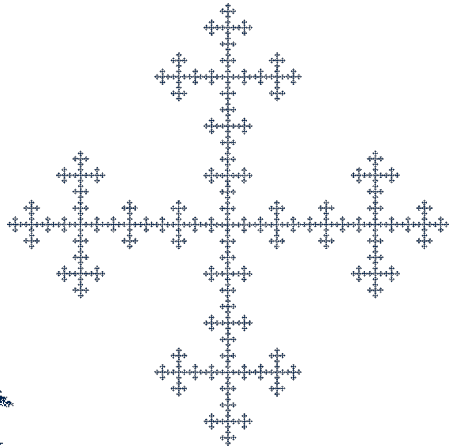
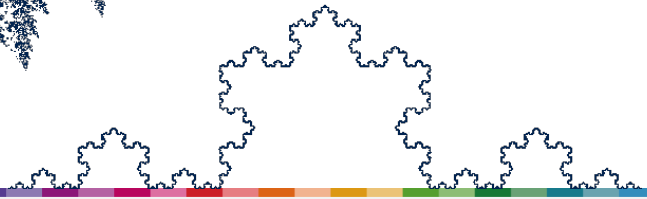
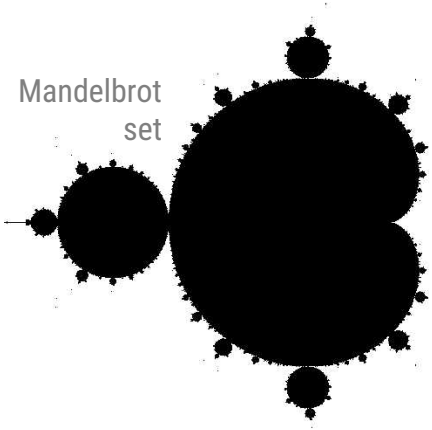


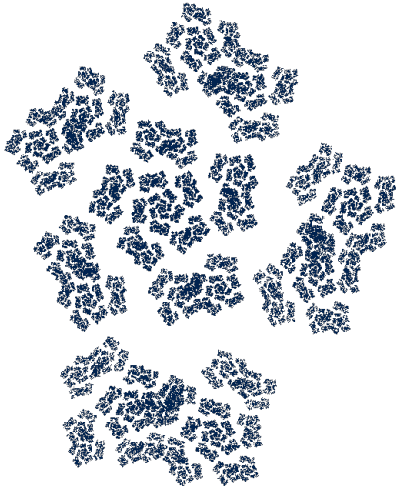


Make your own fractal!

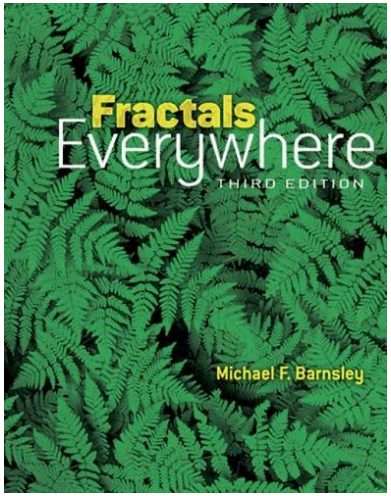


What *is* a Fractal?

- Self-similar
- Nowhere differentiable
- Non-integer dimension



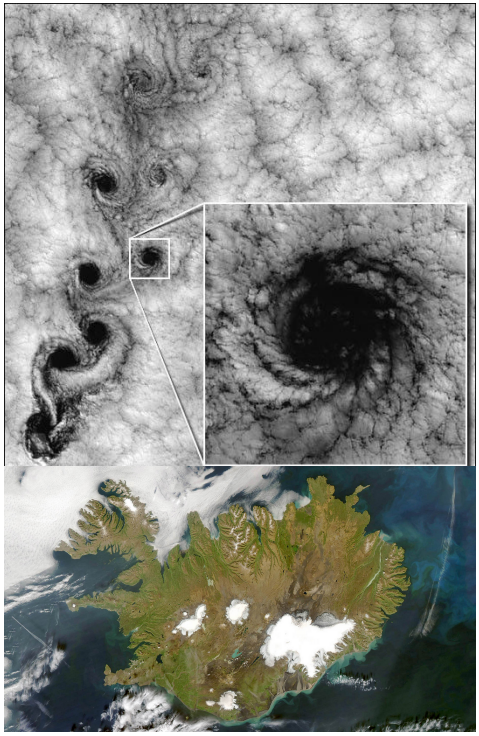
nl.wikipedia.org/wiki/
Romanesco_(groente)



https://m.media-amazon.com/
images/I/61+q6AqRXhL.jpg

www.pflanzen-deutschland.de/
Dryopteris_filix-mas.html

science.nasa.gov/earth/earth-observatory/
landsat-7-reveals-large-scale-fractal-motion-of-
clouds-625/

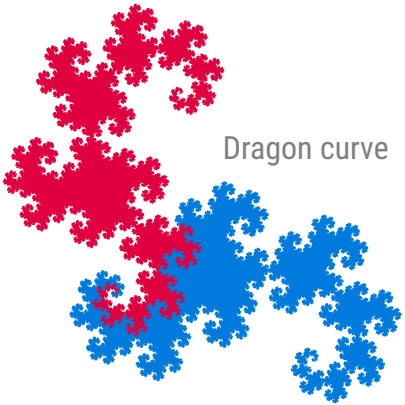


https://eliasvetter.ch/Island/

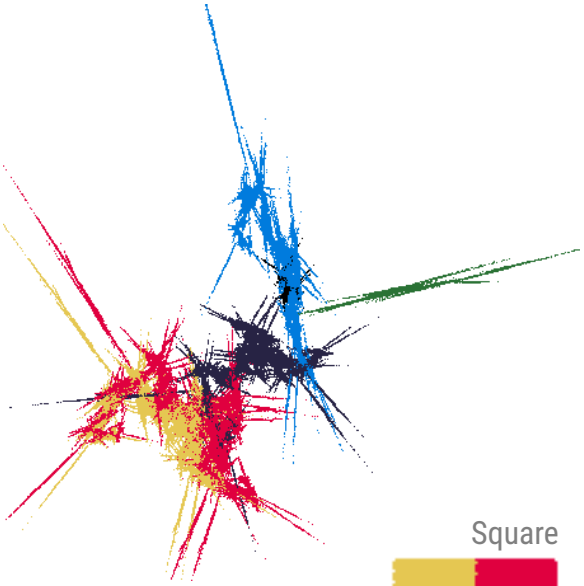
Self-Similar Sets

… consist of **finitely many** smaller copies of themselves

Barnsley fern

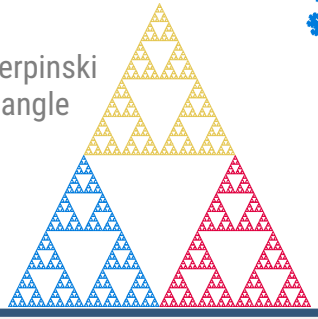


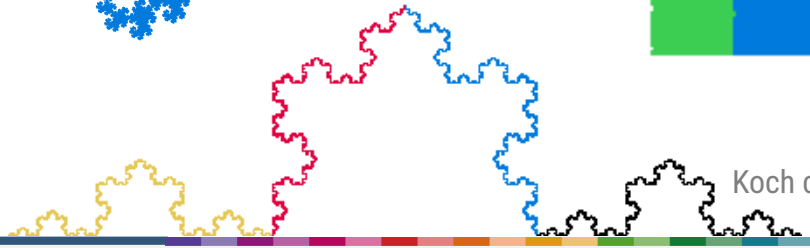
Dragon curve



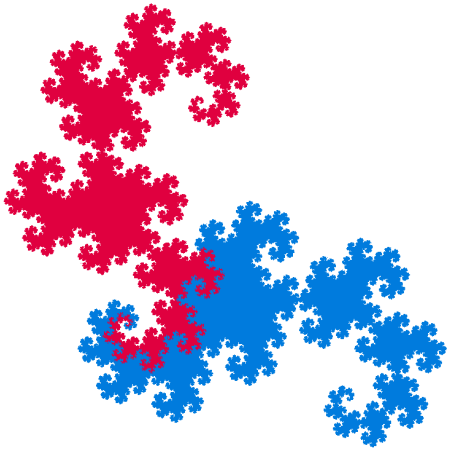
Square

Sierpinski triangle



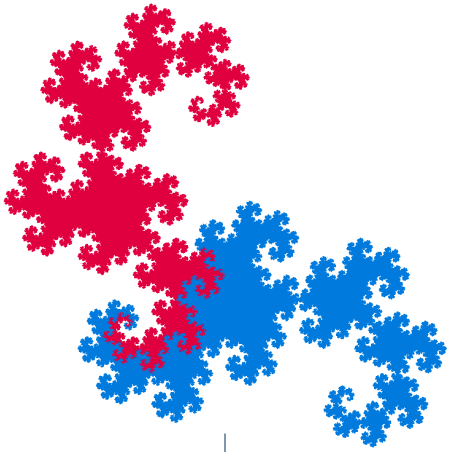


Koch curve

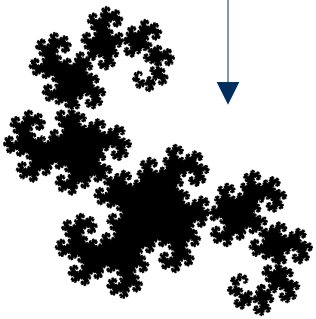


How do we describe a self-similar set?

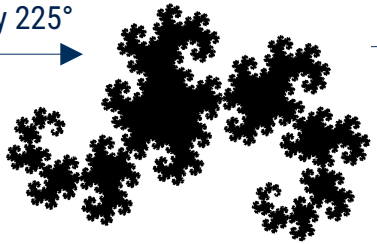
How do we describe a self-similar set?



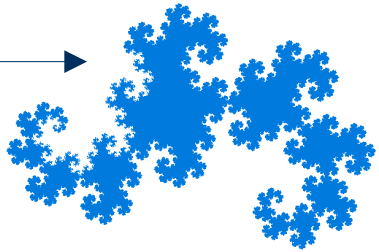
shrink by 1/√2



rotate by 225°



shift



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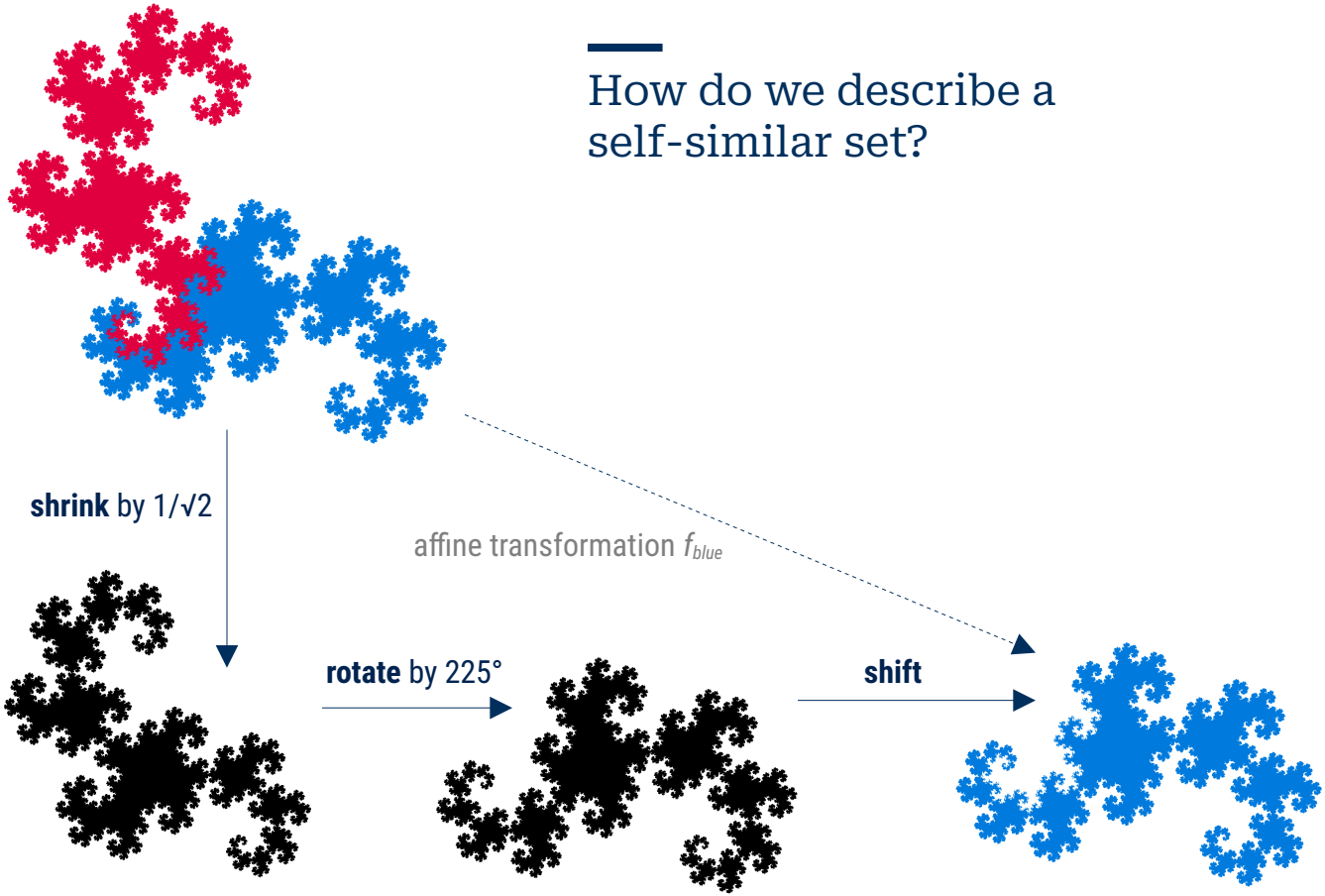
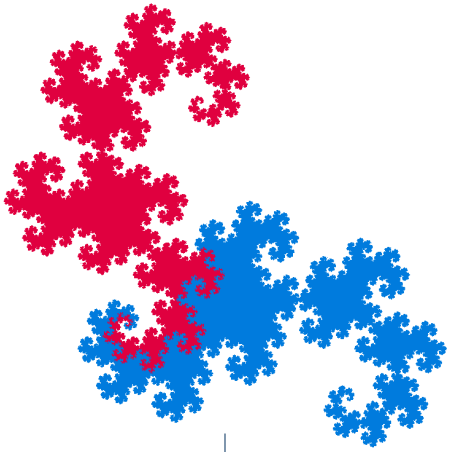




How do we describe a self-similar set?

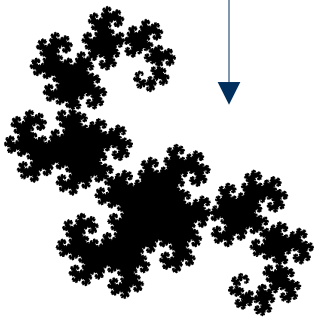
- For each copy *i* :
  Find an affine transformation f_i with
  f_i **(whole set) = copy *i***
- All f_i together describe the set

Iterated
Function
System

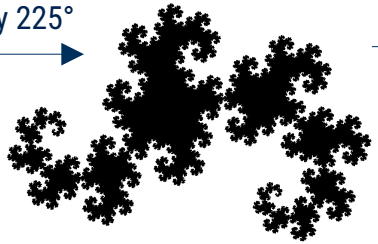
IFS

shrink by 1/√2

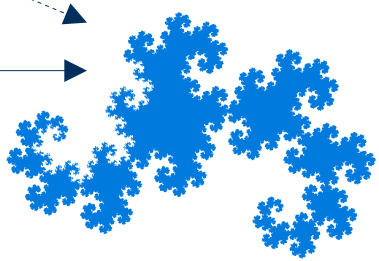
affine transformation f_{blue}

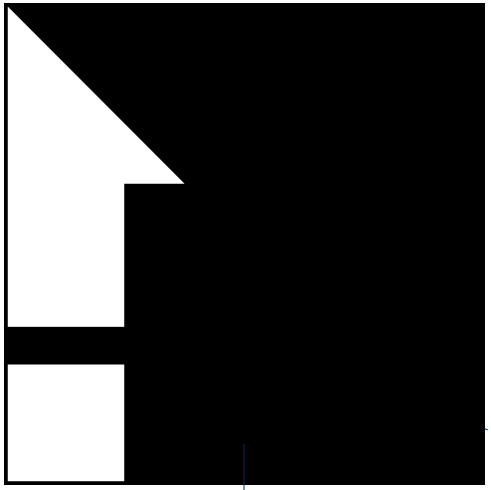


rotate by 225°



shift





shrink by 1/√2

affine transformation f_{blue}

rotate by 225°

shift

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Function
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IFS

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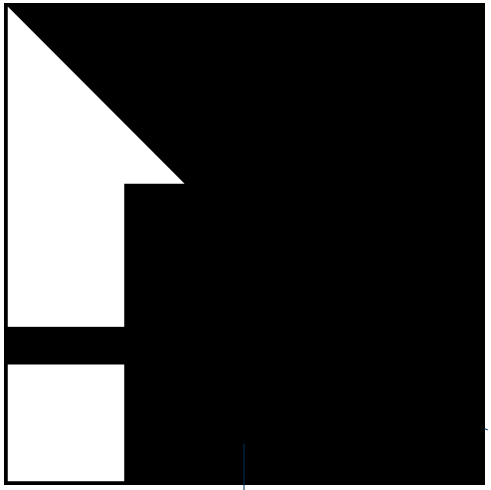
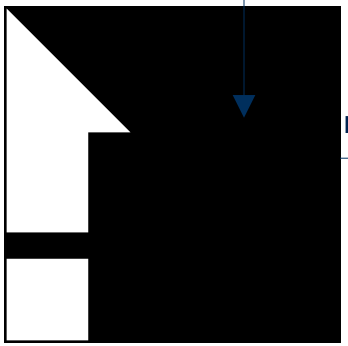
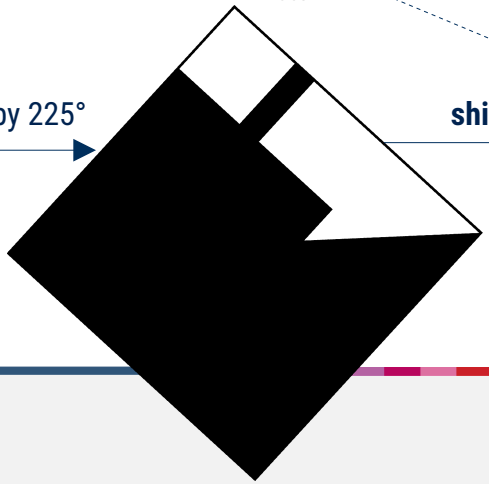


shrink by 1/√2

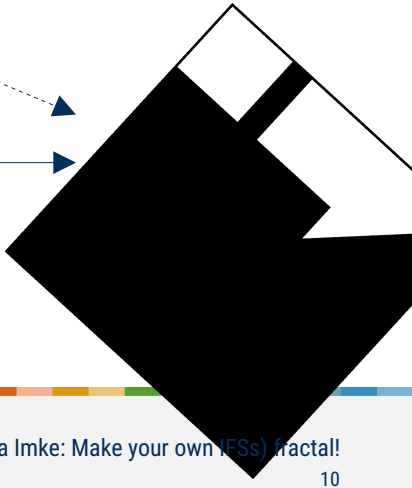


affine transformation f_{blue}

rotate by 225°



shift



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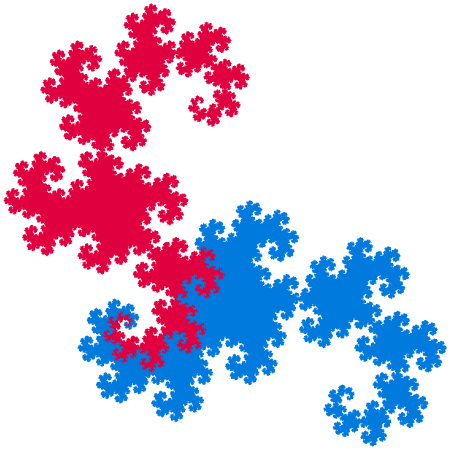
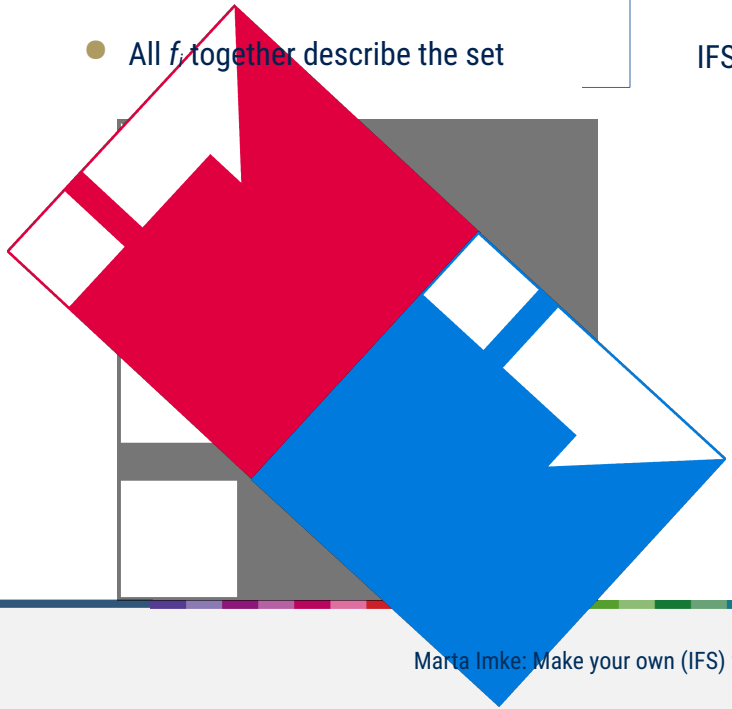
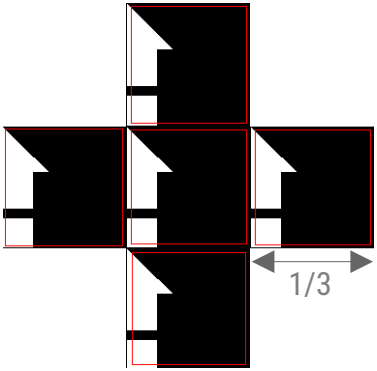
IFS





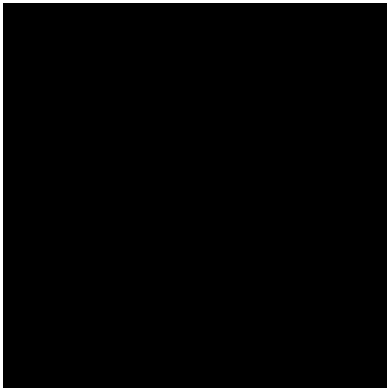
How do I generate a self-similar set?

Given: affine transformations f_i



Copy and paste

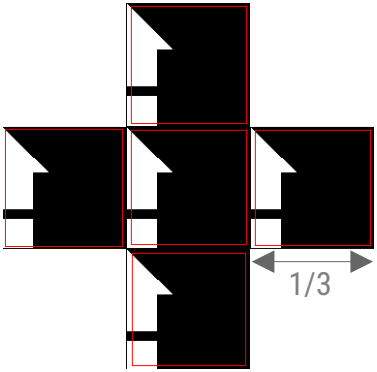
1) Start with any non-empty image



Chaos Game

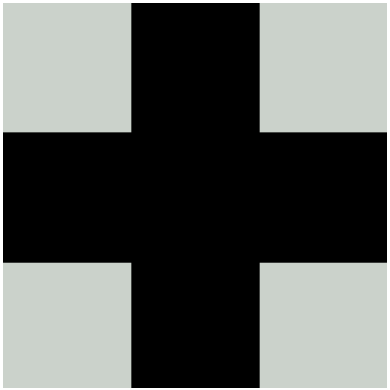
How do I generate a self-similar set?

Given: affine transformations f_i



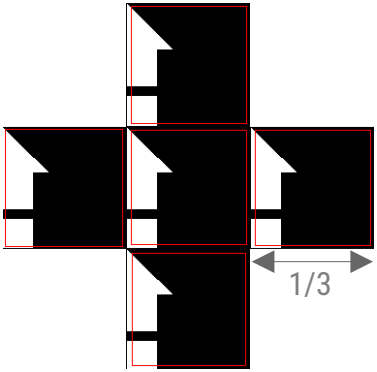
Copy and paste

1) Start with any non-empty image
2) For each *i* :
   transform the image



Chaos Game

How do I generate a self-similar set?

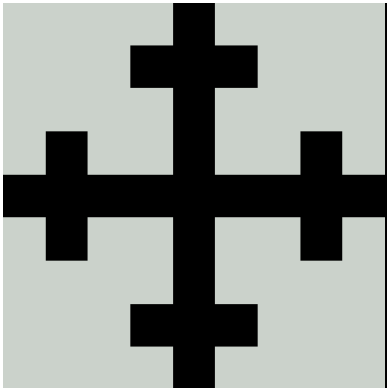


Given: affine transformations f_i

Copy and paste

1) Start with any non-empty image
2) For each *i* :
   transform the image
3) New image = union of transformed ones
4) Repeat

Chaos Game



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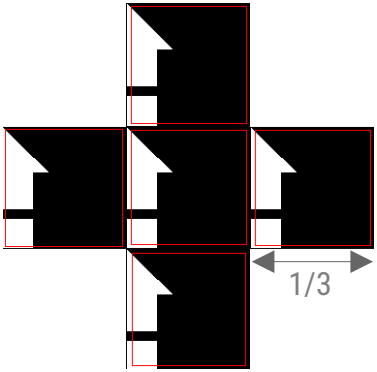

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Copy and paste

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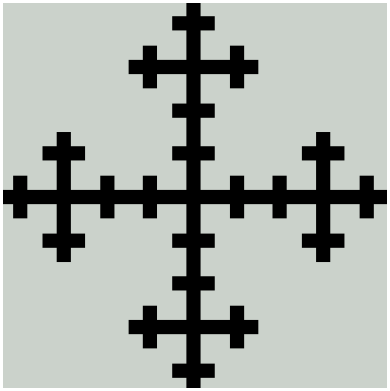
Chaos Game



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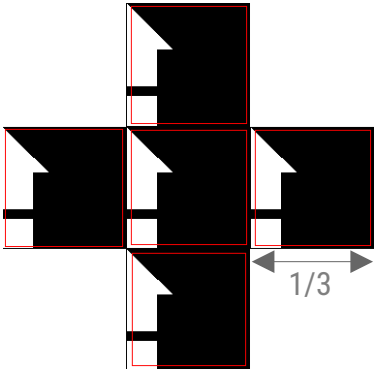

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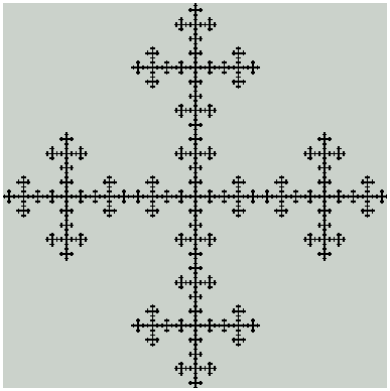
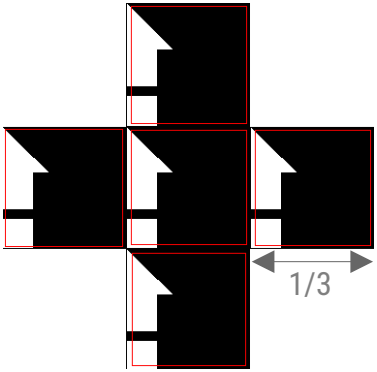


Chaos Game

How do I generate a self-similar set?



Given: affine transformations f_i

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   transform the image
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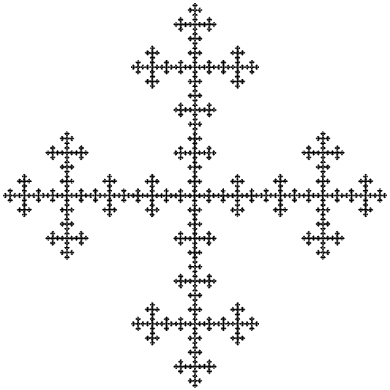
Chaos Game



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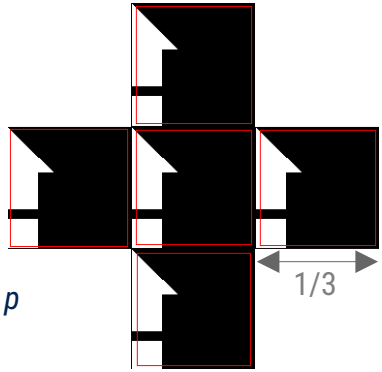
Given: affine transformations f_i



Copy and paste

1) Start with any non-empty image
2) For each *i* :
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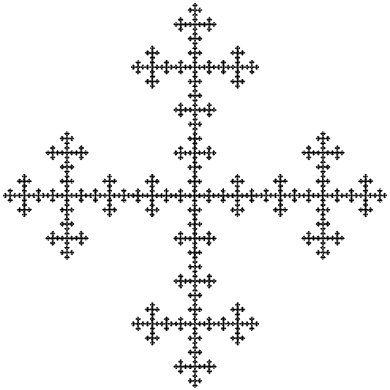
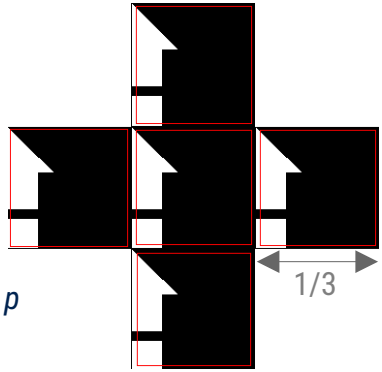
3) New image = union of transformed ones
4) Repeat



Chaos Game

1) Start with any point *p*
2) Draw *p*

How do I generate a self-similar set?



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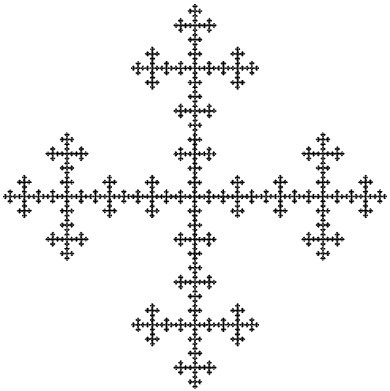
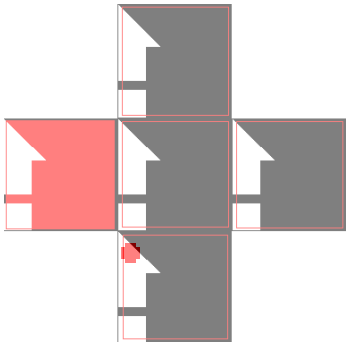


Chaos Game

1) Start with any point *p*
2) Draw *p*
3) Select a random f_i



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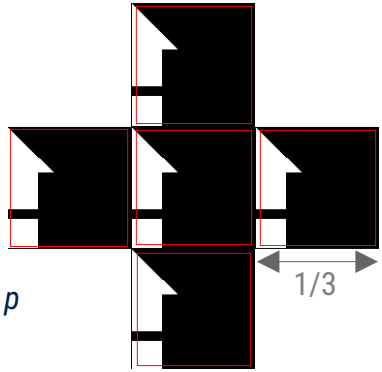

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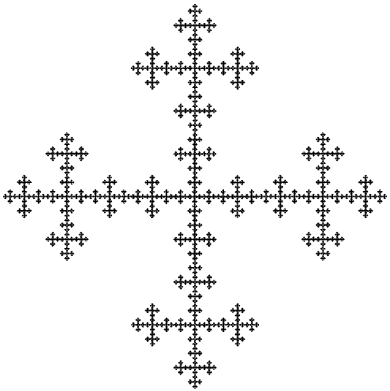
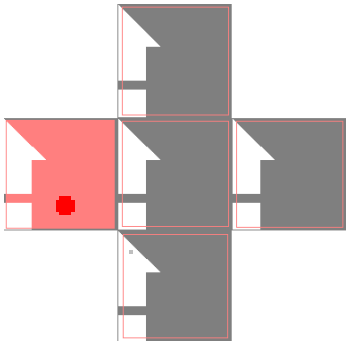


Chaos Game

1) Start with any point *p*
2) Draw *p*
3) Select a random f_i
4) *new_p* = f_i *(p)*



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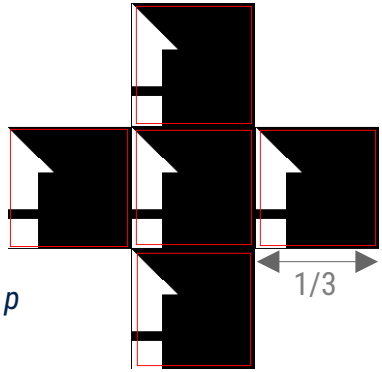

Given: affine transformations f_i

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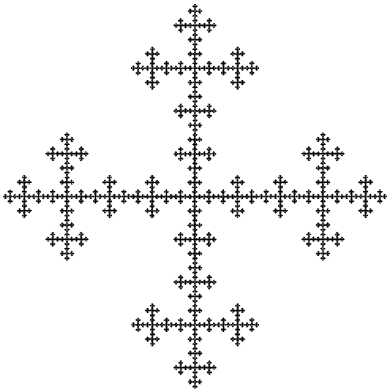

Chaos Game

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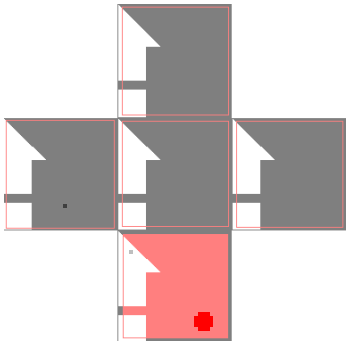
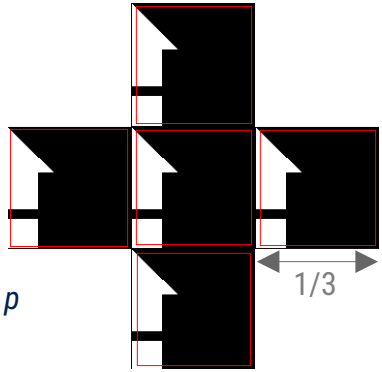
5) Repeat



3 points

How do I generate a self-similar set?



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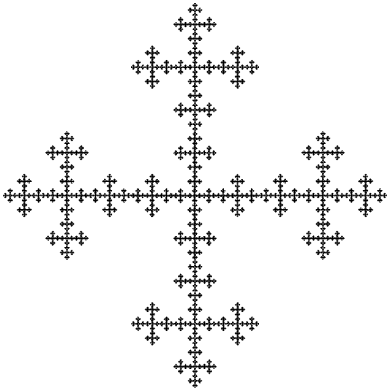
3) New image = union of transformed ones
4) Repeat

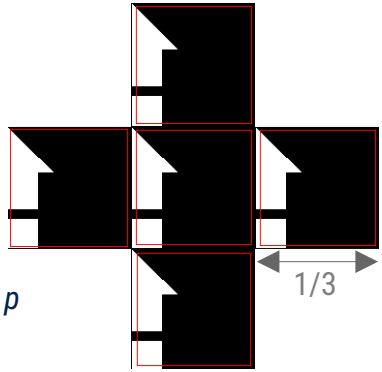


Chaos Game

1) Start with any point *p*
2) Draw *p*
3) Select a random f_i
4) *new_p* = f_i *(p)*
5) Repeat

10 points

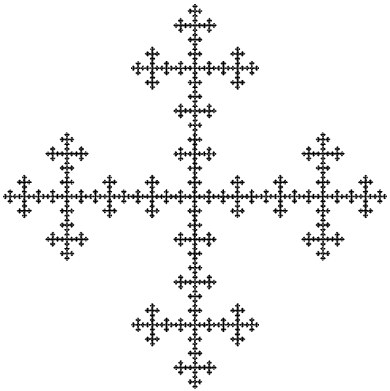
How do I generate a self-similar set?



Given: affine transformations f_i

Copy and paste

1) Start with any non-empty image
2) For each *i* :
   transform the image
3) New image = union of transformed ones
4) Repeat



Chaos Game

1) Start with any point *p*
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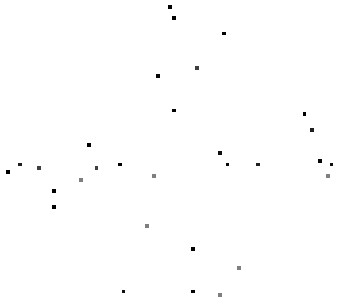
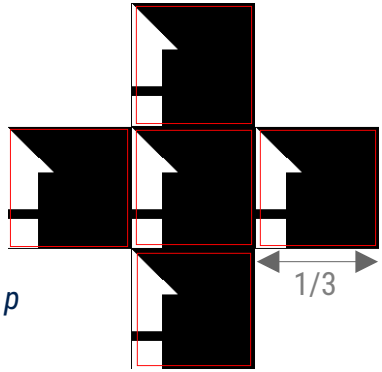
3) Select a random f_i
4) *new_p* = f_i *(p)*
5) Repeat



30 points

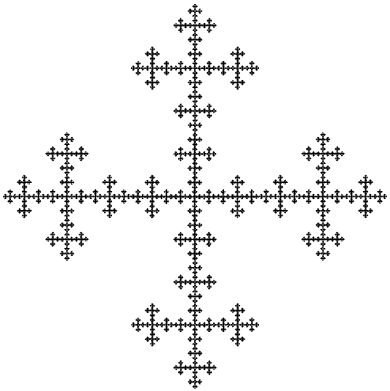
How do I generate a self-similar set?



Given: affine transformations f_i

Copy and paste

1) Start with any non-empty image
2) For each *i* :
   transform the image
3) New image = union of transformed ones
4) Repeat



Chaos Game

1) Start with any point *p*
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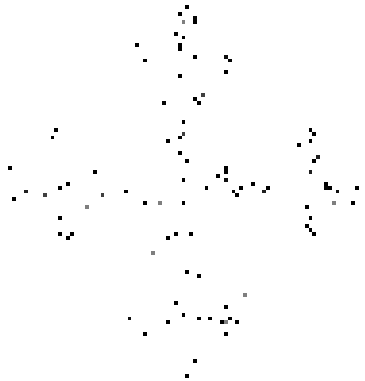
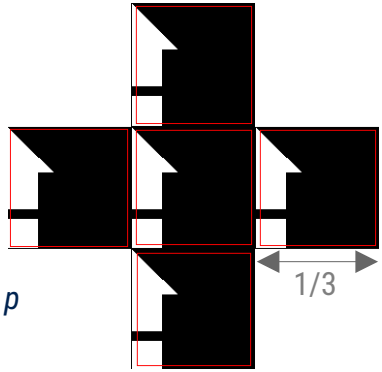


100 points

How do I generate a self-similar set?



Given: affine transformations f_i

Copy and paste

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   transform the image
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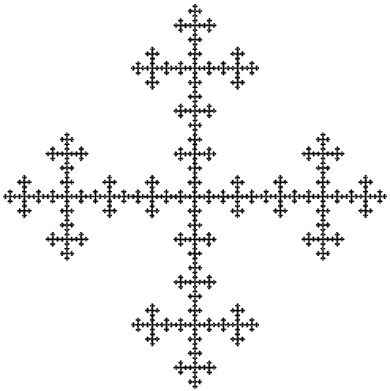
4) Repeat



Chaos Game

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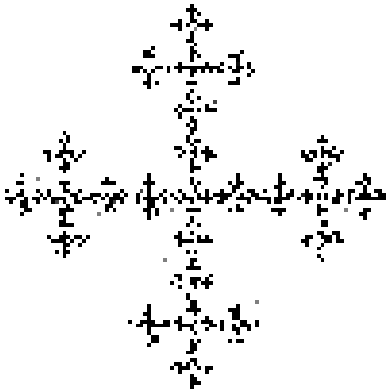
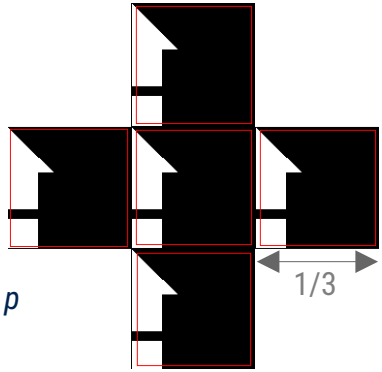


1,000 points

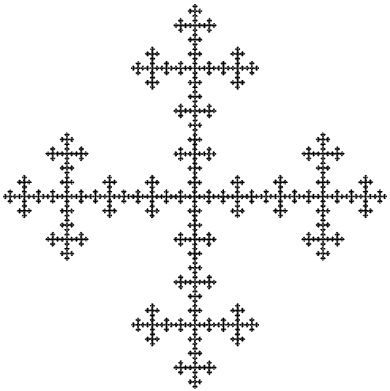
How do I generate a self-similar set?



Given: affine transformations f_i

Copy and paste

1) Start with any non-empty image
2) For each *i* :
   transform the image
3) New image = union of transformed ones
4) Repeat



Chaos Game

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4) *new_p* = f_i *(p)*
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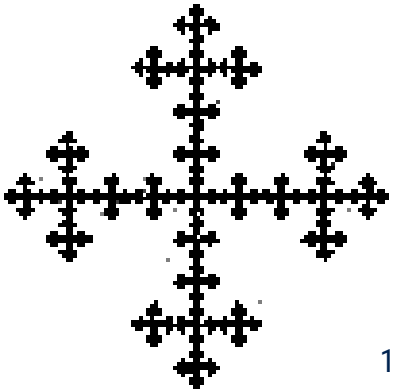
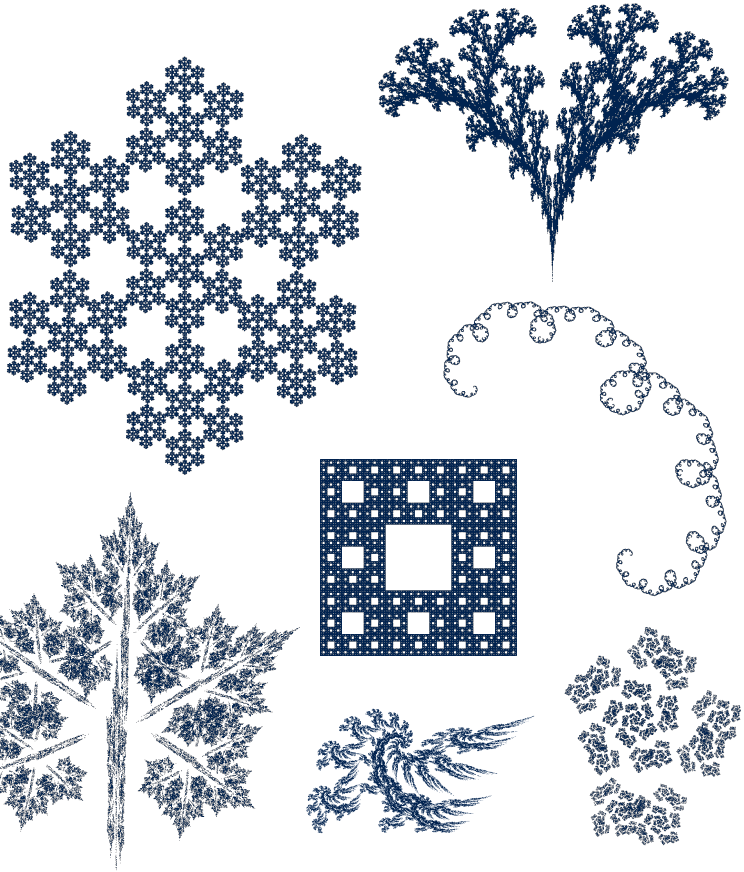


10,000 points



See you(r fractal)
on fracmi.cc !