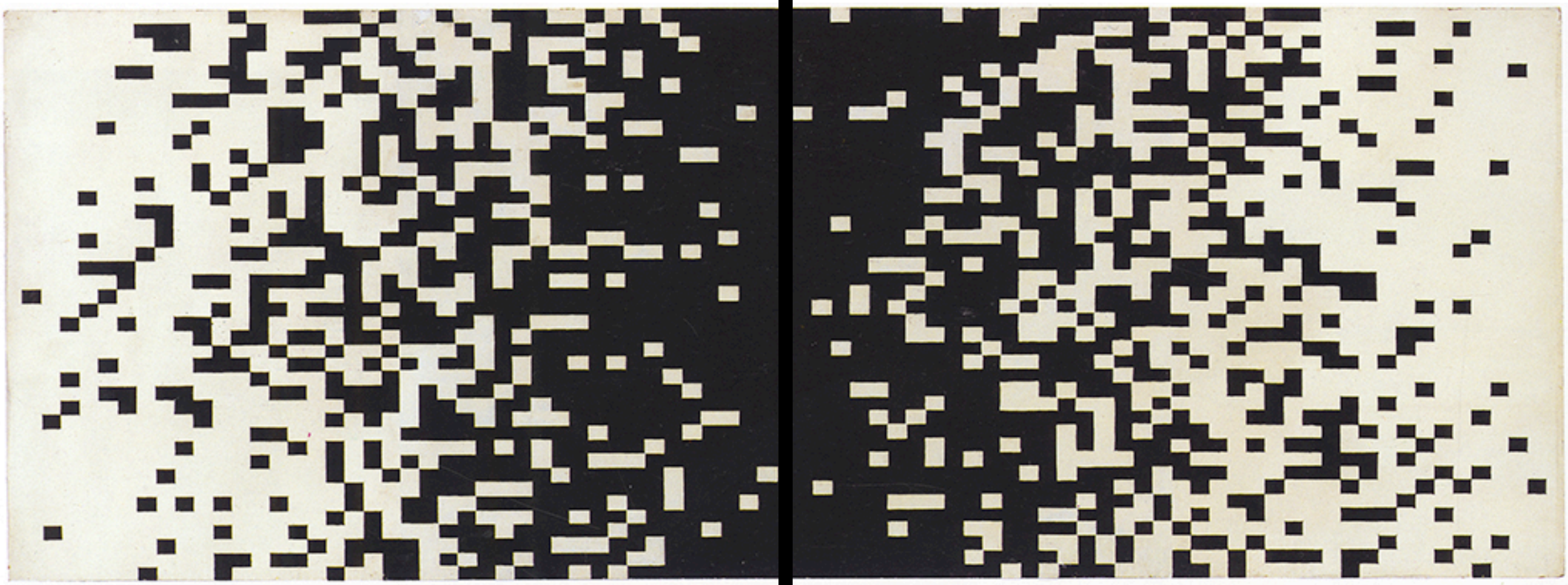
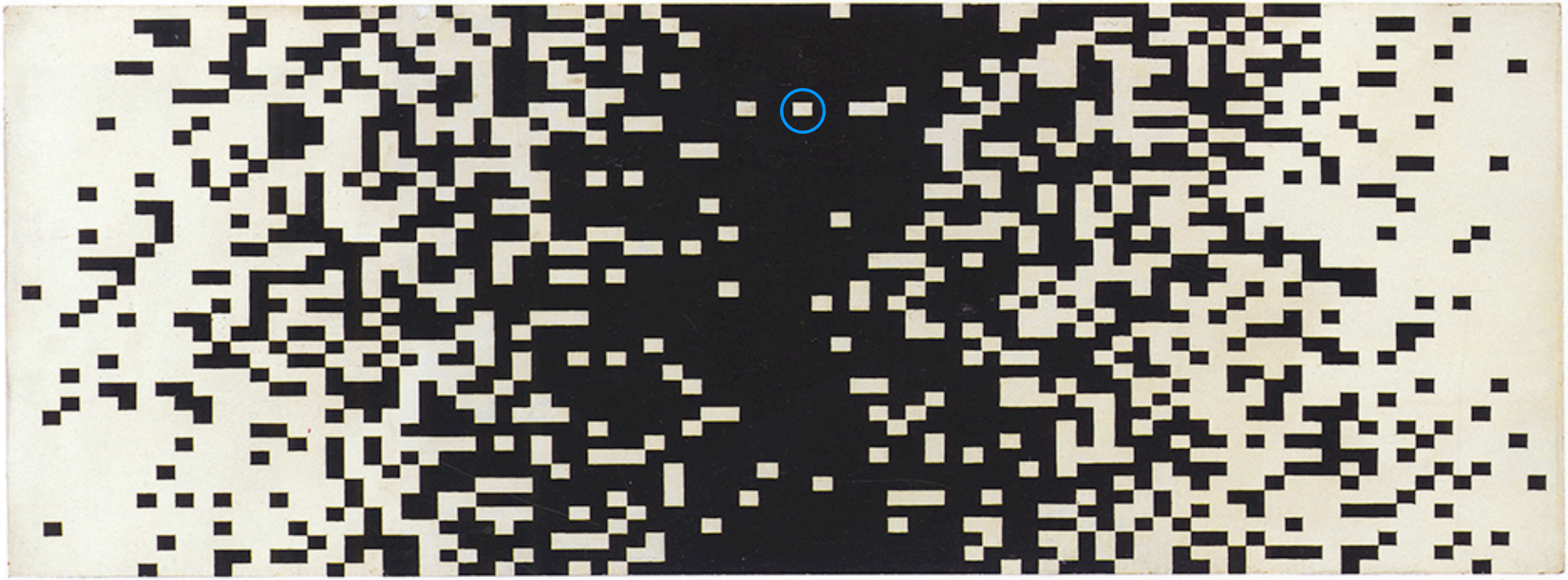
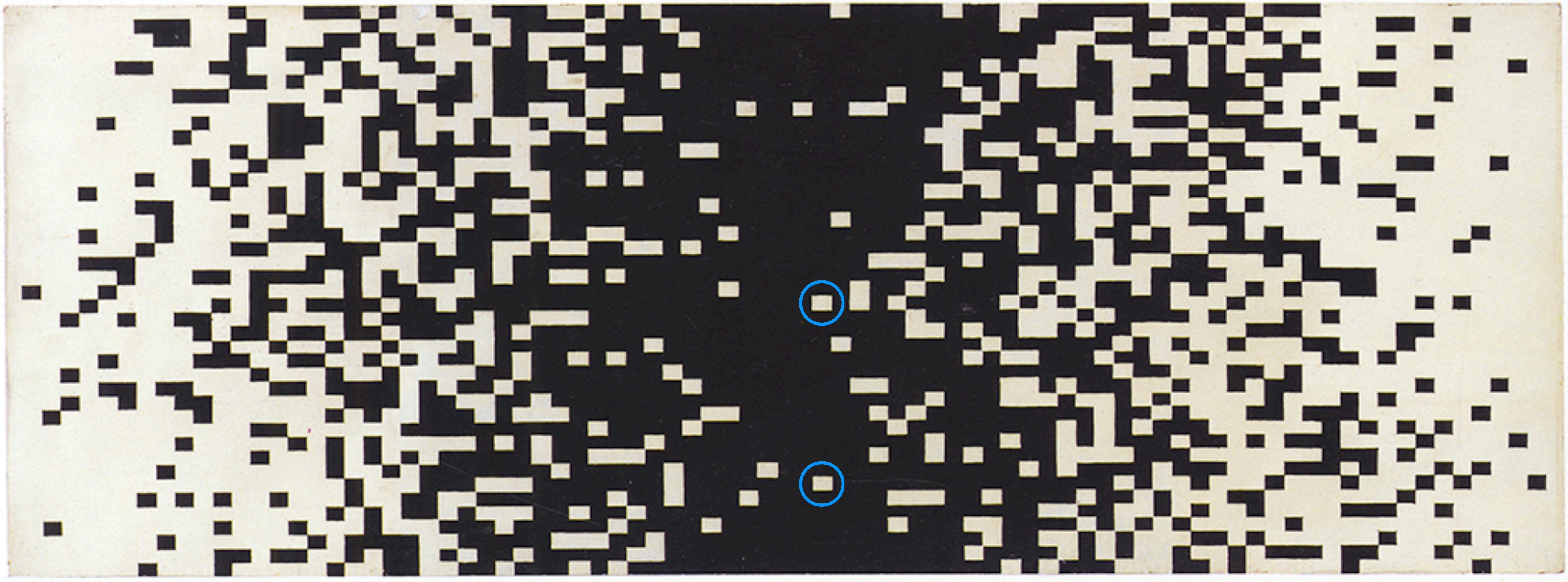
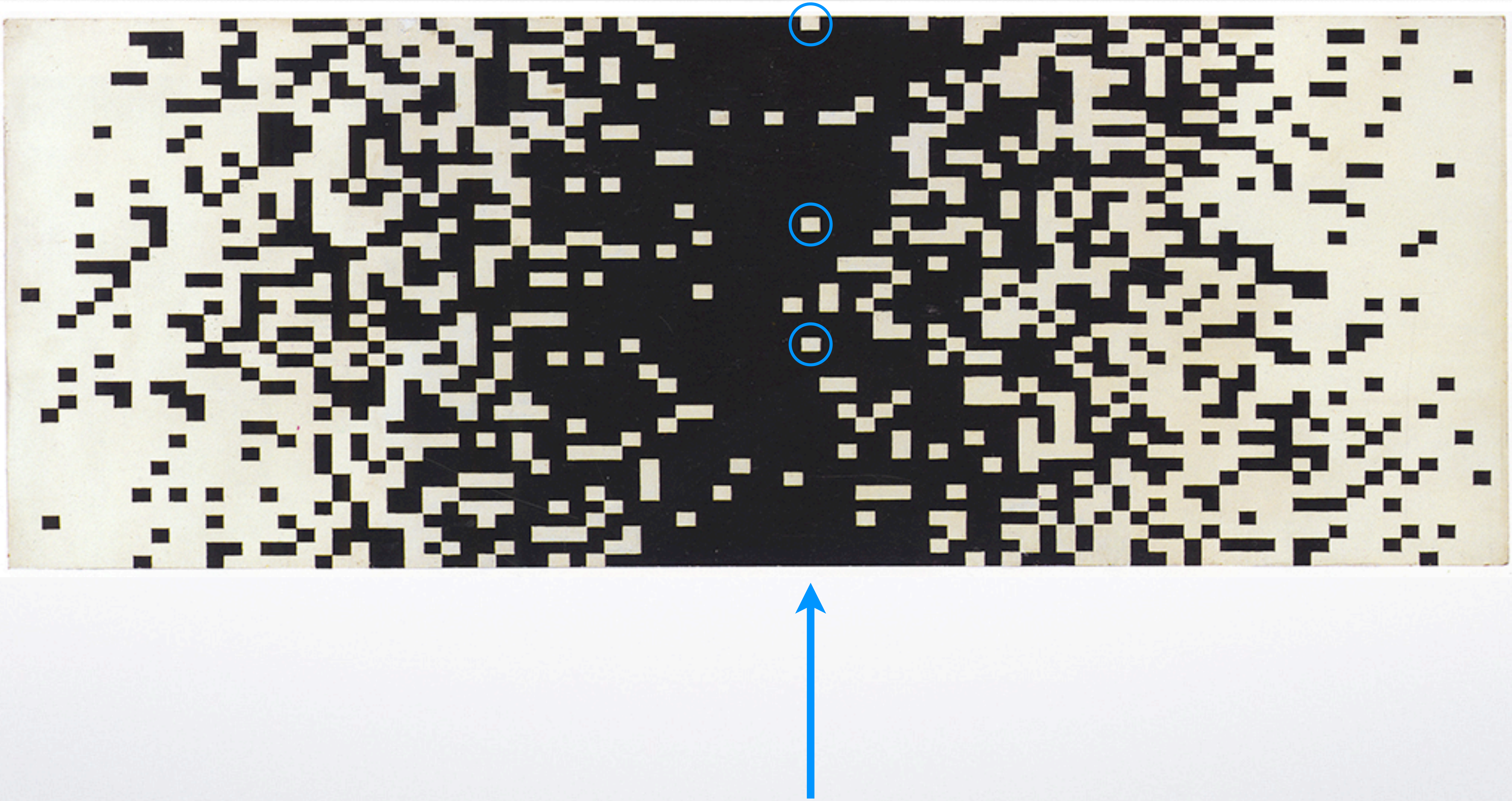


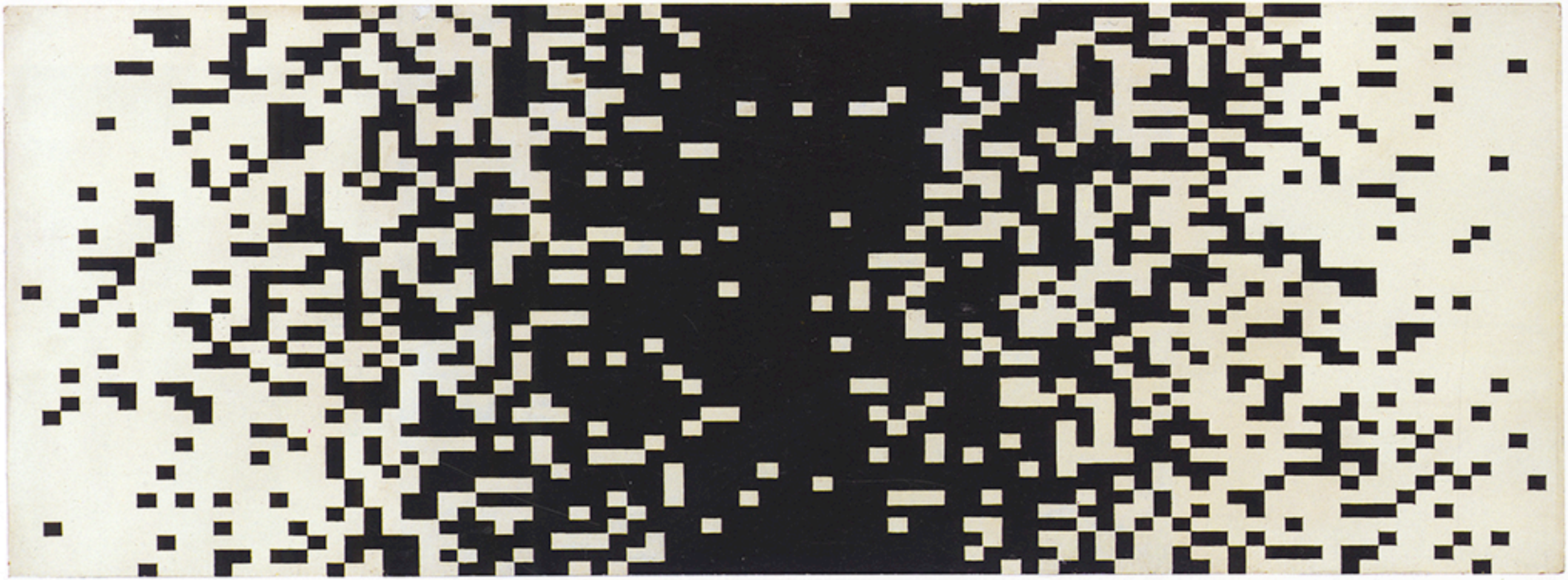






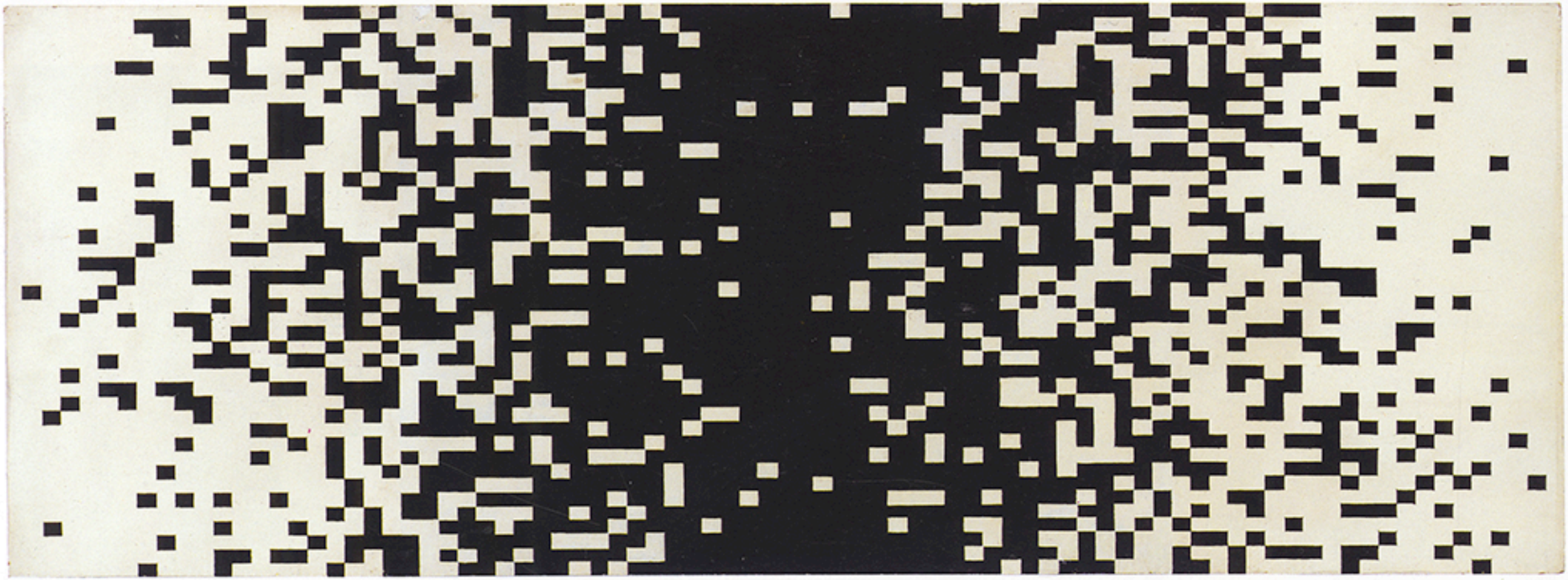






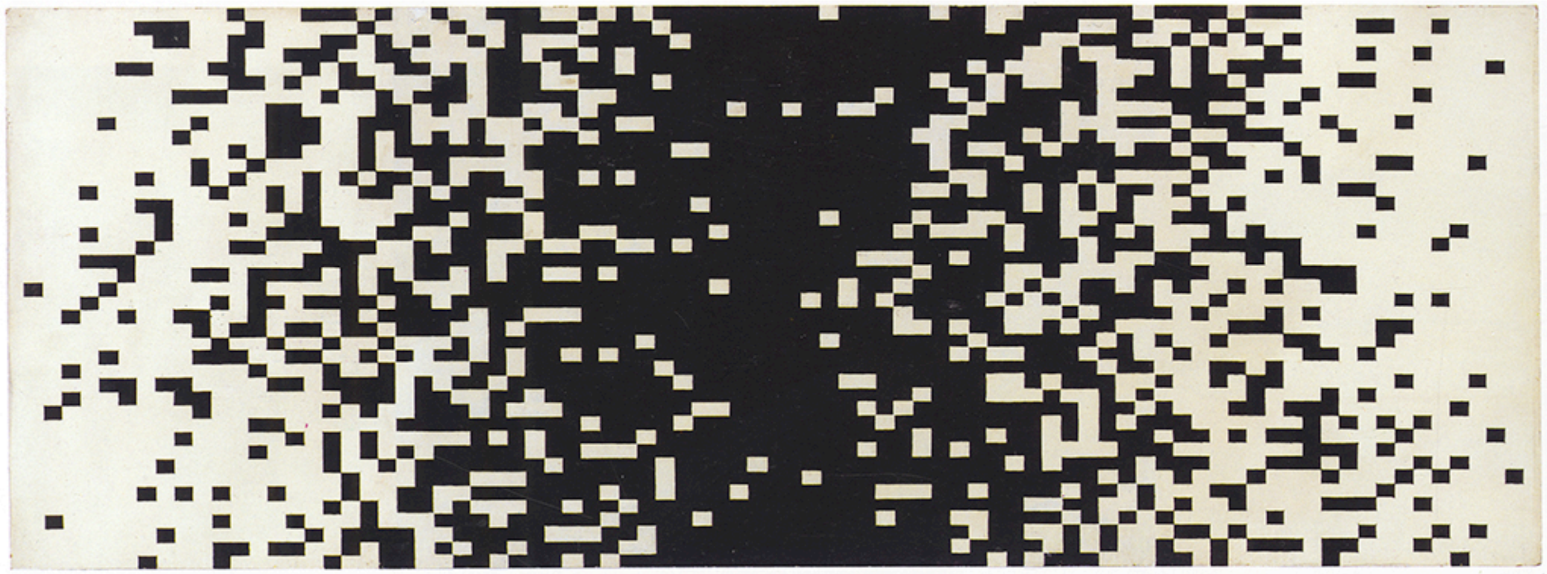
Rectangles were placed according to numbers drawn out of a hat!

Yve-Alain Bois, Jack Cowart, and Alfred Pacquement. Ellsworth Kelly: The Years in France, 1948-1954. Washington, DC: National Gallery of Art, 1992.



Each of the first 41 columns contains one more **black** rectangle than the one to its left.

Each of the next 40 following columns contains one more **white** rectangle than the one to its left.



Perhaps it's too restrictive to think of *Seine* as the particular instance which was painted – let's consider rather the **whole ensemble of possibilities**!

Questions:

① What can art do for physics?

② What can physics do for art?

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In 1985, Sapoval, Rosso, and Gouyet introduced a model for **diffusion fronts** now called **gradient percolation**.

Imagine a snapshot of dye molecules in water diffusing away from a vertical source. What does it look like?

B. Sapoval, M. Rosso, J. F. Gouyet, The fractal nature of a diffusion front and the relation to percolation, J. Physique Lett. 46, 149-156 (1985).

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It'll look like *Seine*!

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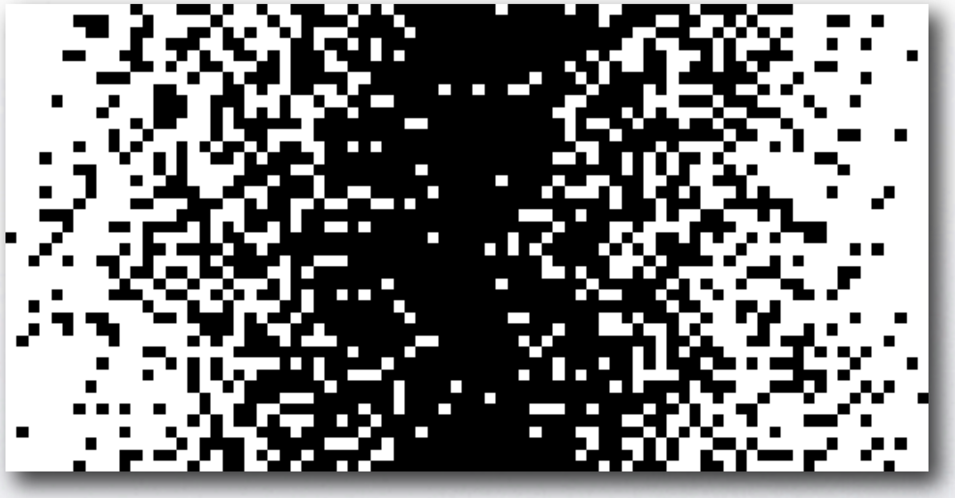
① What can art do for physics?

The **frontier** of any sort of **random propagation** can be modeled by gradient percolation:

A line of ants pouring out of a nest, the edge of a rusted metal, the spread of a disease...

They'll look like *Seine*, too!



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Questions / Answers:

① *Seine* ended up being a model for diffusion fronts!
② **What can physics do for art**?

Let's look "deeper" into *Seine*, and focus on one **visual feature** that has **physical significance.**

What do we **usually** see in the *Seine* model?

Let's draw some numbers out of a ~~hat~~ computer!

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Why do we *always* see this sort of picture, with 384±15 clusters?

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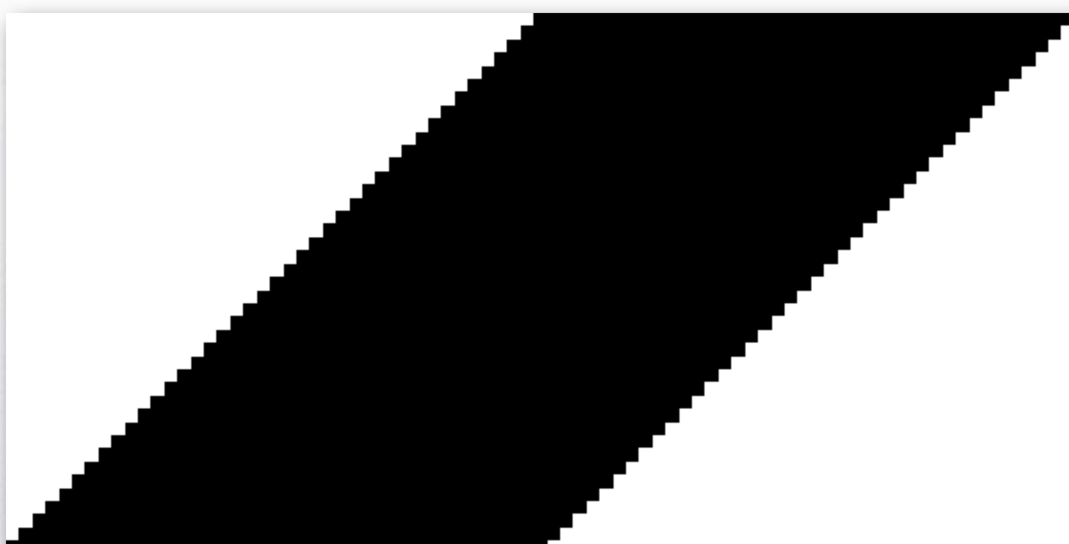
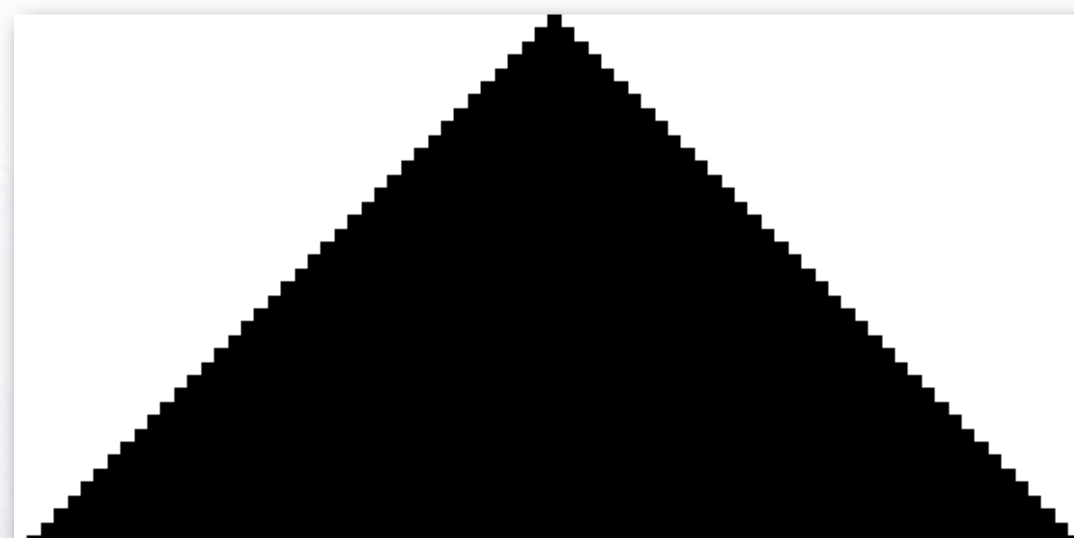
What do we **usually** see in the *Seine* model?

Let's draw some numbers out of a ~~hat~~ computer!

And *never* something like this, with three connected clusters?

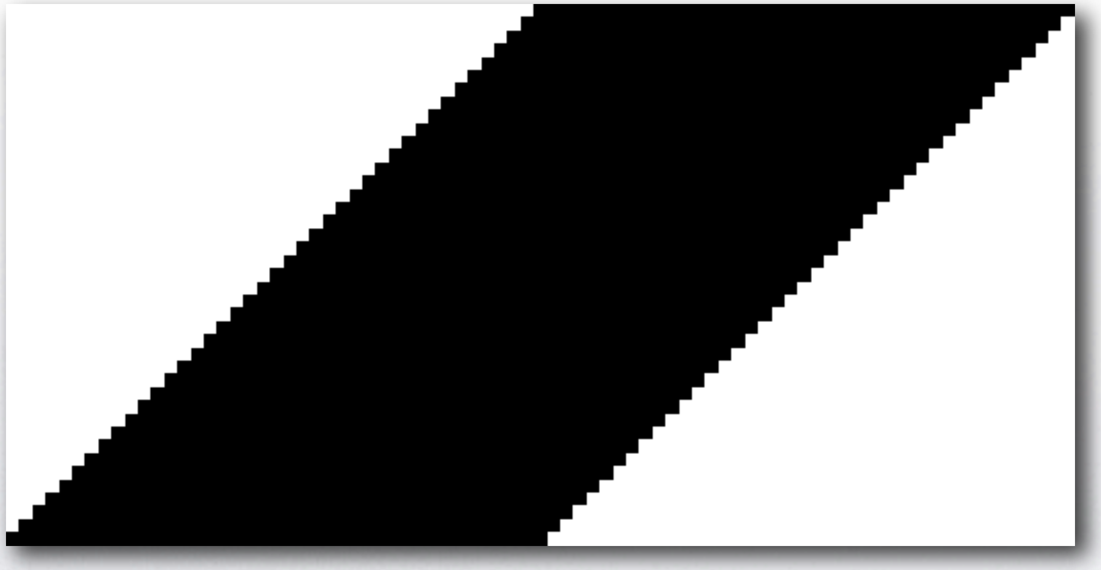


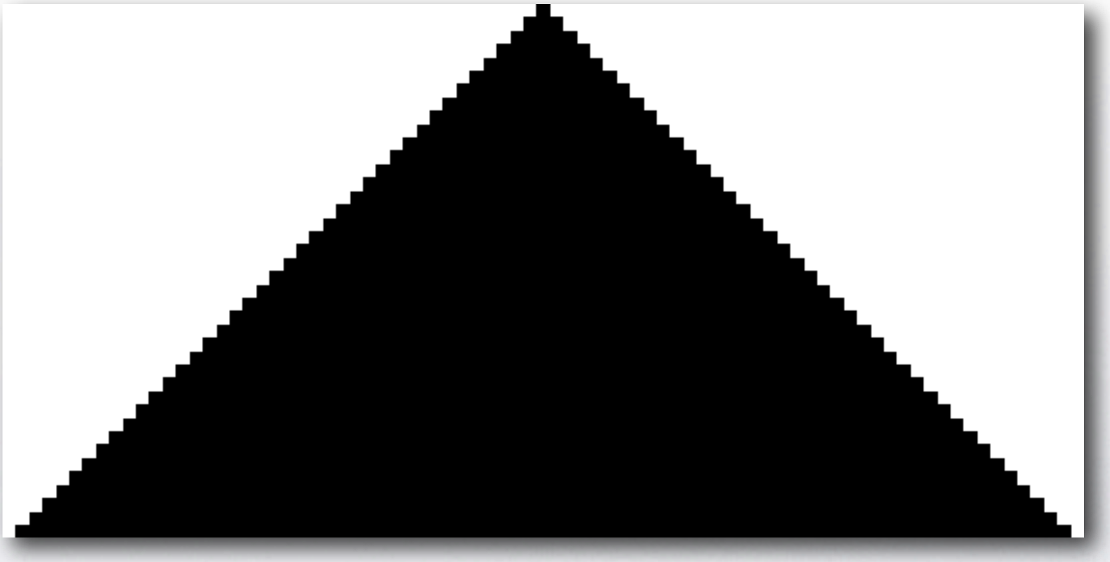


What do we **usually** see in the *Seine* model?

There are roughly 1.98×10^{665} different possible configurations.

How many times would we have to "win the lottery" in a row to draw one of these?



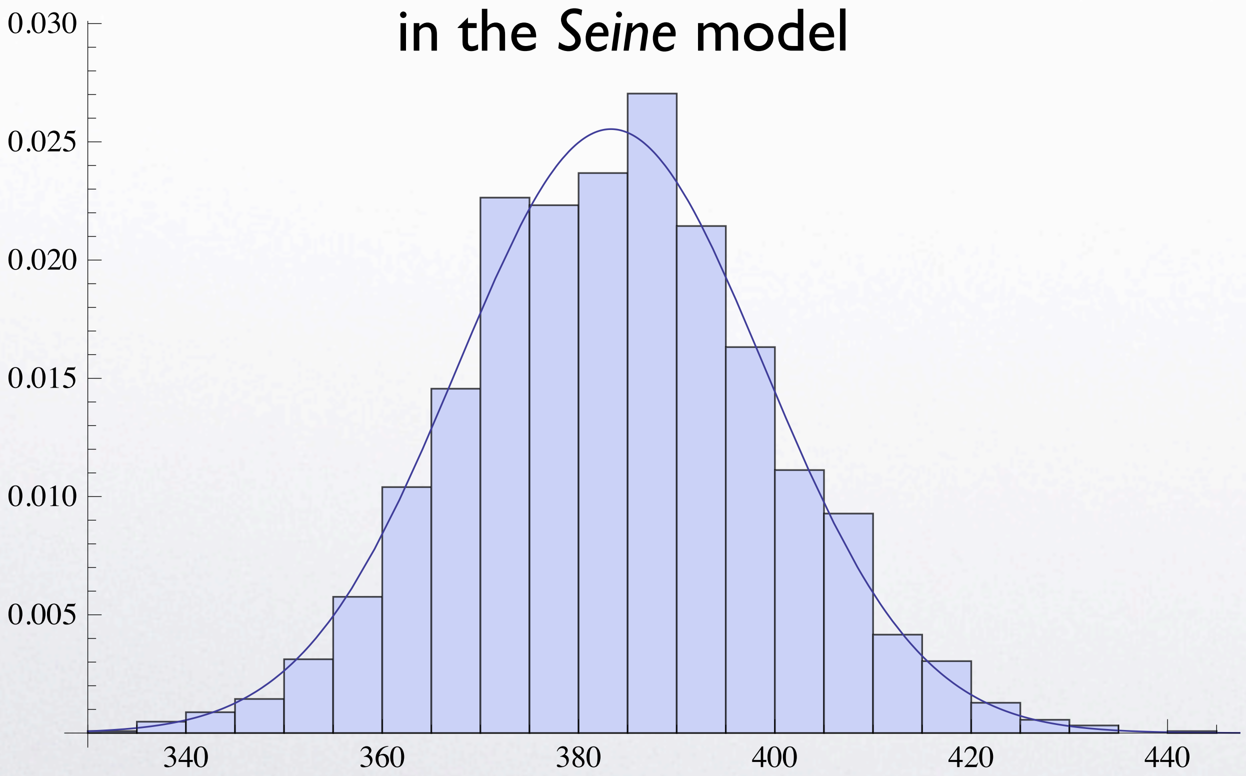


Key physics fact: Large **random** systems often exhibit **predictable** behavior!

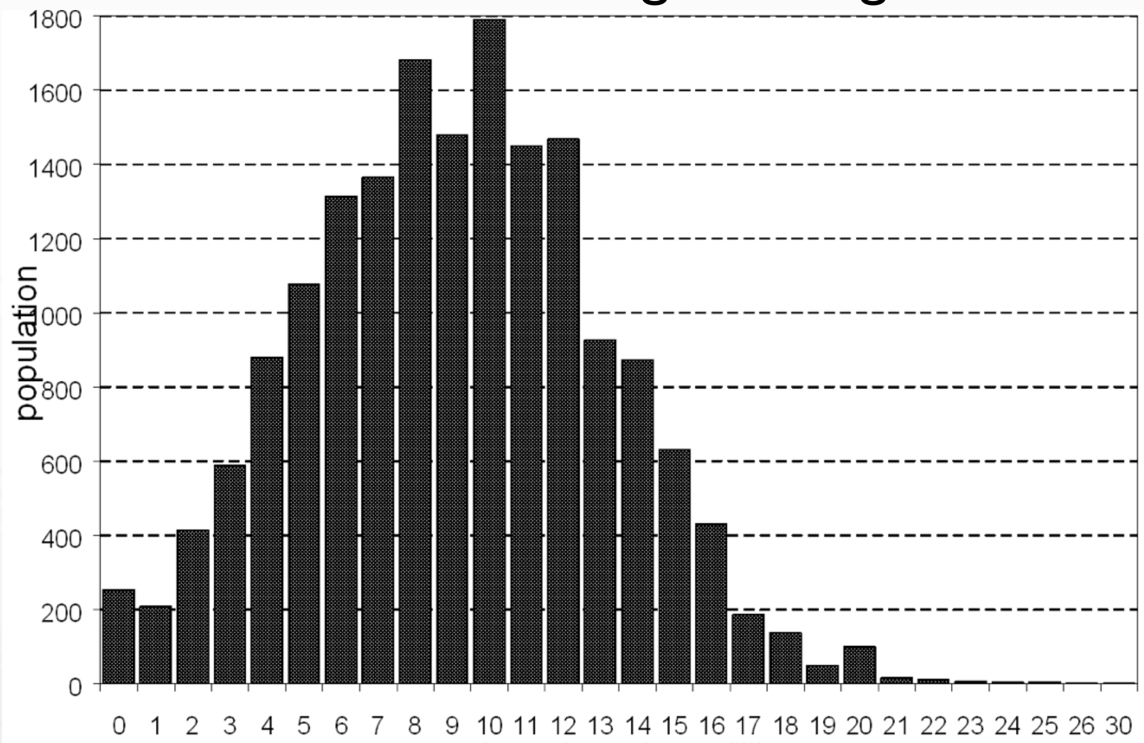
Predictable behavior in **random systems**?

This is expressed by various **central limit theorems**:
–why "everything" is statistically distributed via the **bell curve**
–why stock prices look like **Brownian motion**

Distribution of number of clusters in the *Seine* model



Number of amalgam fillings



http://www.xs4all.nl/~stgvisie/AMALGAM/EN/SCIENCE/tubingen.html

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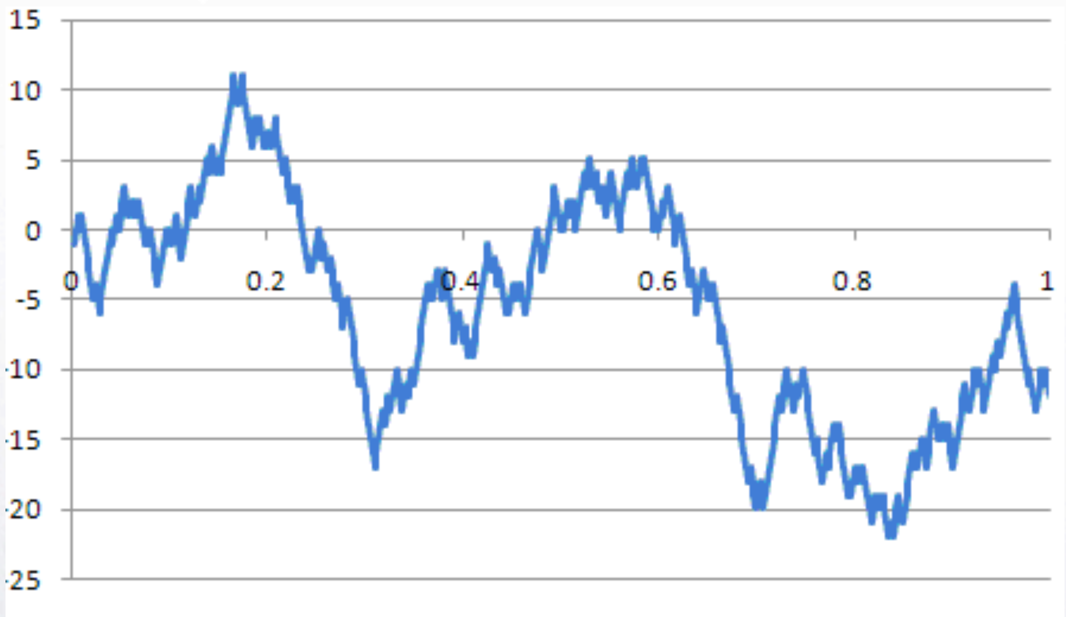

http://gammamath.com/sub/RandomWalk.shtml

http://www.databison.com/index.php/stock-chart-with-scroll-and-zoom/

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–why "everything" is statistically distributed via the **bell curve**
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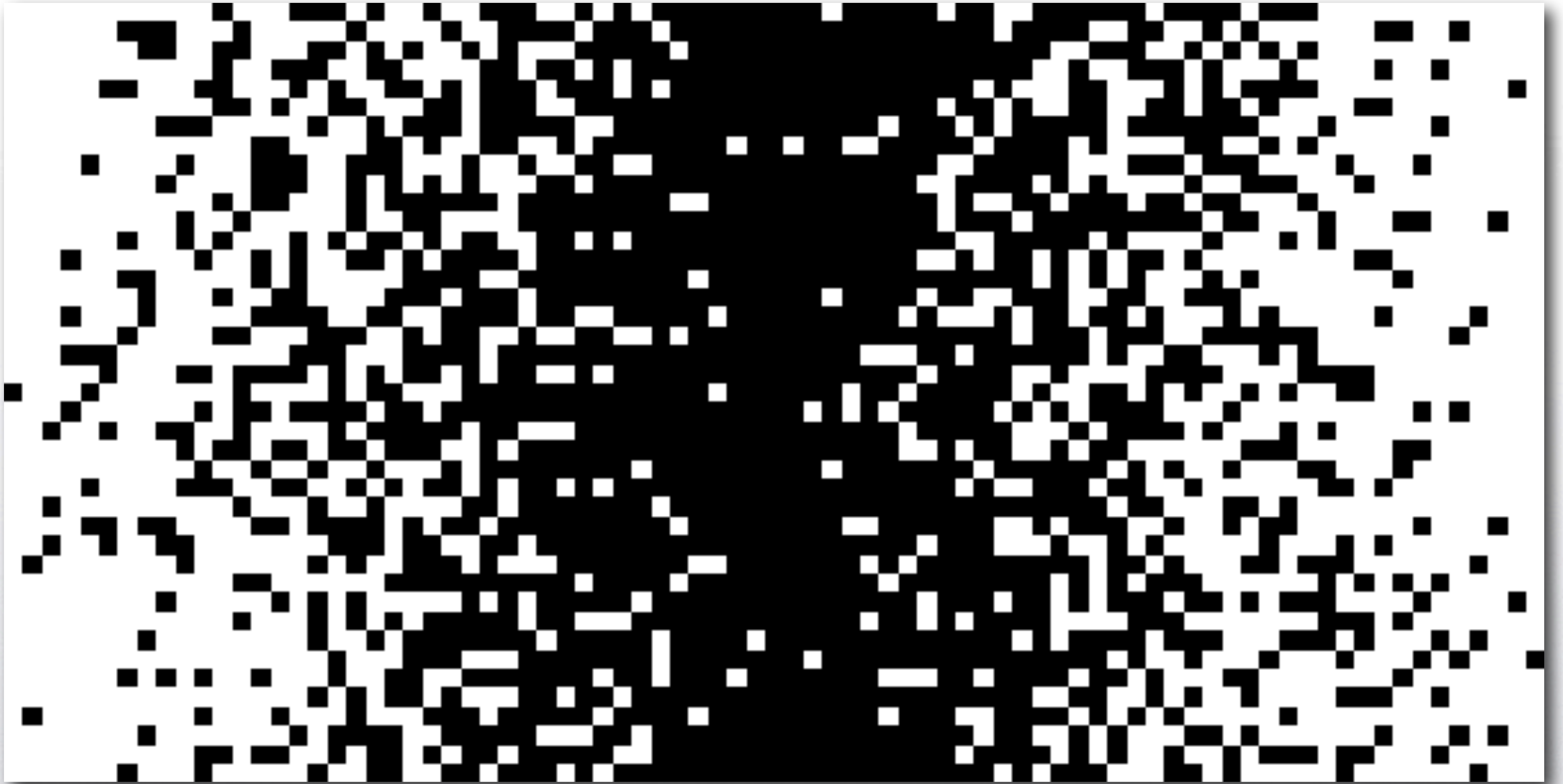
This principle applies very broadly!

What do these sorts of laws say about what we **see** in *Seine* / diffusion fronts?

Three biggest clusters:

Land ———————— Water ———————— Land



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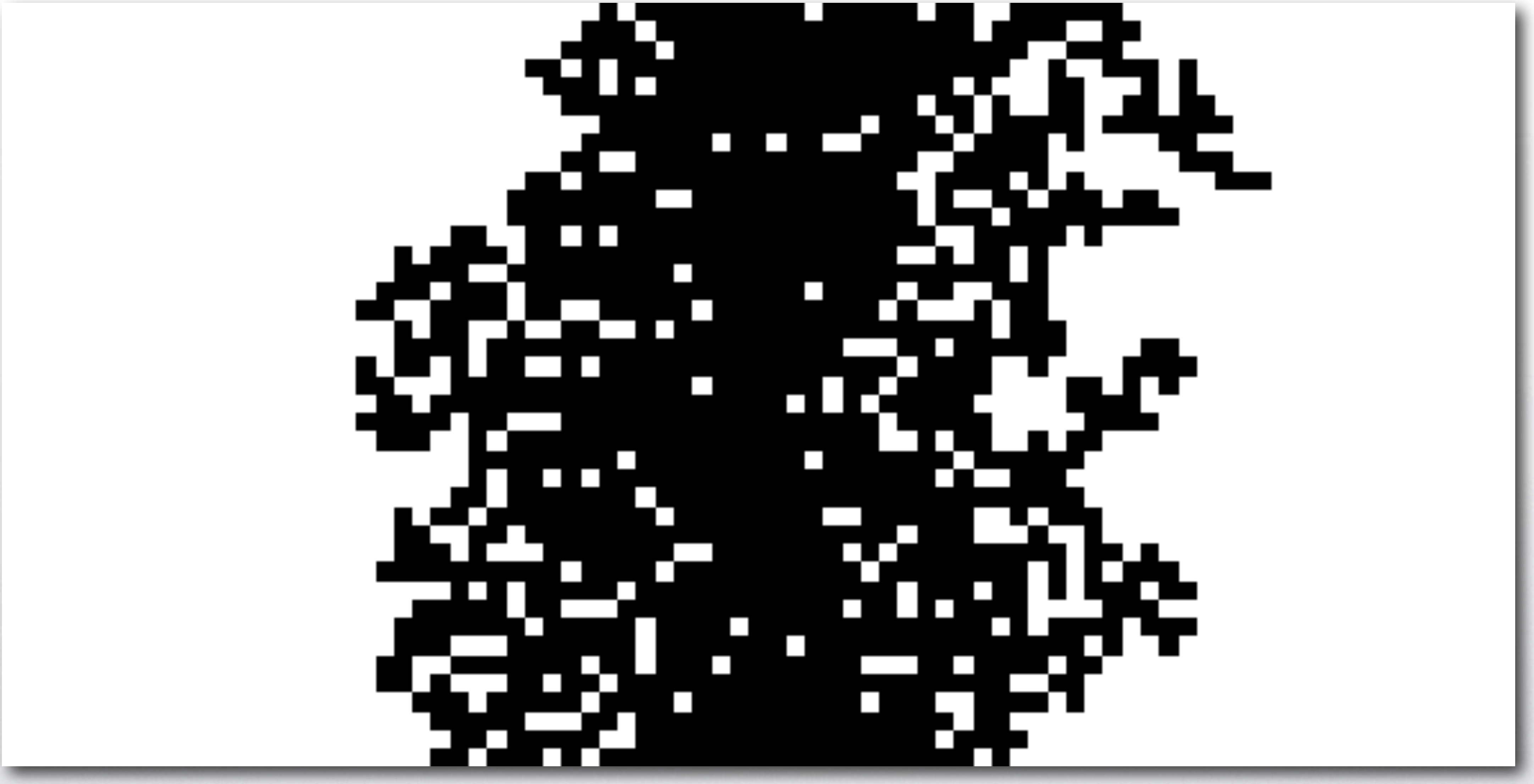

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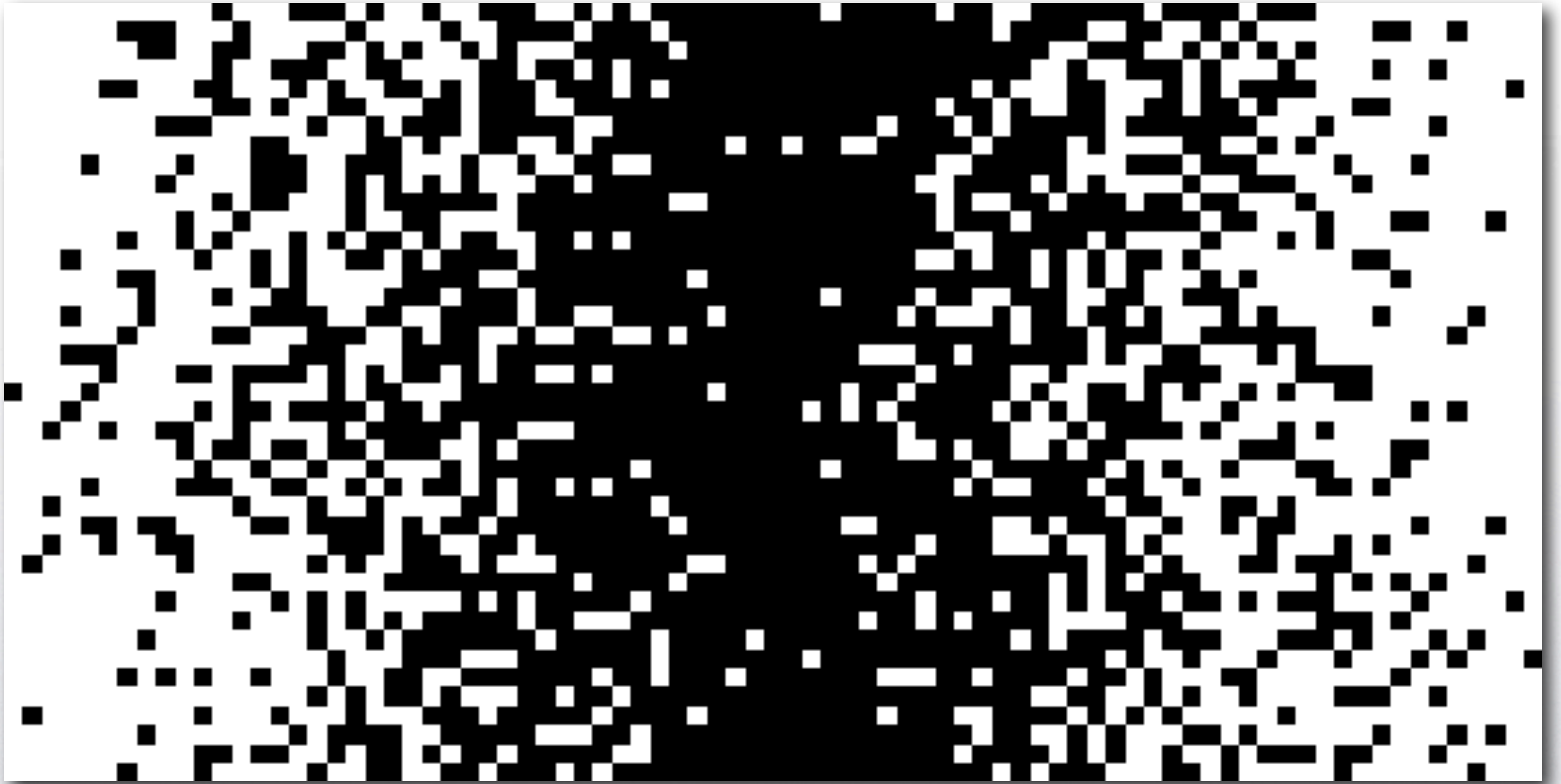
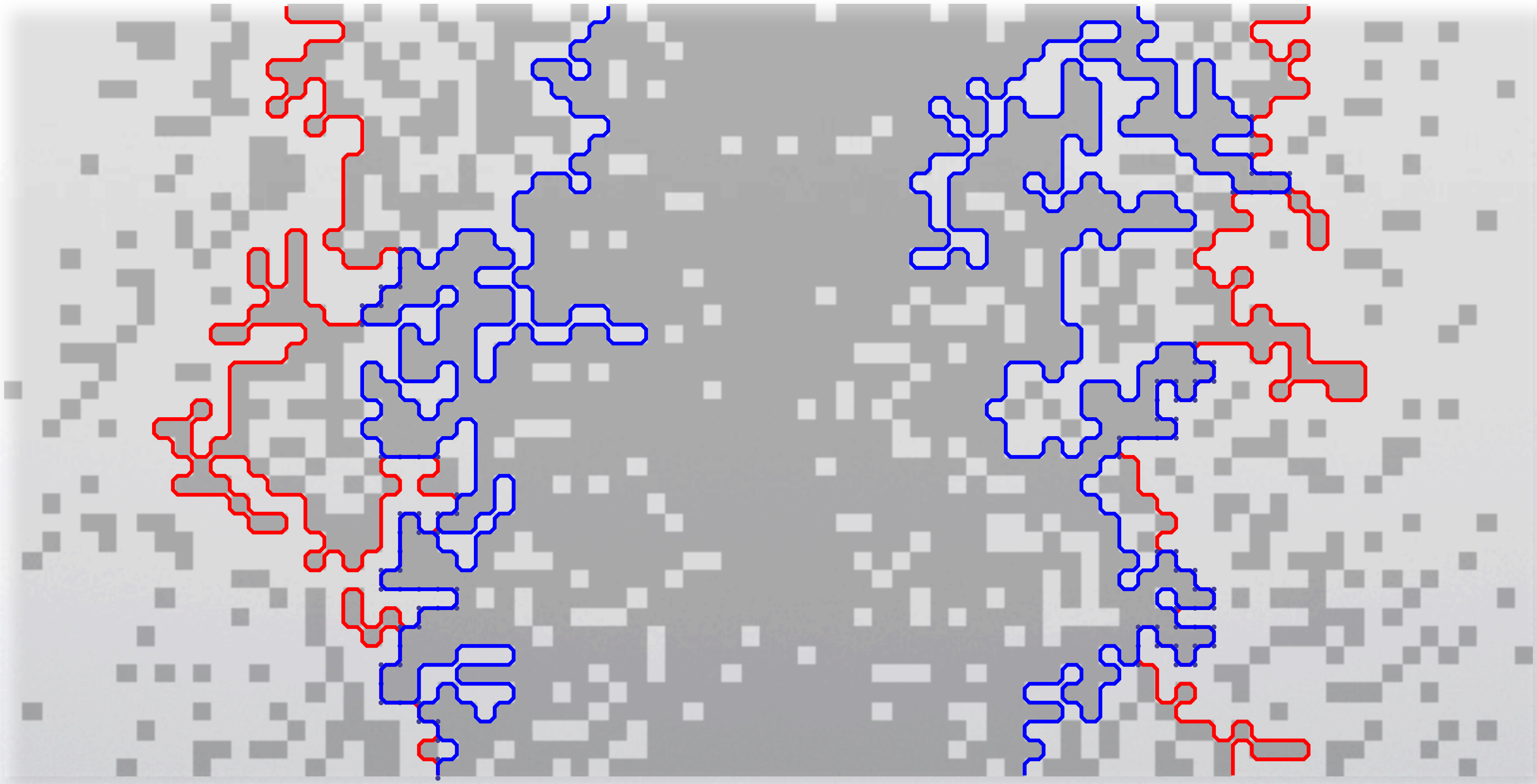


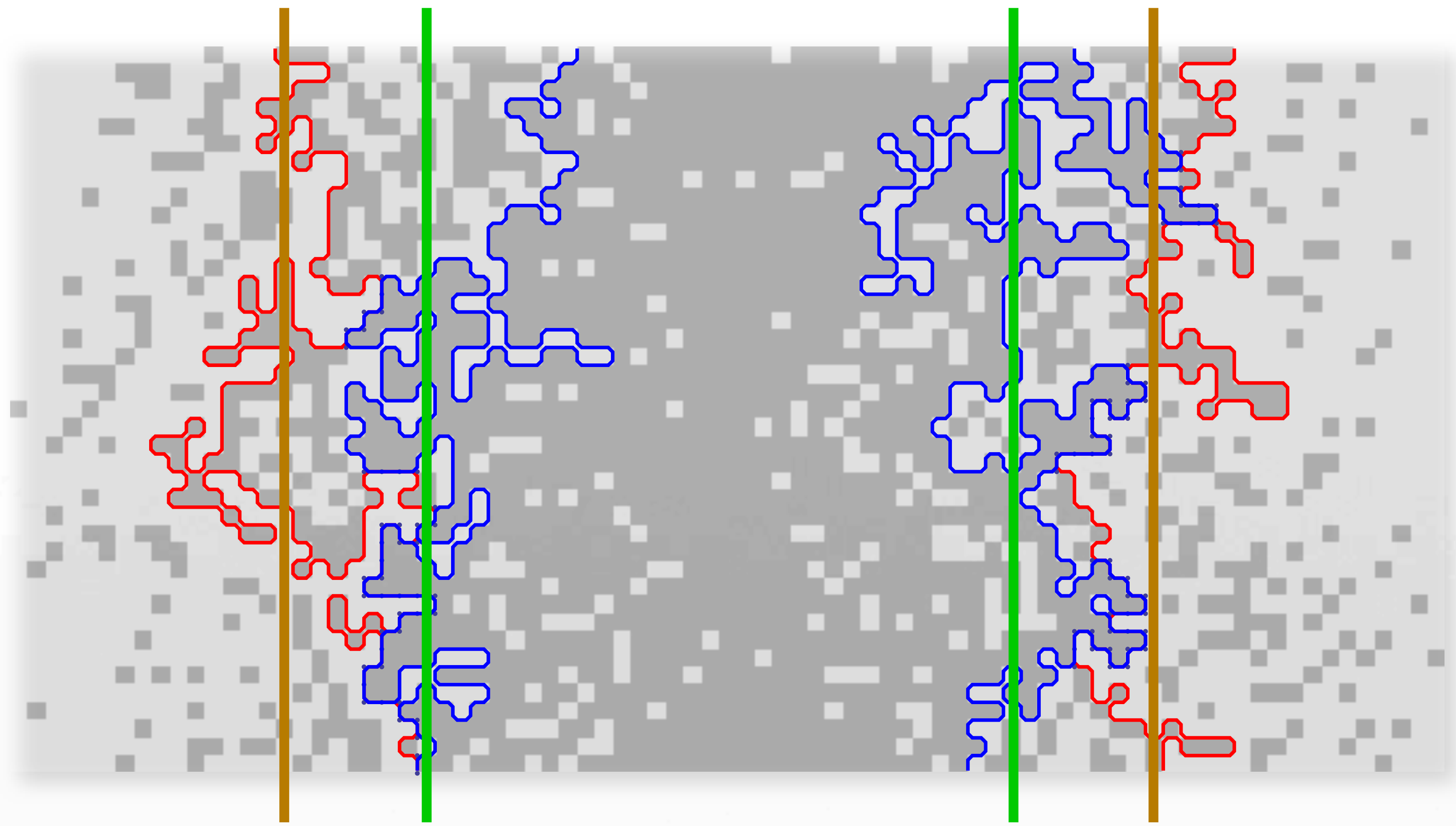
Three biggest clusters:

Land ——————— Water ——————— Land

I'll call the boundaries of the three biggest clusters "shorelines":



(These curves are precisely the **diffusion fronts**!)



These shorelines are **random curves**.

It was **guessed** that they are very, very likely to be wiggles around the columns that are 59.4% white and 59.4% black.

(59.4% is the **critical probability** in ordinary percolation)

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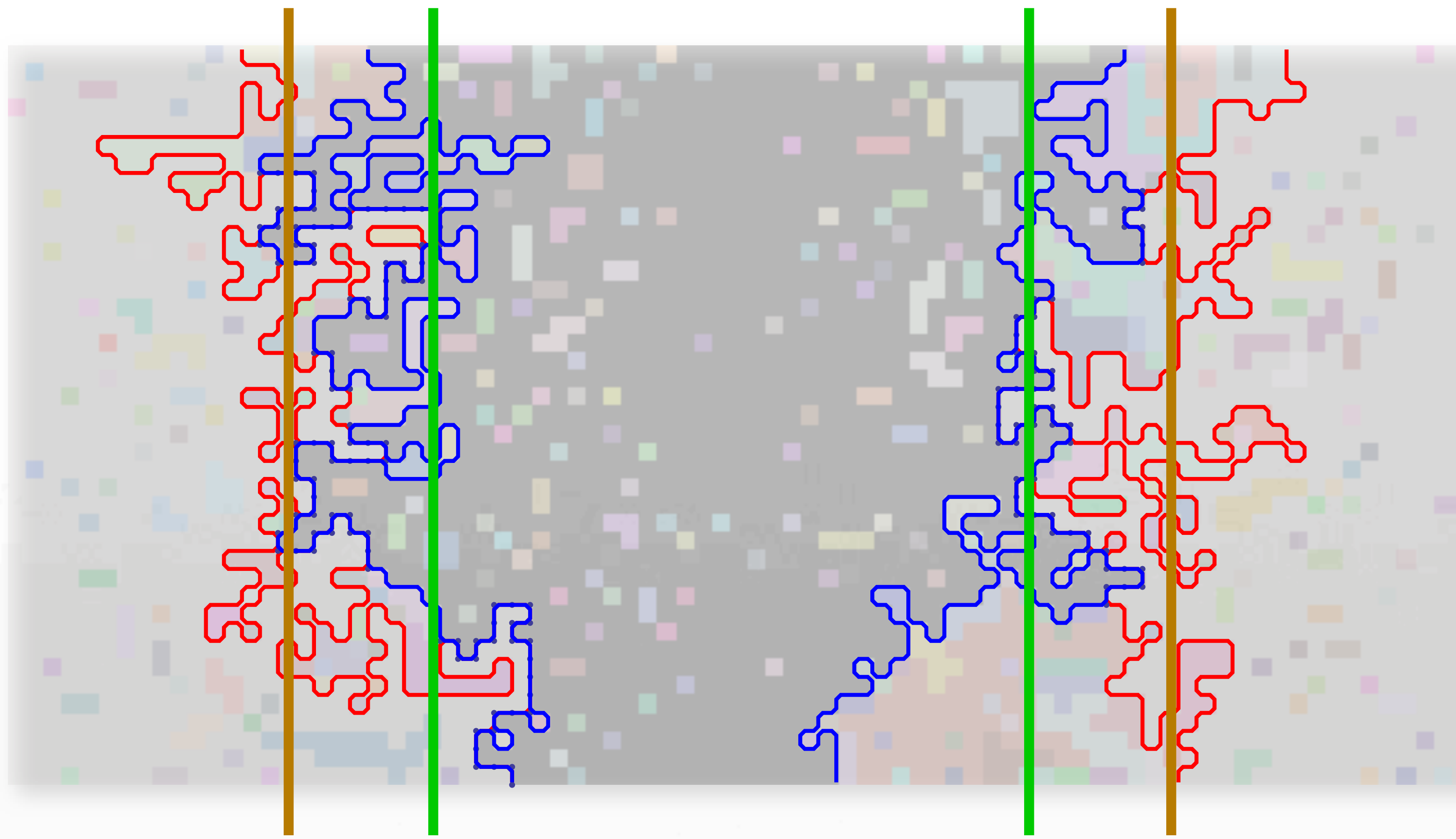

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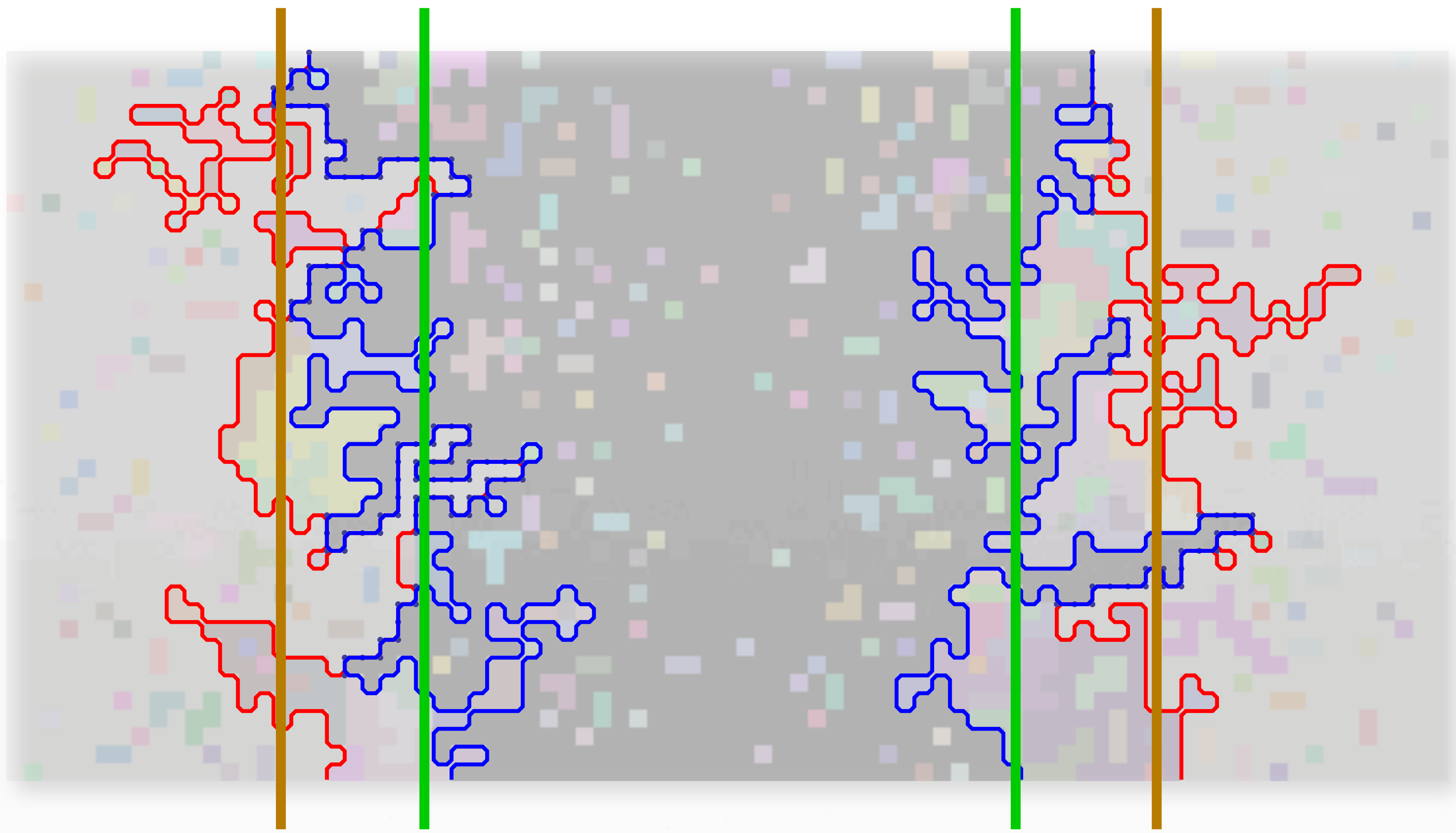

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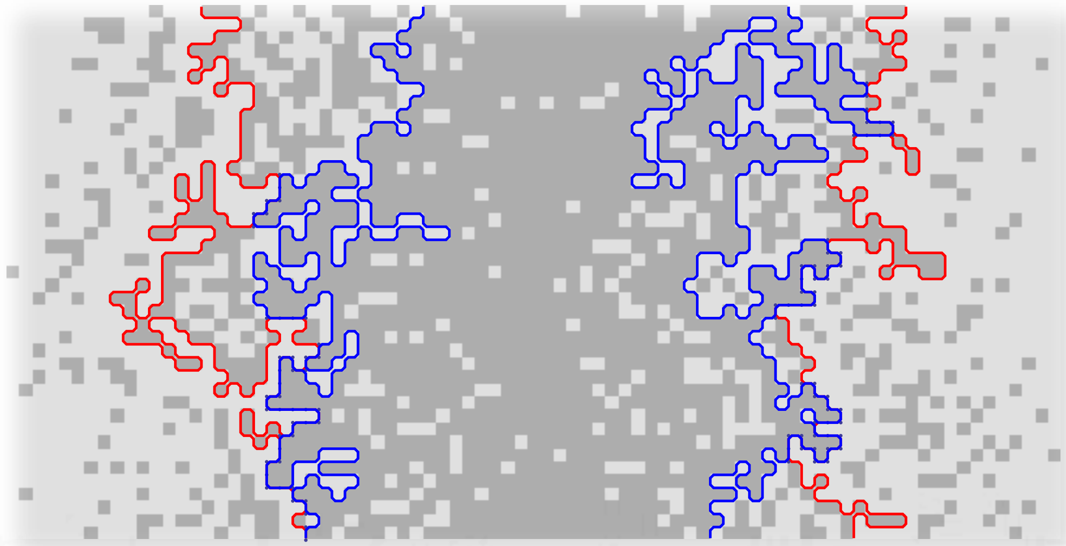
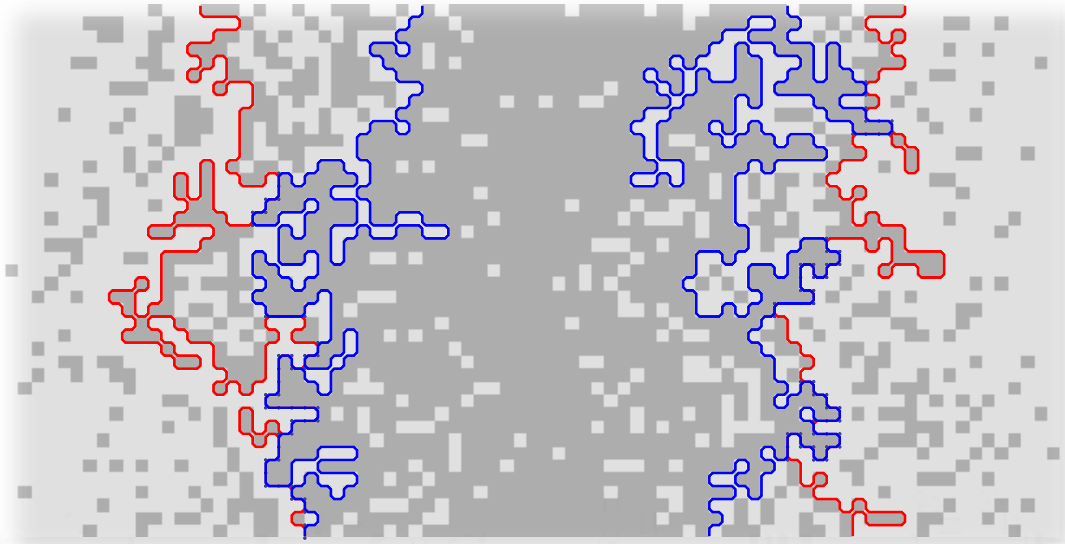


41×81

Trick Question: Do the shorelines traverse a **wider** or **narrower** region on a **bigger** grid?



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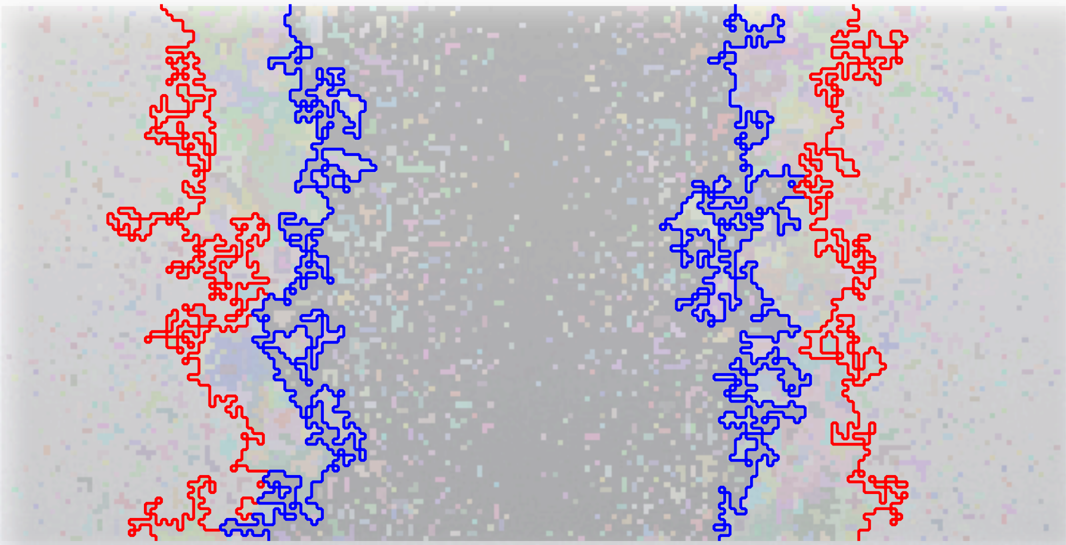
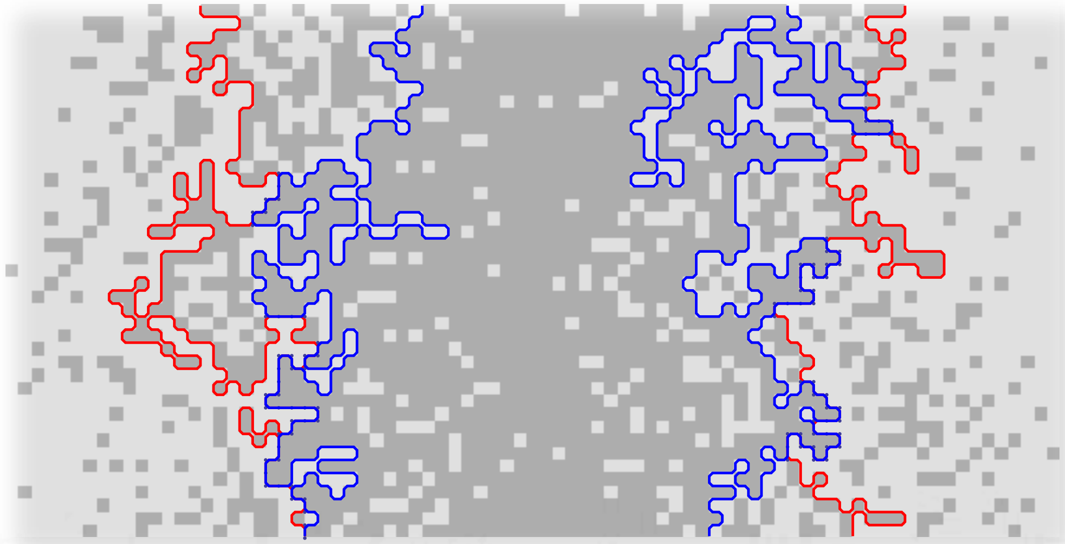


100×199



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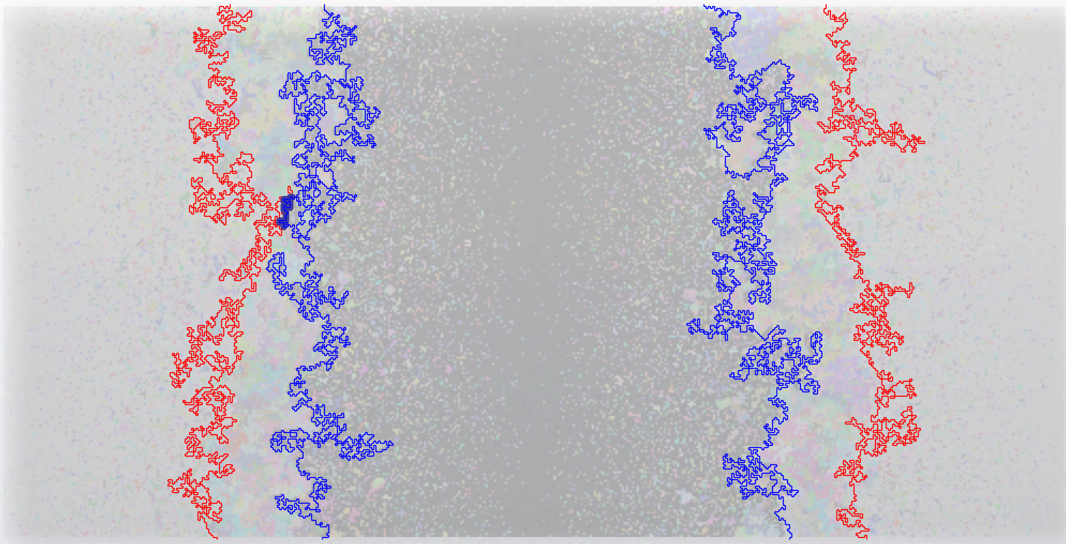
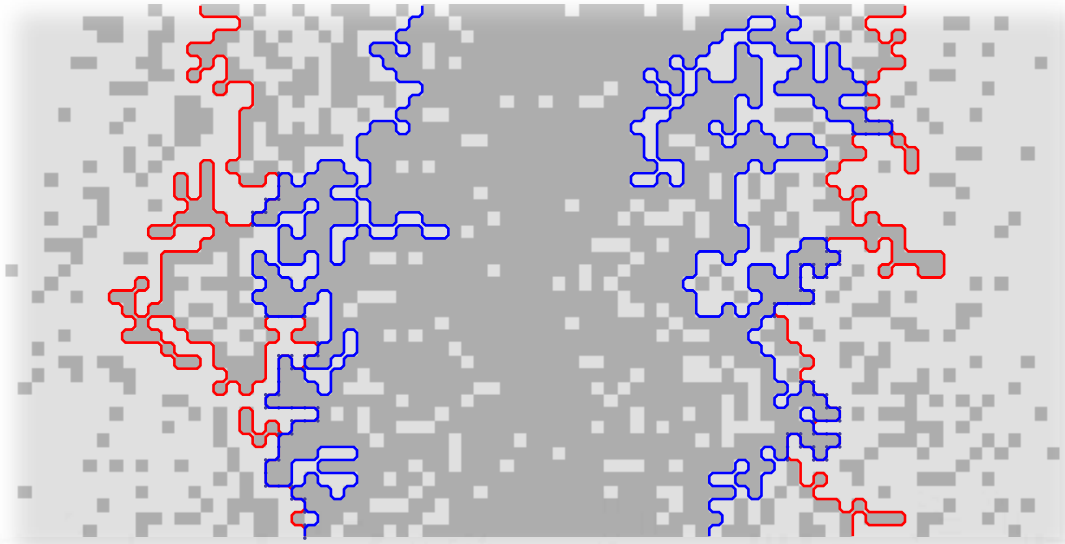


250×499



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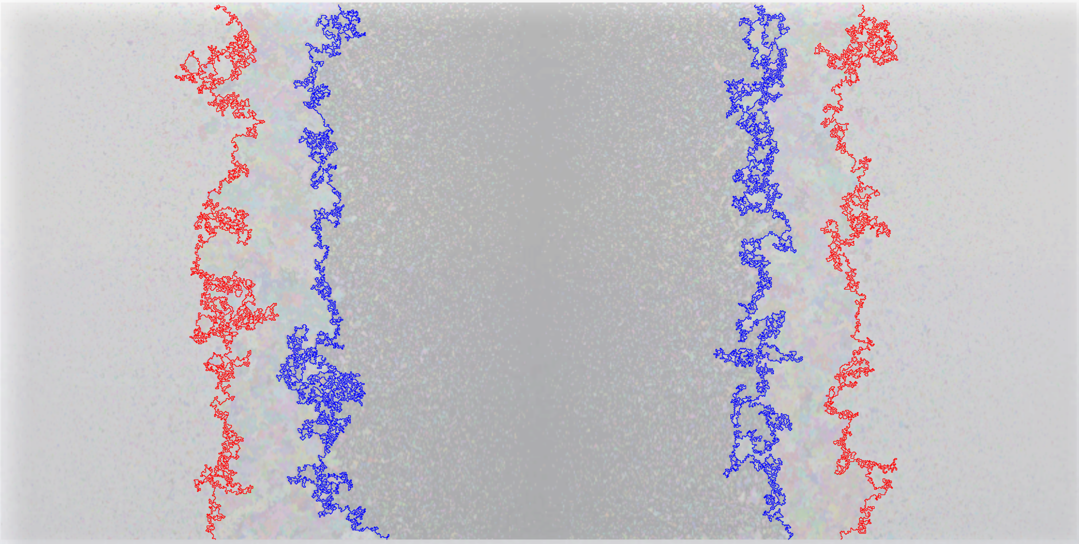
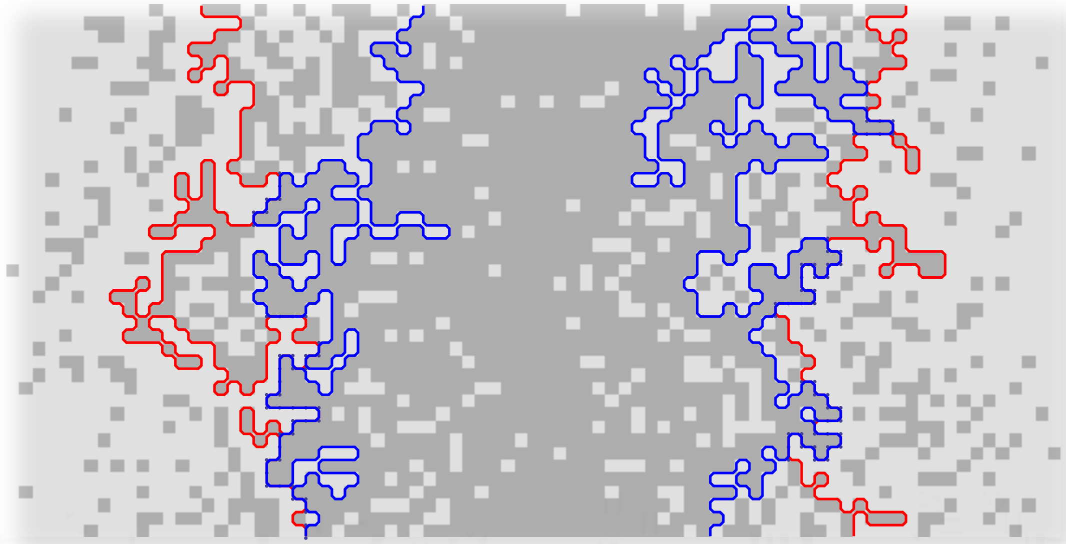


500×999



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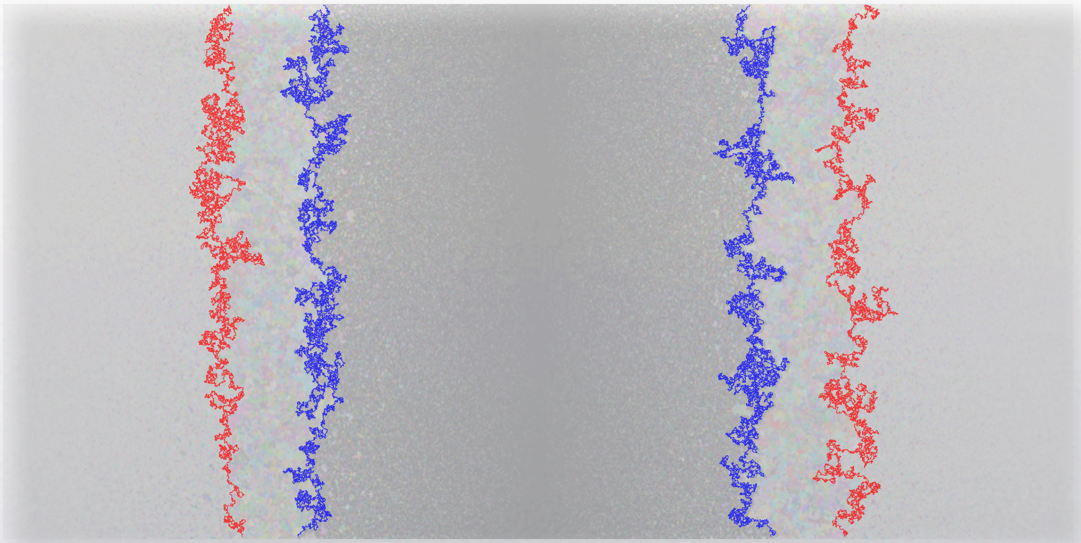
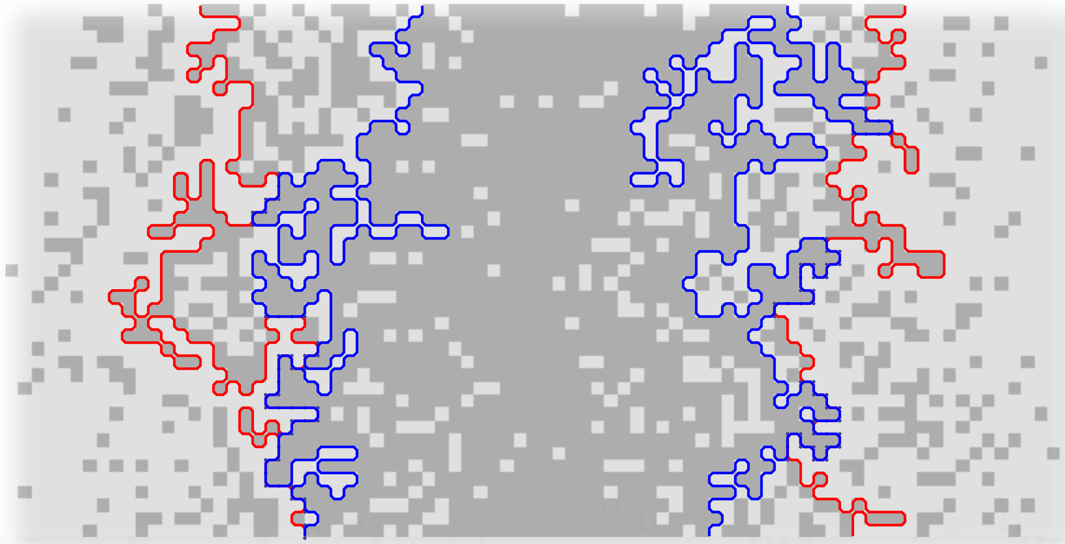


1000×1999



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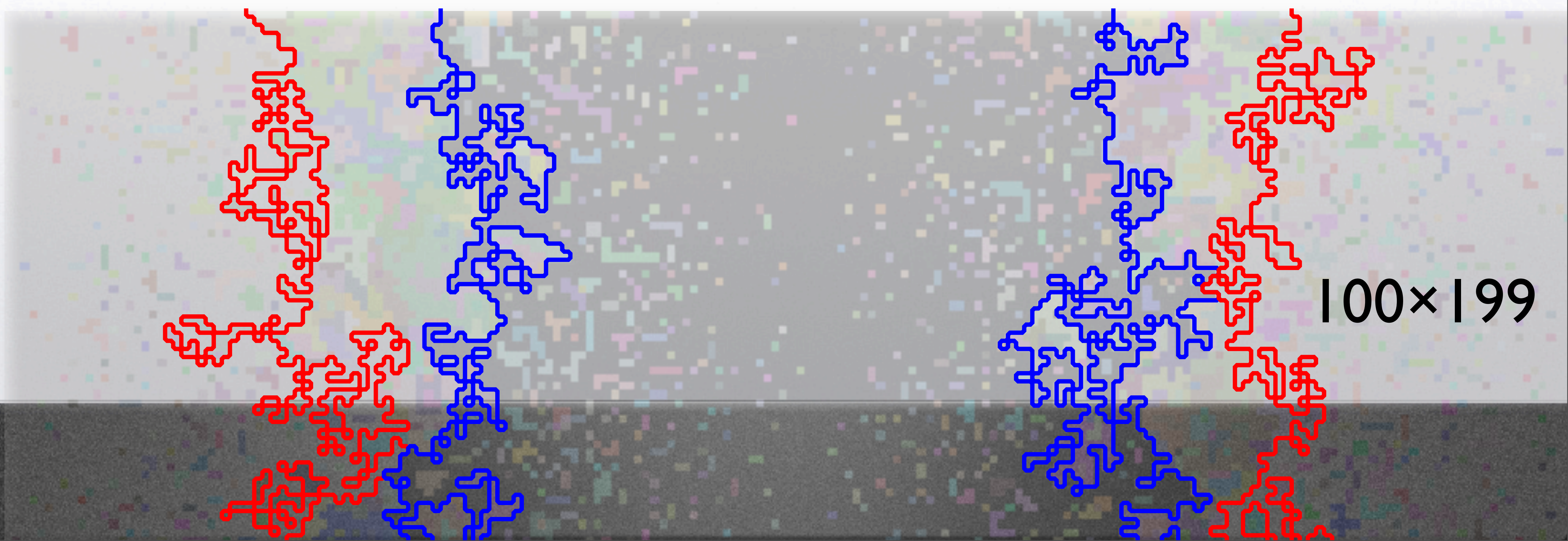

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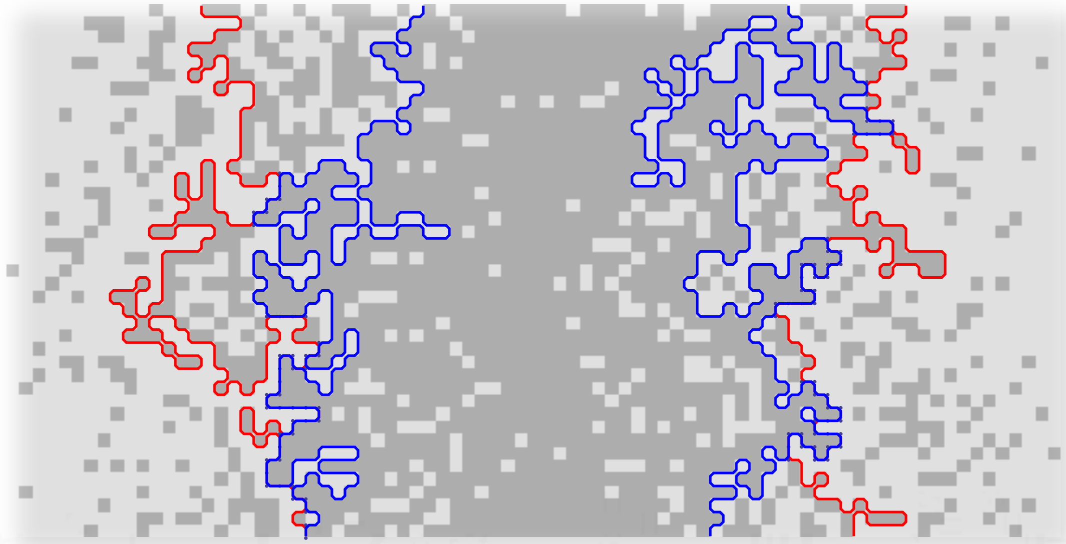


41×81

The width of these curves is **guessed** to scale as

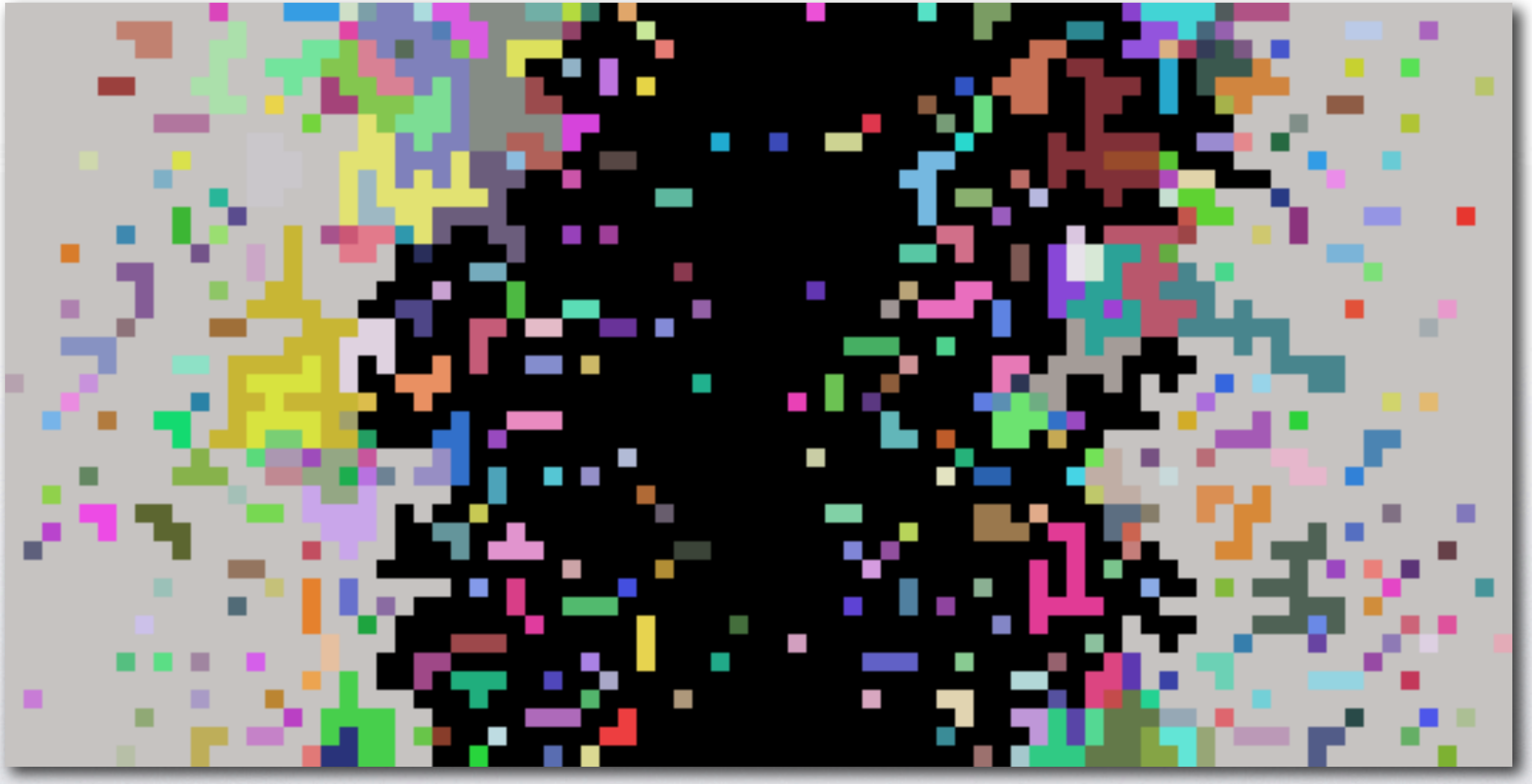
(Width of the grid in squares)$^{4/7}$.

The shores get wider, but they widen slower than the grid itself does!

B. Sapoval, M. Rosso, J. F. Gouyet, The fractal nature of a diffusion front and the relation to percolation, J. Physique Lett. 46, 149-156 (1985).

Proof on the **triangular grid:** Pierre Nolin, Critical exponents of planar gradient percolation, Annals of Probability 36, 1748-1776 (2008).

The random curves on the river banks of *Seine* are just one geometric feature we might study...



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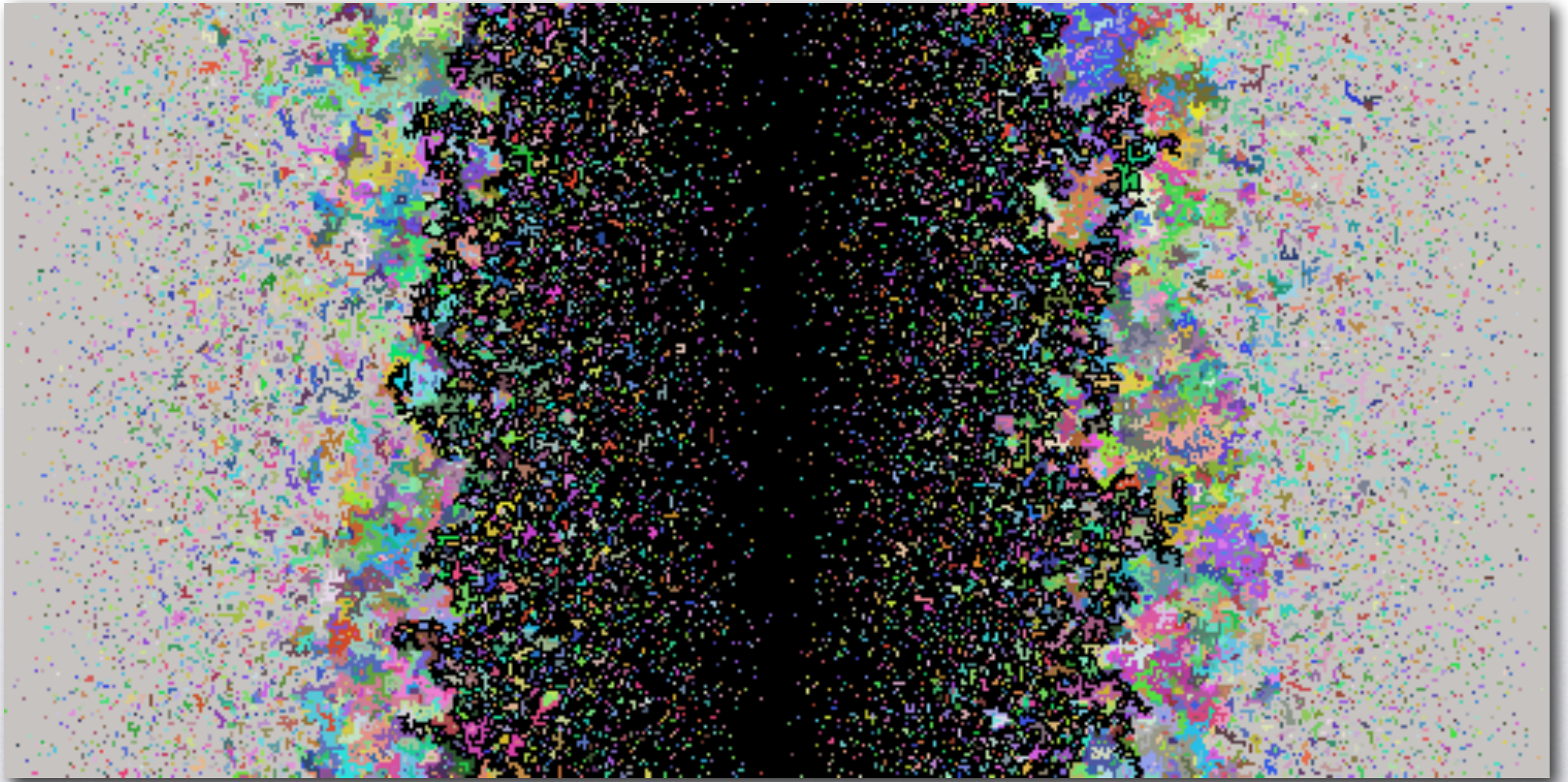

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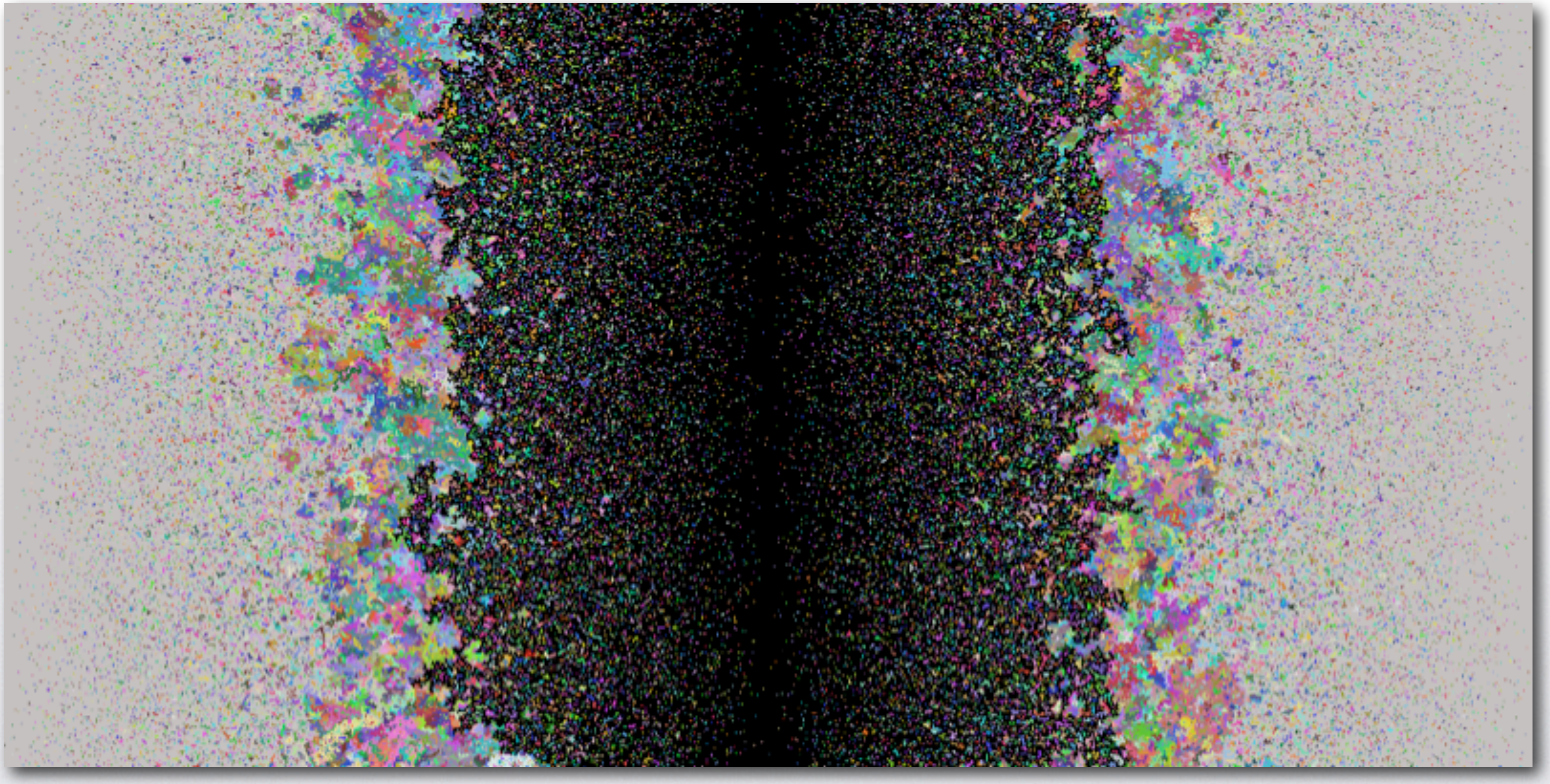

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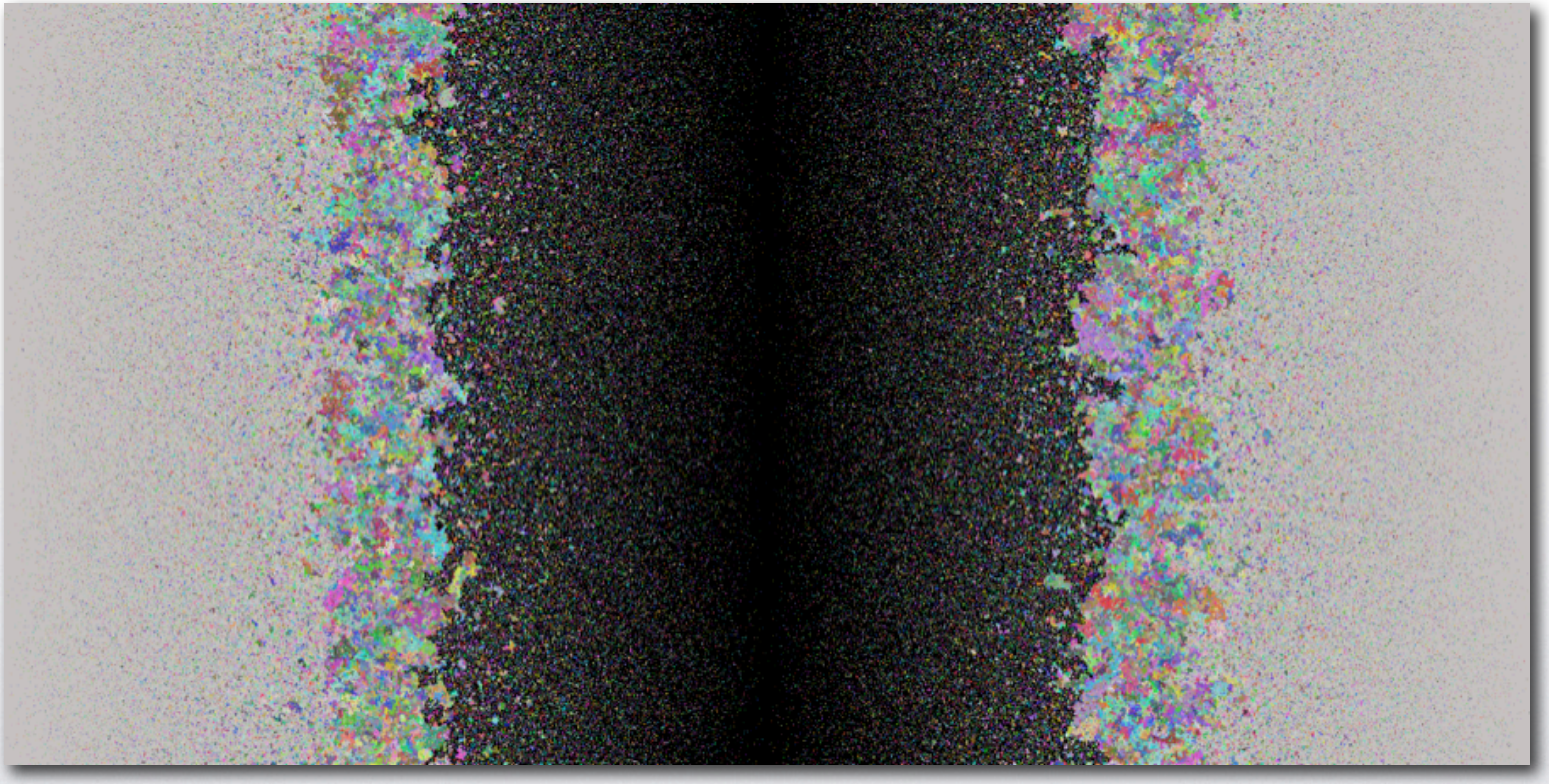

Conclusions

I described the set of possibilities of the painting *Seine*.

It turned out to be gradient percolation, a model of **diffusion fronts**.

The model is **random**, but large random objects are almost deterministic in some ways!

The "shorelines" of *Seine* are a strange **random curve** with properties that are still not well understood.

6 years **after** Kelly painted *Seine*, Broadbent and Hammersley wrote a paper introducing **percolation**.

59% open (white)

61% open (white)

Will water flow between left and right?

S. R. Broadbent and J.M. Hammersley, Percolation processes, Math. Proc. Camb. Phil. Soc. 53, 629-641 (1957)

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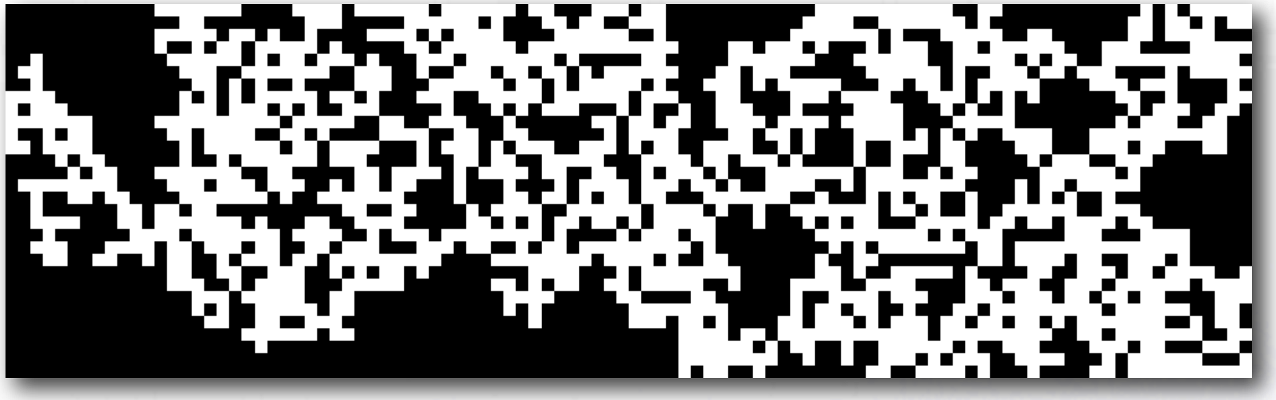

61% open (white)

Only if there's a **connected** open cluster from left to right!

S. R. Broadbent and J.M. Hammersley, Percolation processes, Math. Proc. Camb. Phil. Soc. 53, 629-641 (1957)

References

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