

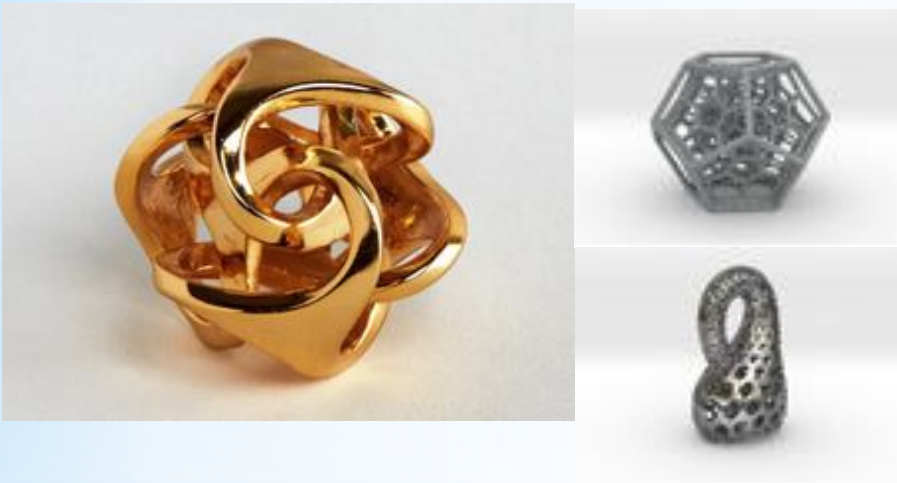
The Making Of Mathematical Art

Christopher R. H. Hanusa

Queens College

Mathematics + Art ?

Bathsheba Sculpture

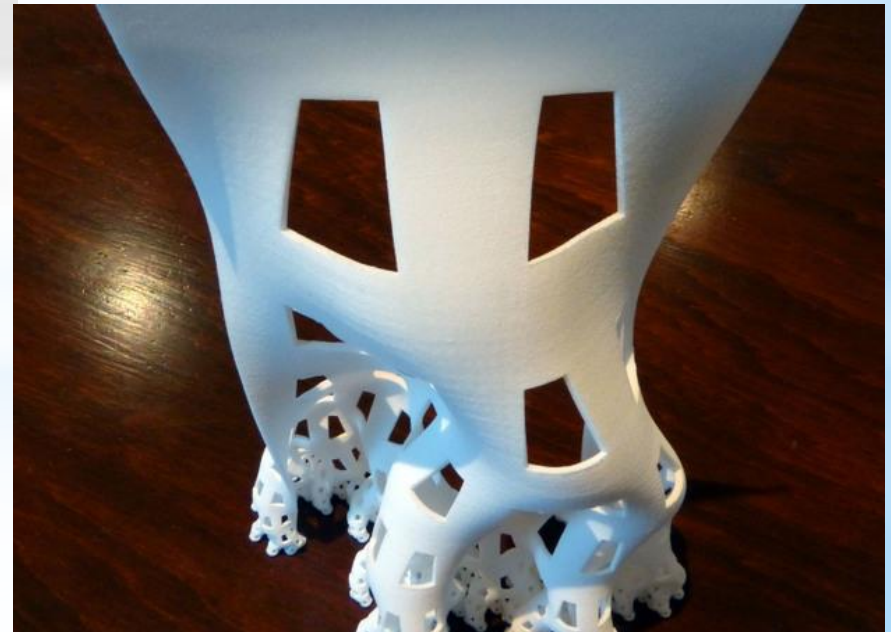
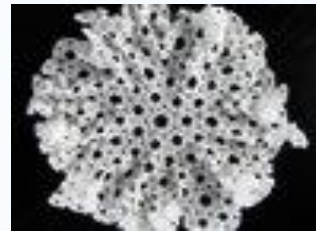


Mathematics + Art ?

Bathsheba Sculpture



Henry Segerman

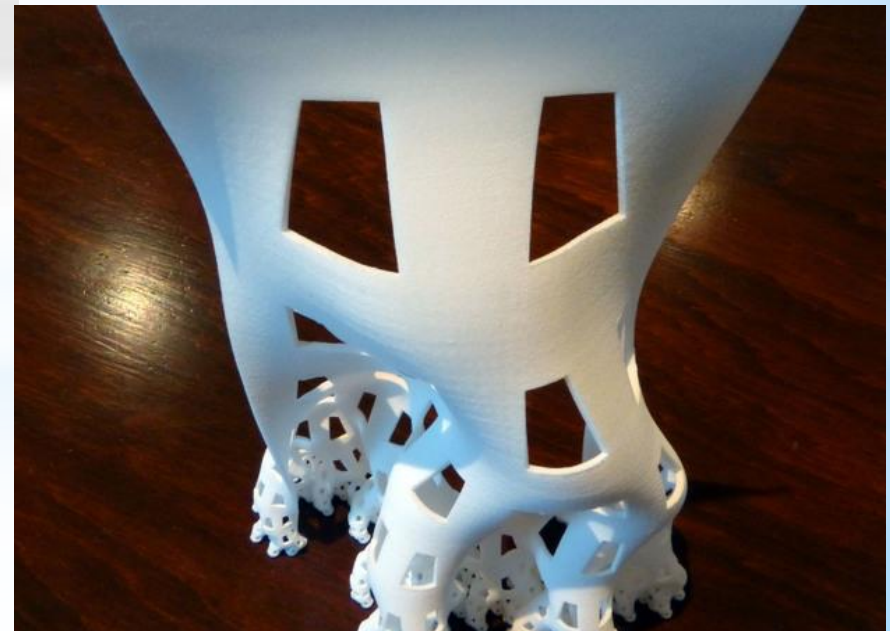
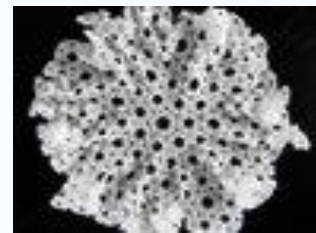


Mathematics + Art ?

Bathsheba Sculpture



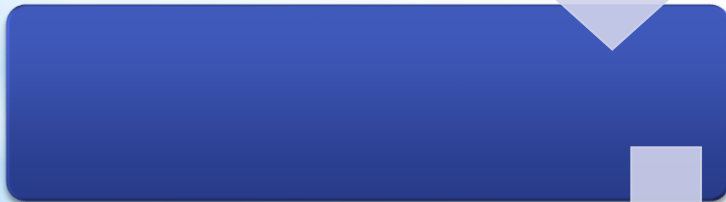
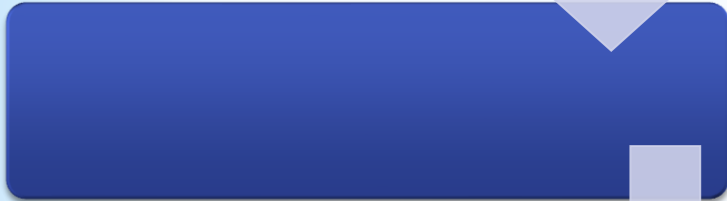
Henry Segerman



- Repetition
- Symmetry
- Geometry
- Higher Dimensions

The Design Process

Inspiration



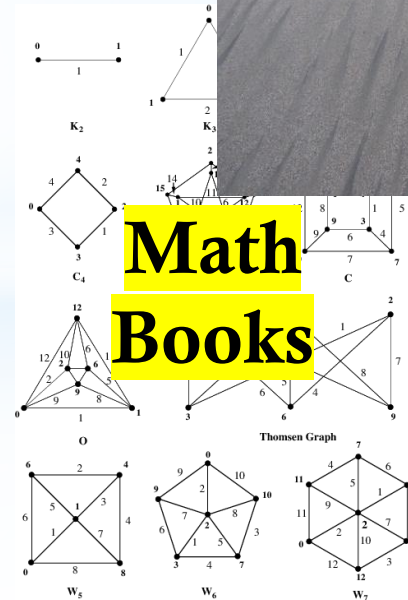
Nature

The Design Process

Inspiration

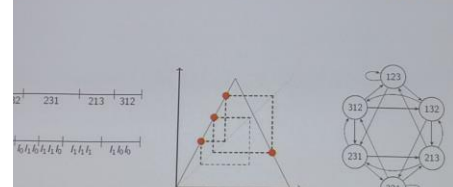


Nature



Math
Books

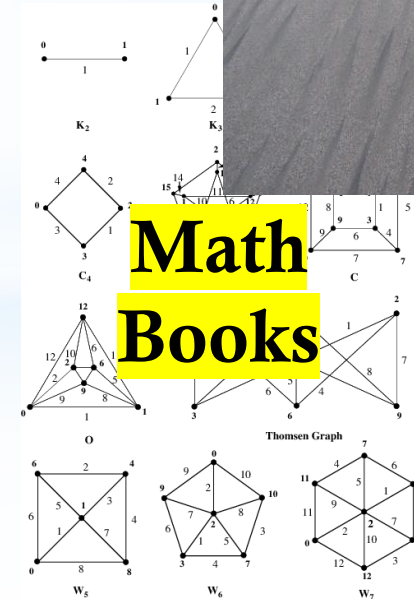
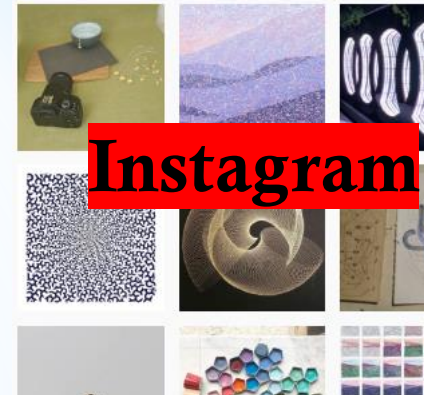
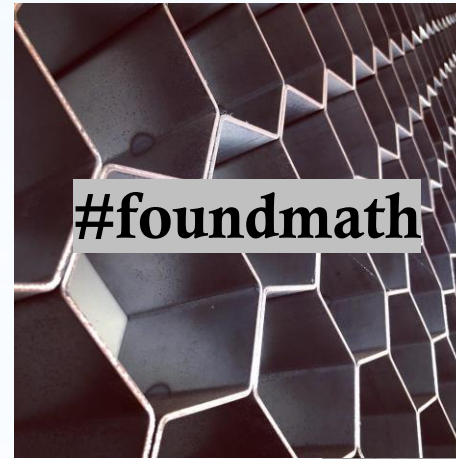
Understanding Extending Pattern-Based techniques



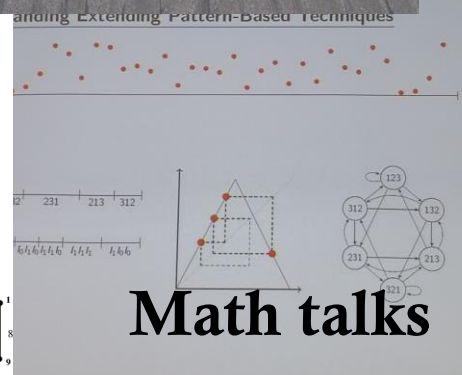
Math talks

The Design Process

Inspiration



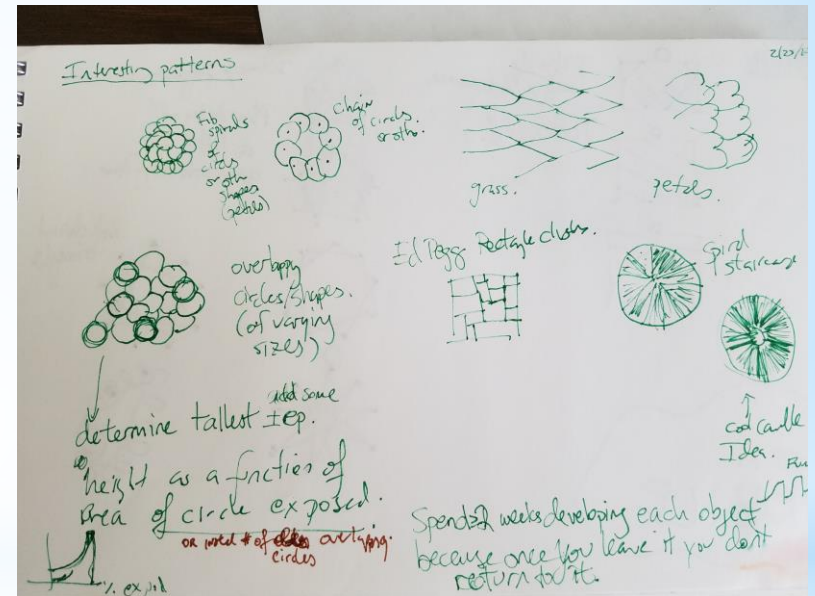
**Math
Books**



The Design Process

Inspiration

Concept



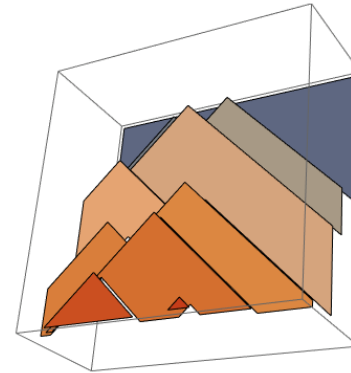
The Design Process

Inspiration

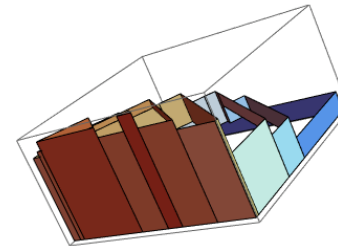
Concept

Design

```
prims = MeshPrimitives[mesh, 2];  
f[x_, y_] := .5 - (y) / 2;  
fvals = Map[f @ RegionCentroid[#] &, prims];  
maxz = Max[fvals] + .1;  
minz = Min[fvals] - .1;  
flats = Graphics3D[Table[{ColorData["LightTemperatureMa
```



```
minz = Min[fvals] - .1;  
bdrys = Map[MeshPrimitives[BoundaryDiscretizeRegion[#,  
segs = MeshPrimitives[mesh, 1];  
polypairs = Map[Flatten[{Position[bdry, #], Position[bc  
blankwalls = MapThread[RegionProduct[#, Line[Transpose  
(*Show[blankwalls] *)  
walls = Graphics3D[Table[{ColorData["LightTemperatureMa  
First@MeshPrimitives[DiscretizeRegion[blankwalls[
```



The Design Process

Inspiration

Concept

Design

Prototype



The Design Process

Inspiration

Concept

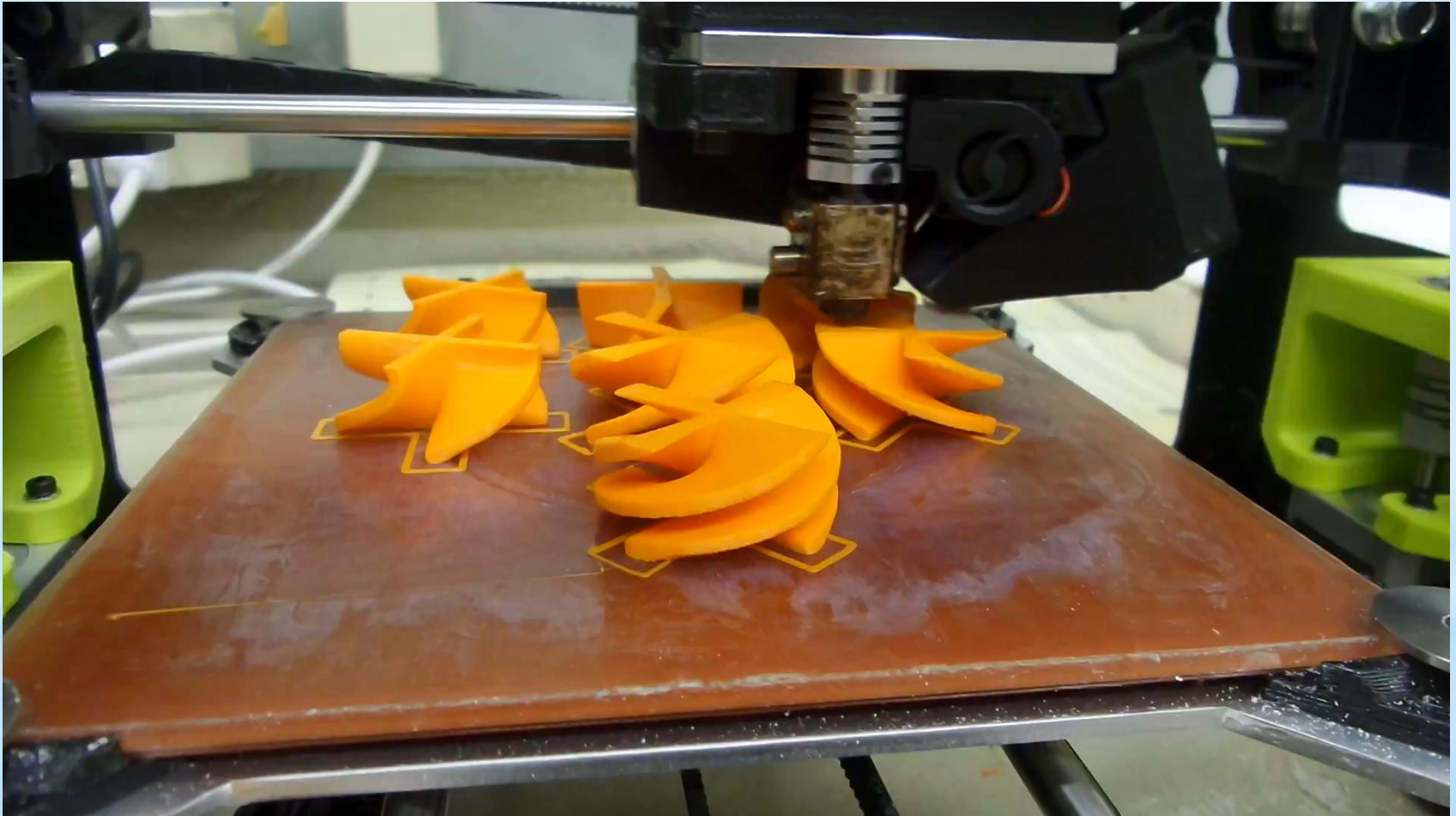
Design

Prototype

Final Artwork

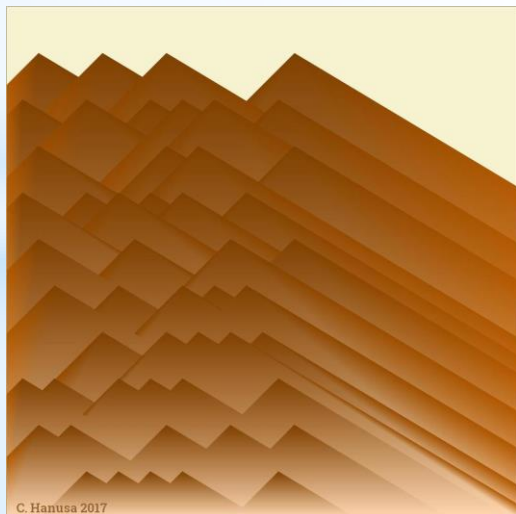
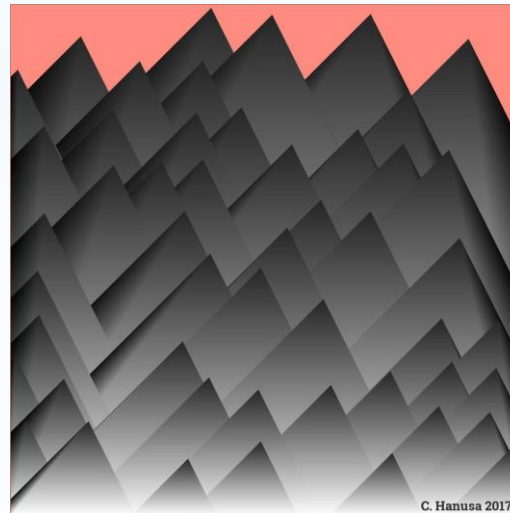
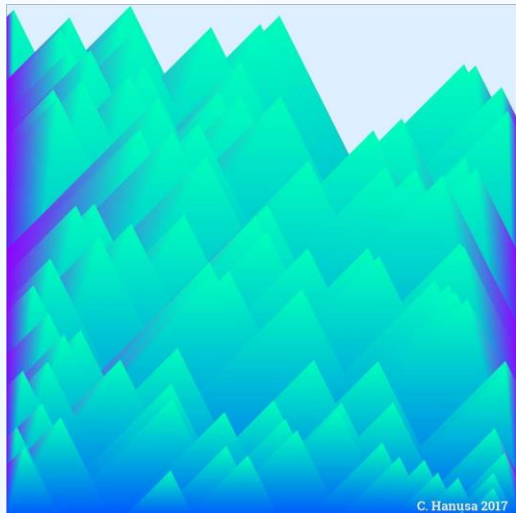


What does 3D Printing look like?



Mathematical Images

Sand Art (2017)



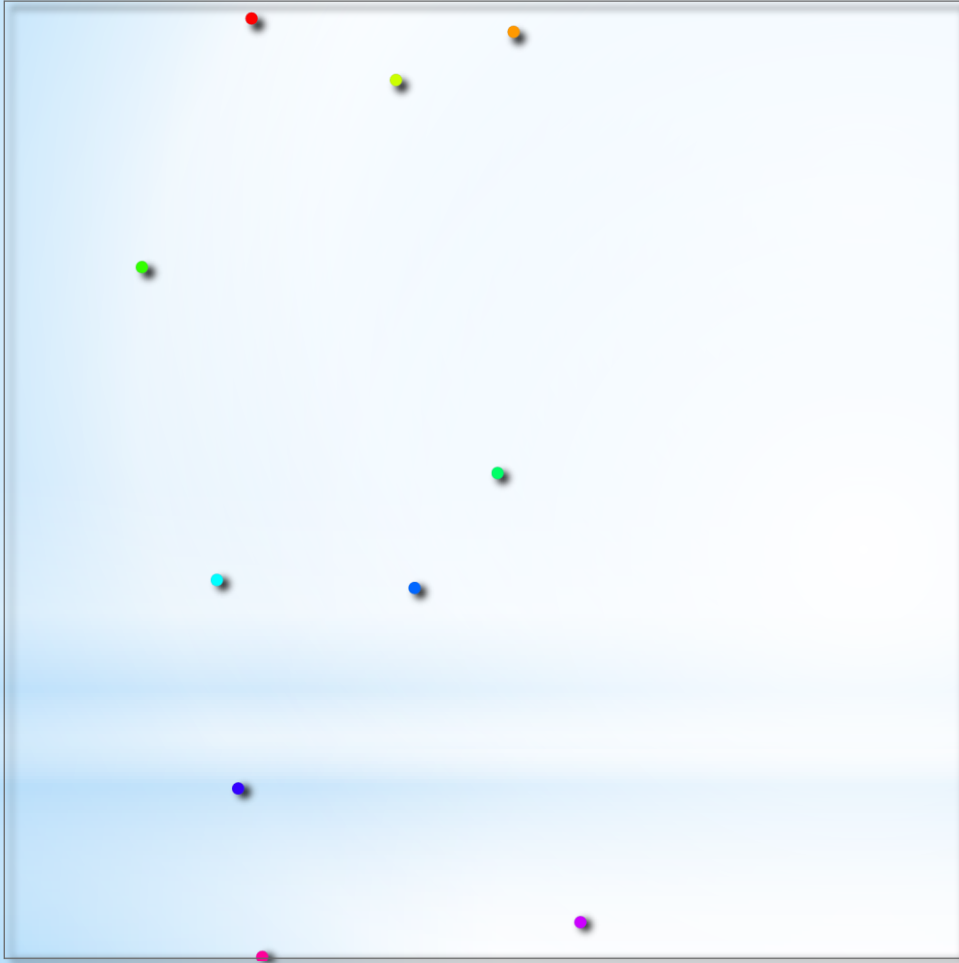
Inspiration: Playa Hermosa



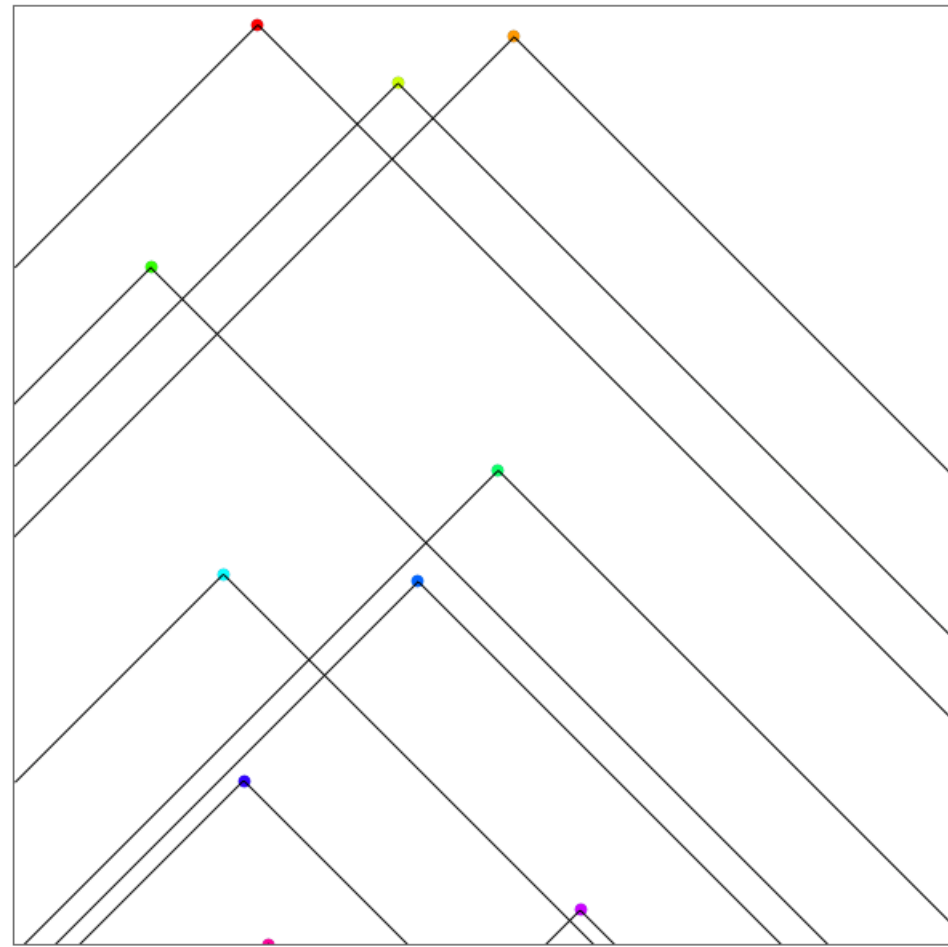
Deconstruction



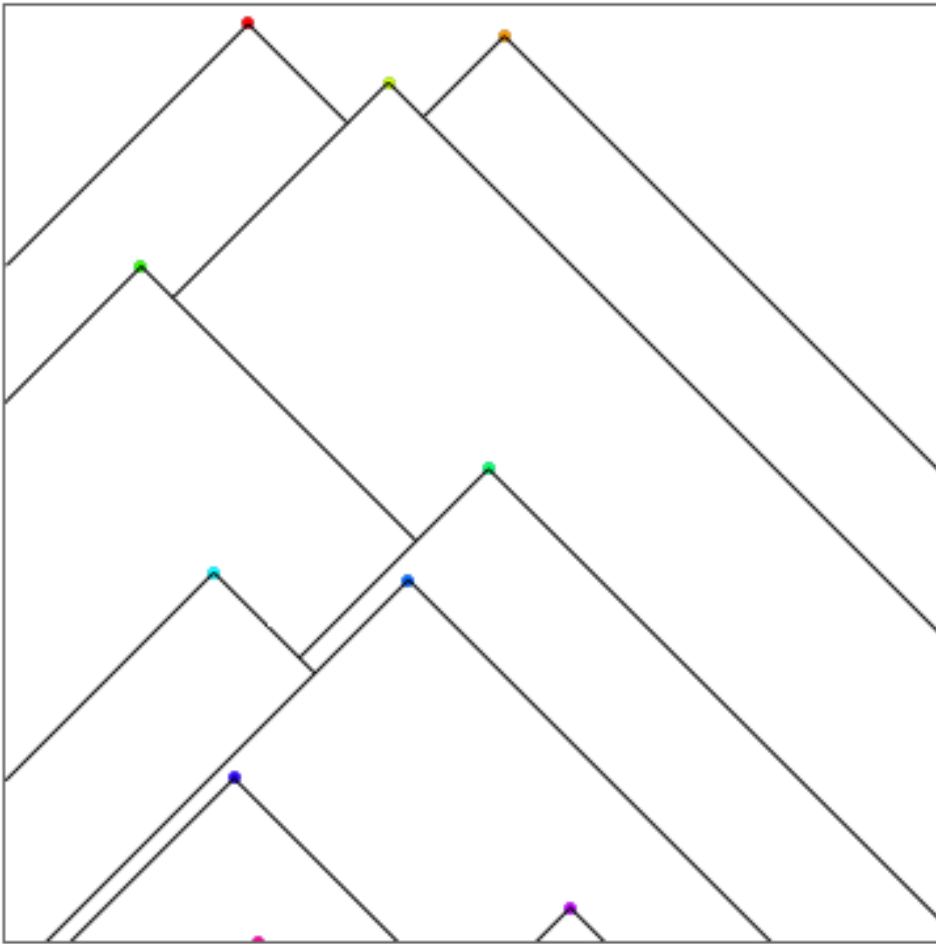
Reconstruction



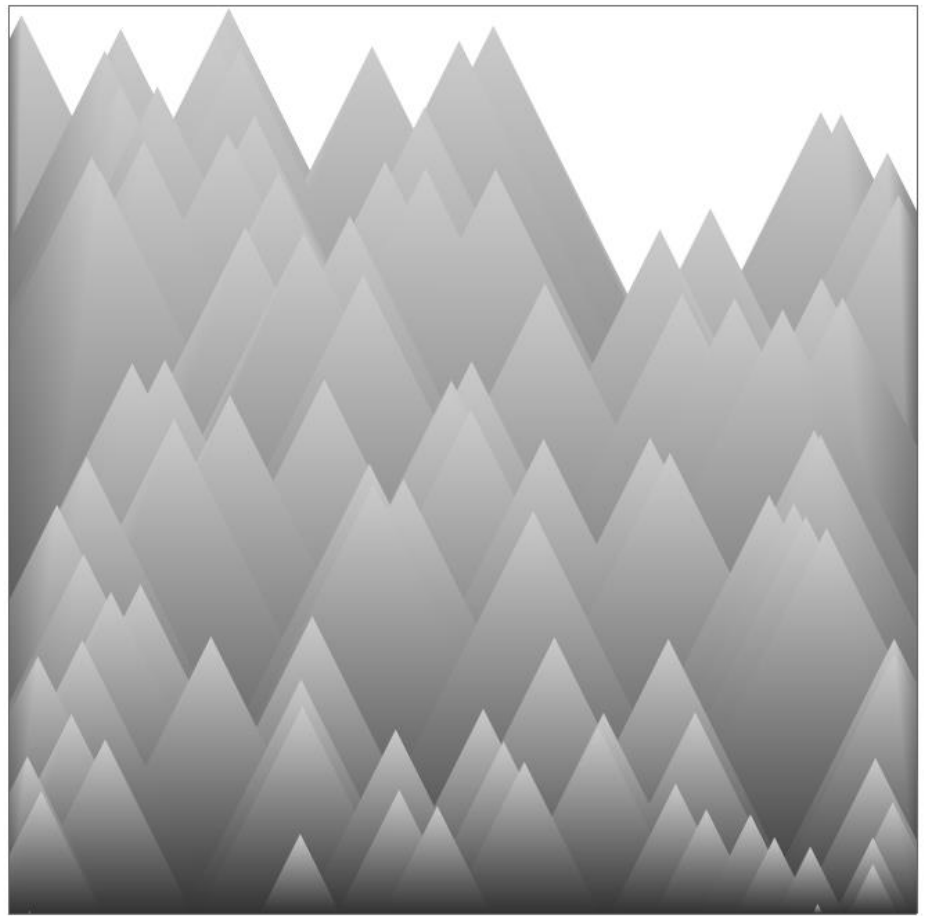
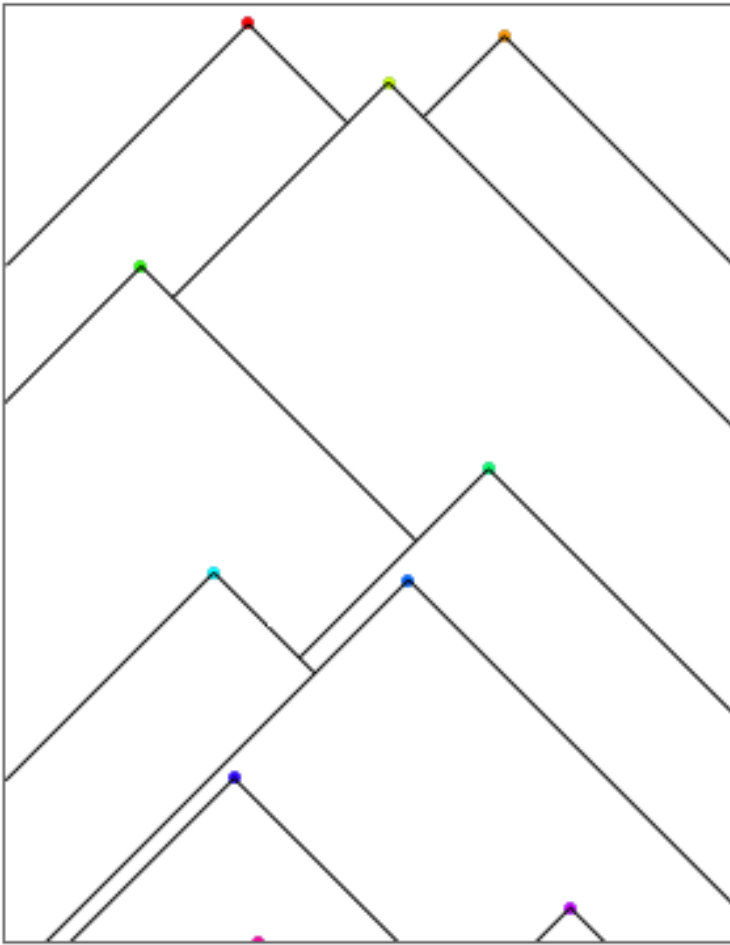
Reconstruction



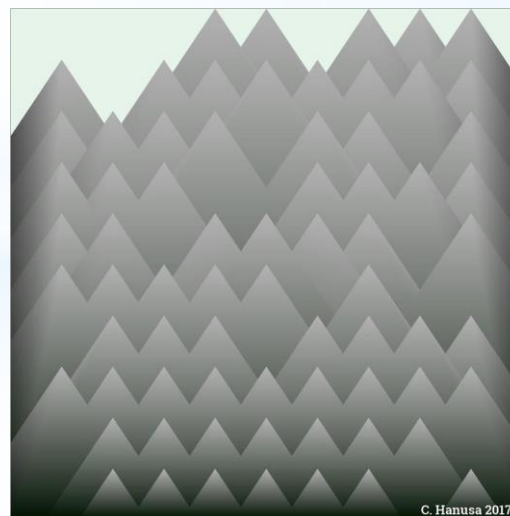
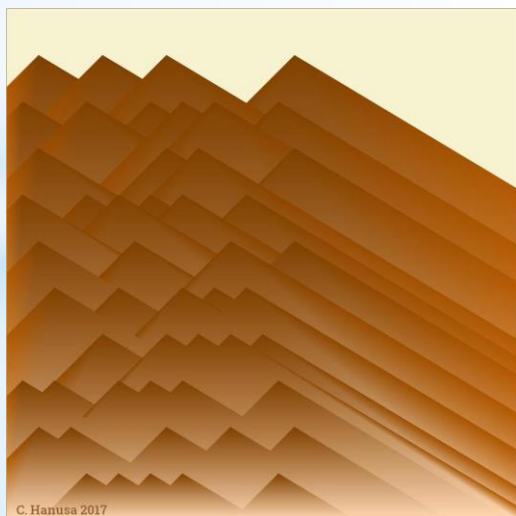
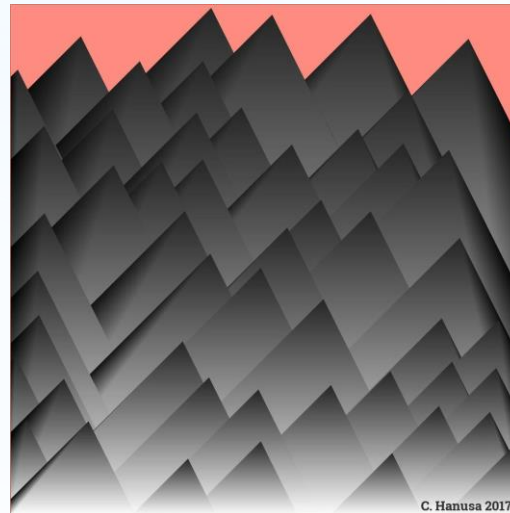
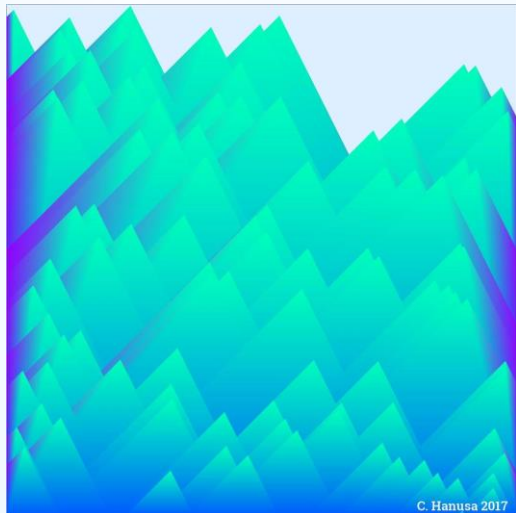
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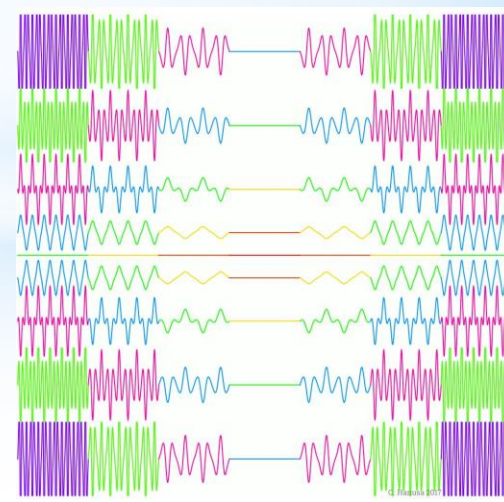
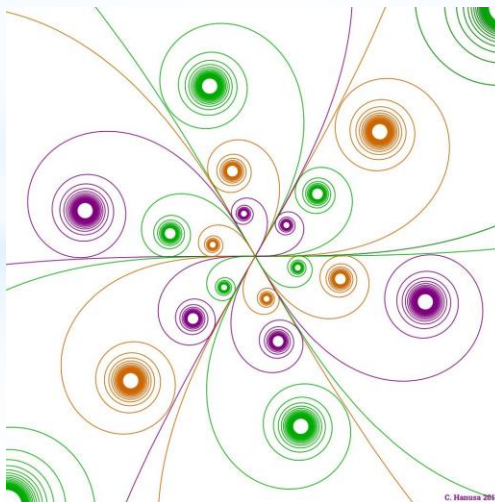
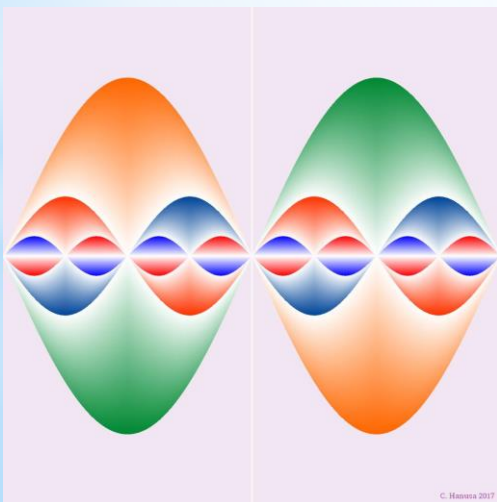
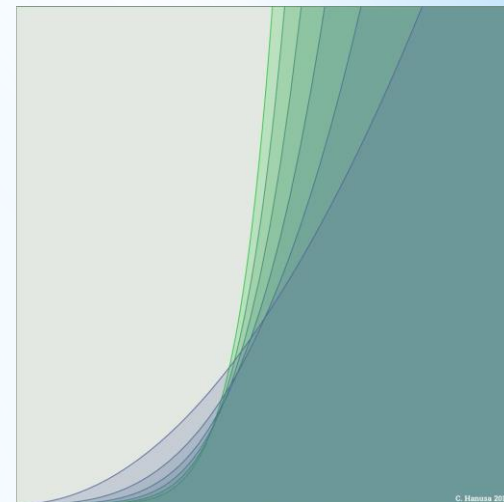
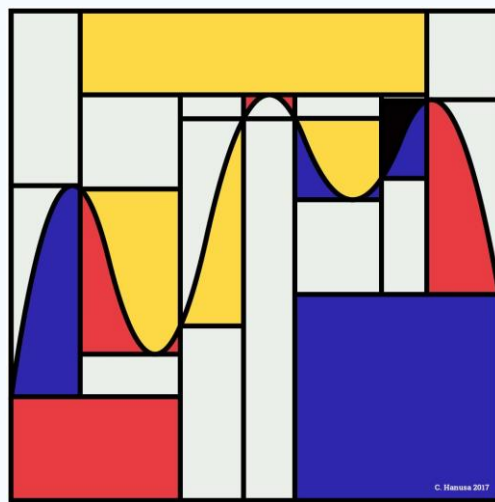
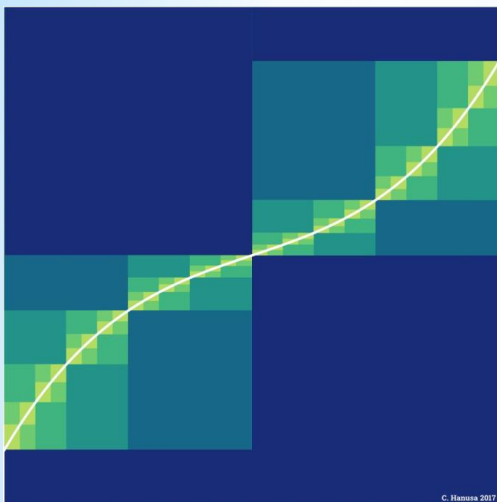
Reconstruction



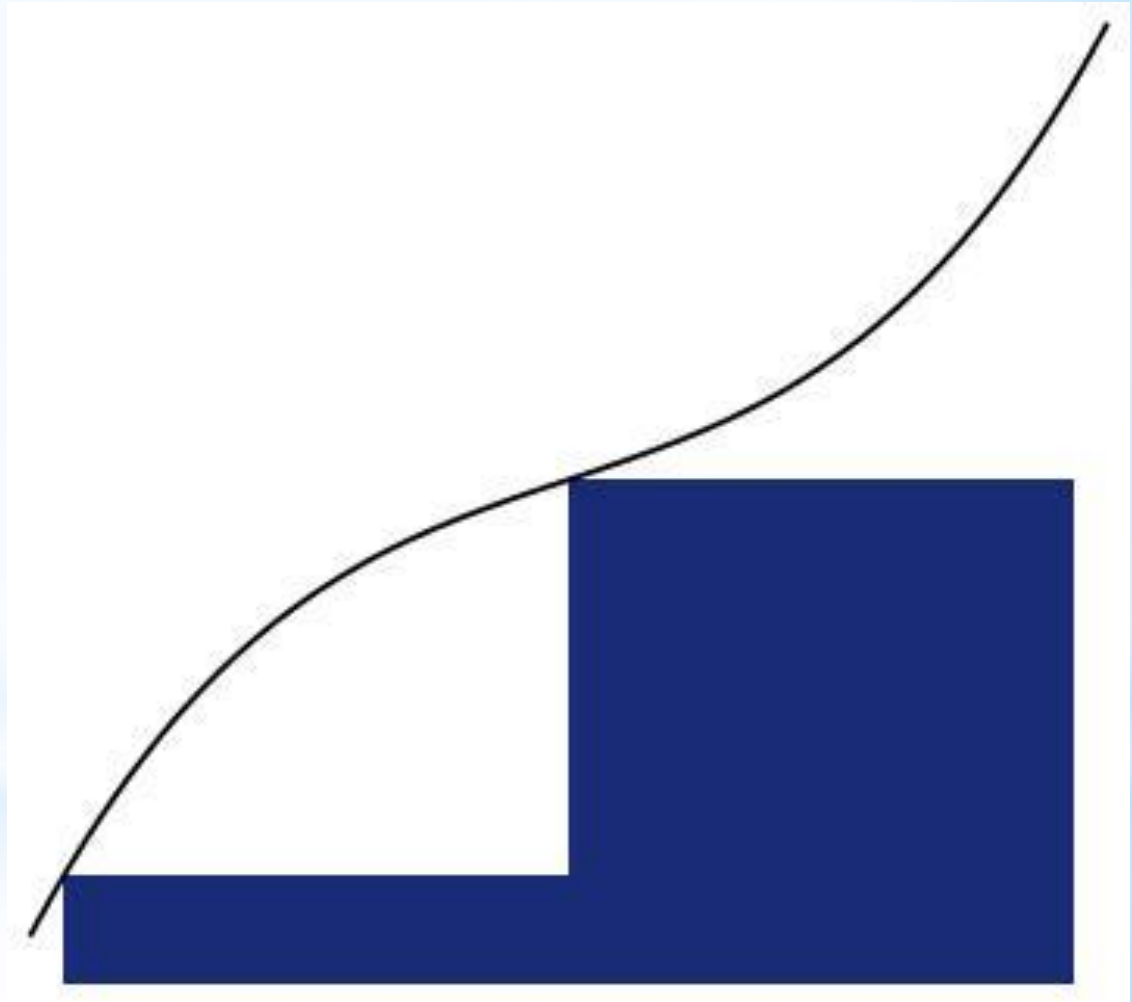
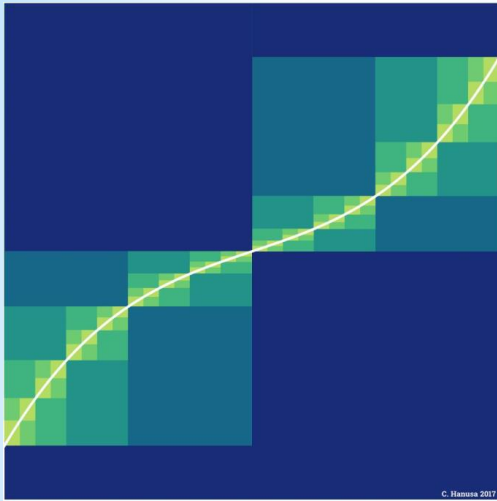
Sand Art (2017)



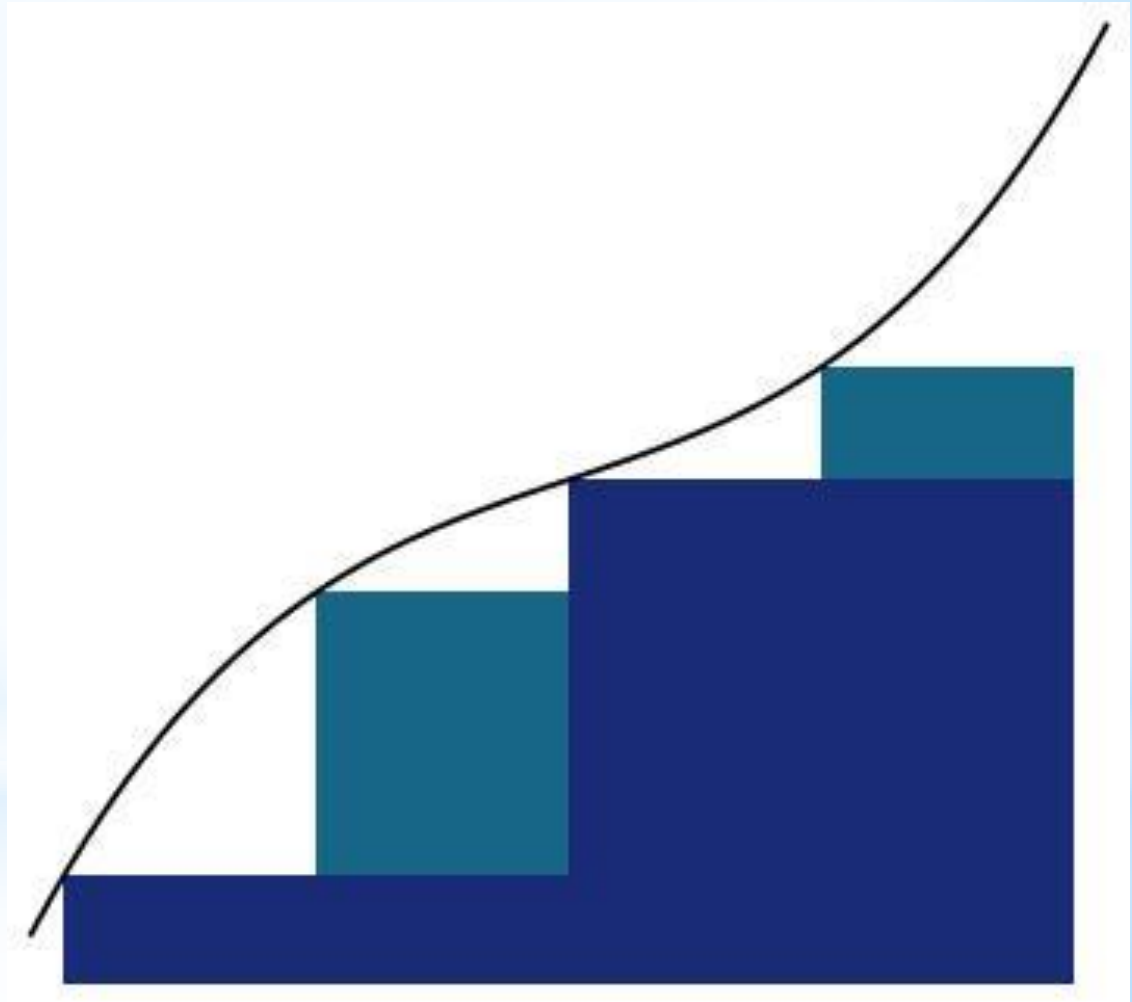
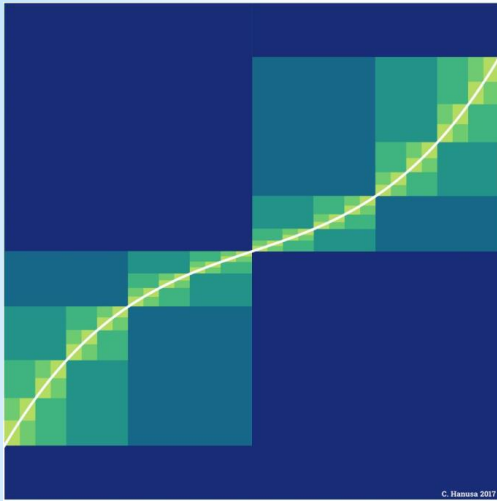
Calculus Art (2017)



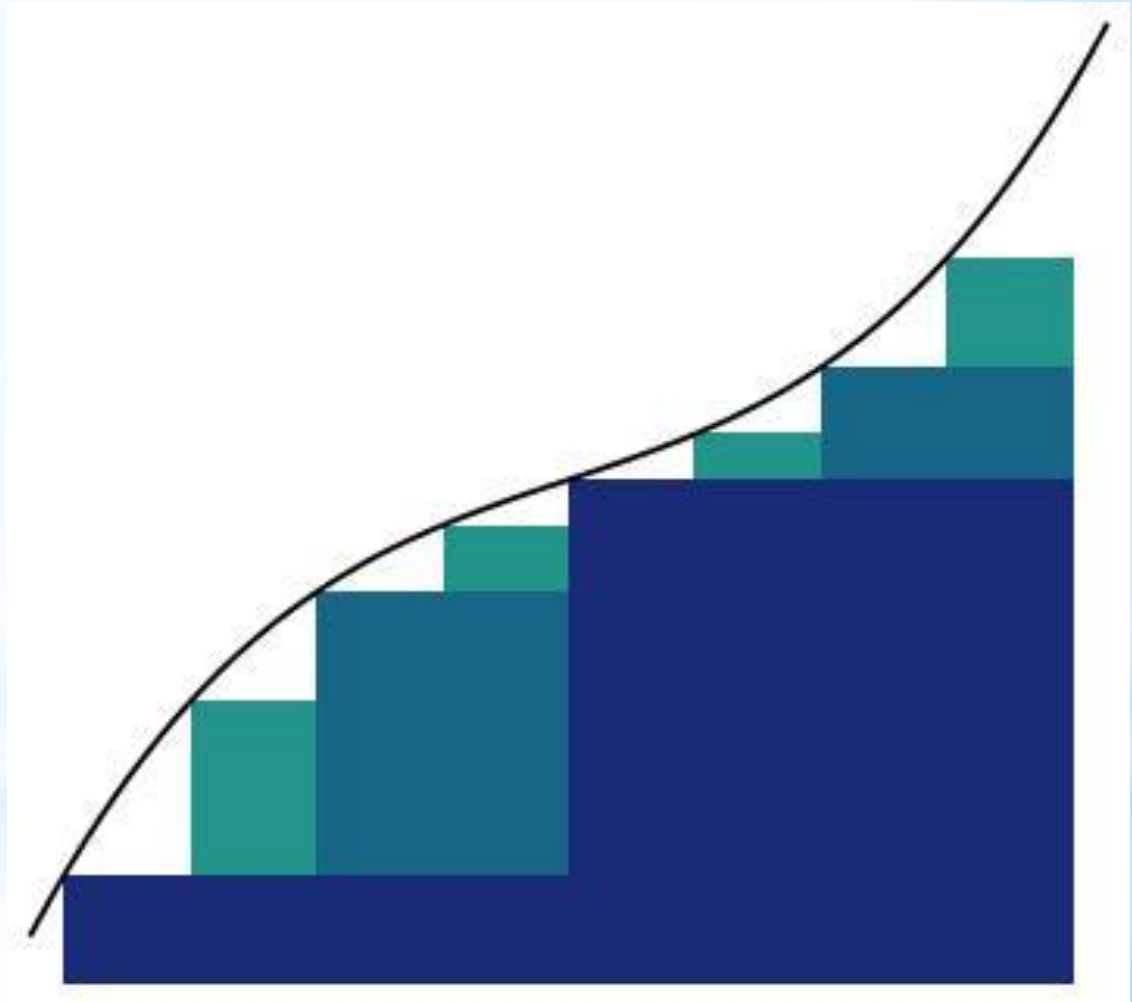
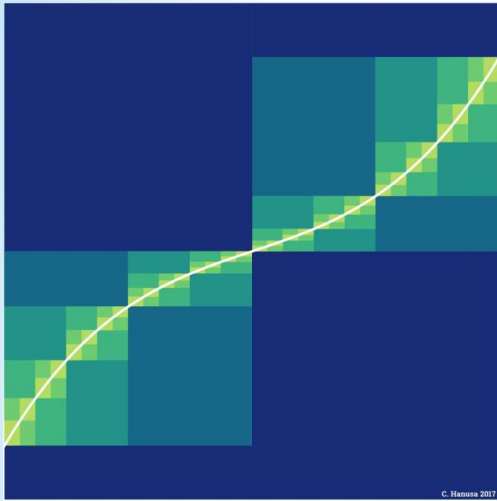
Riemann Valley (2017)



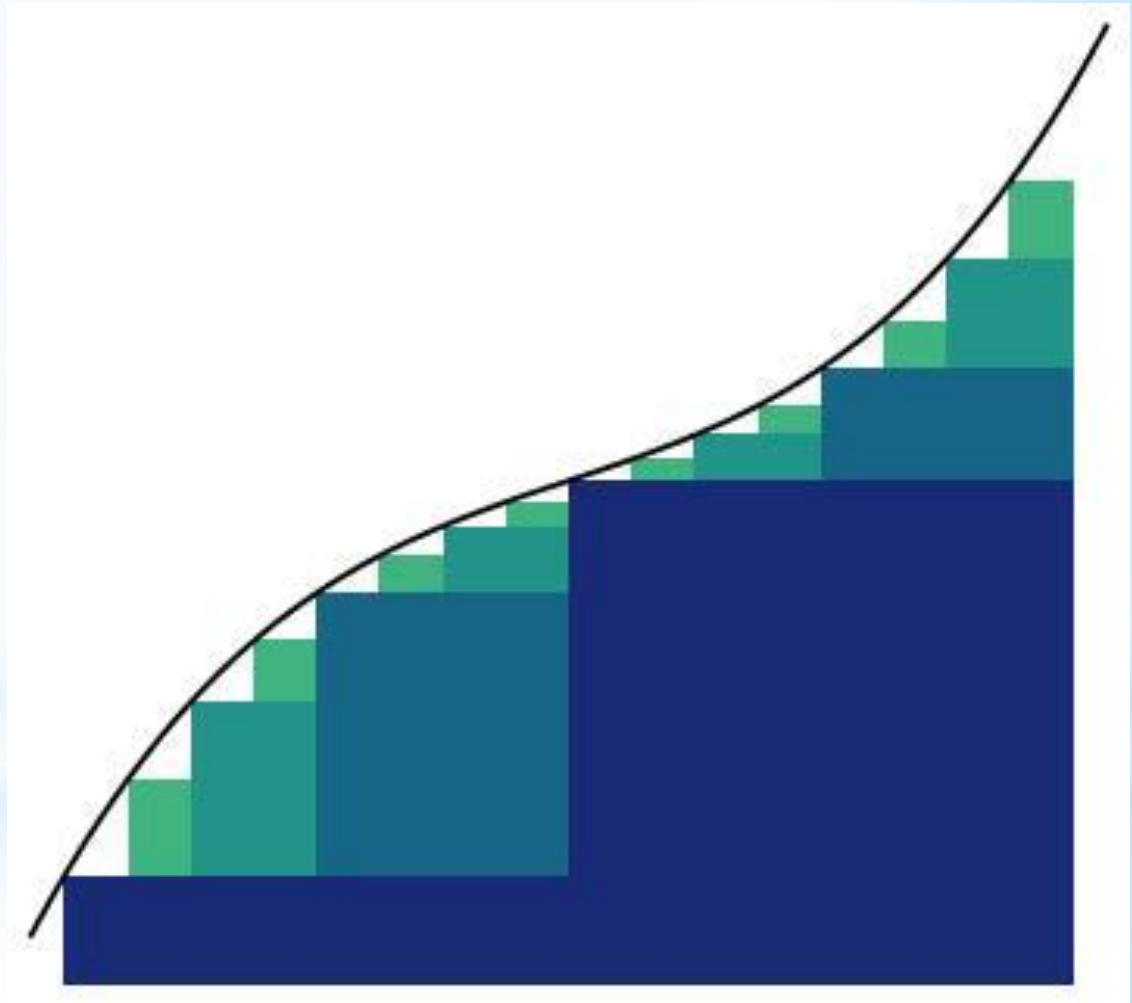
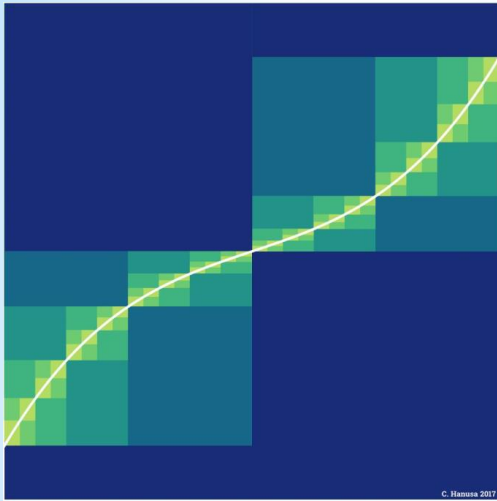
Riemann Valley (2017)



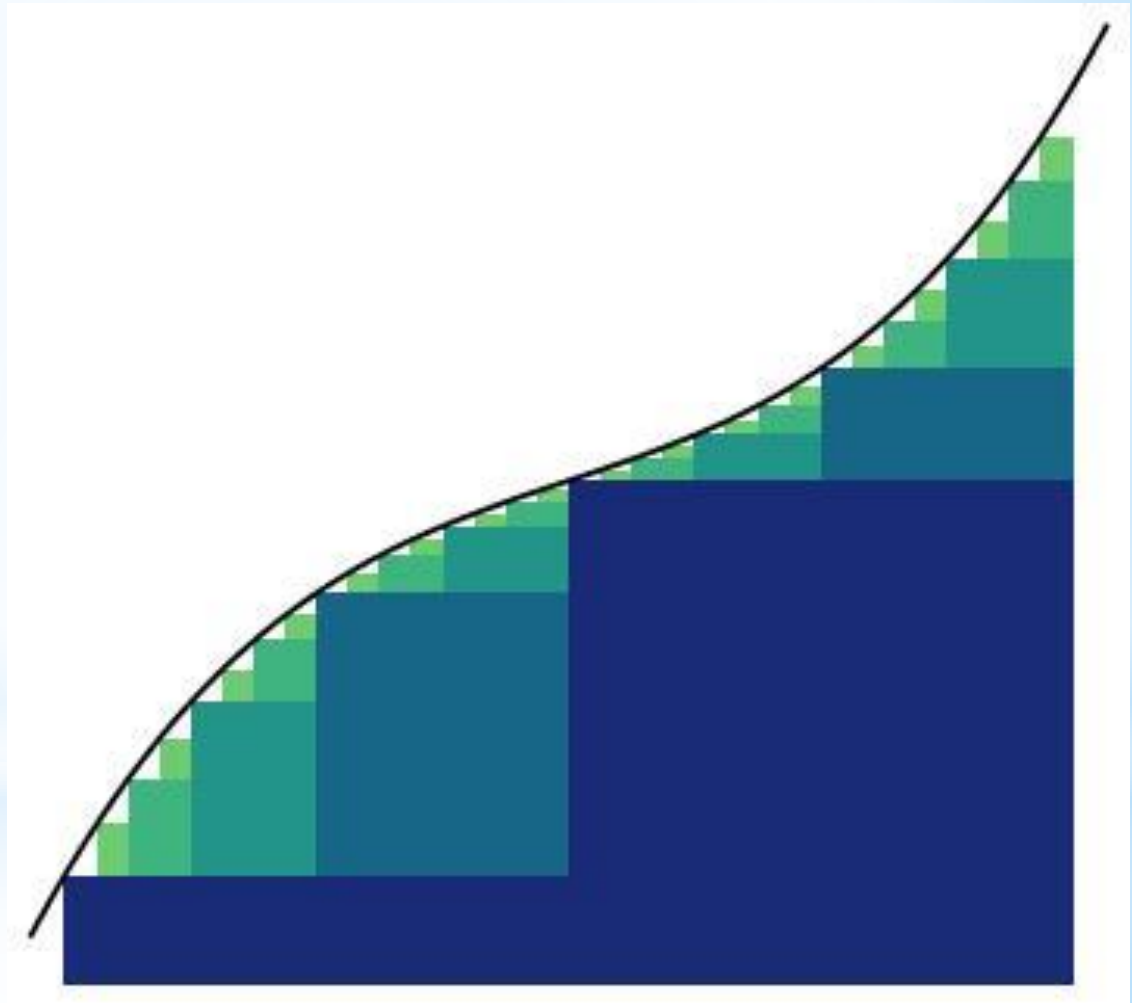
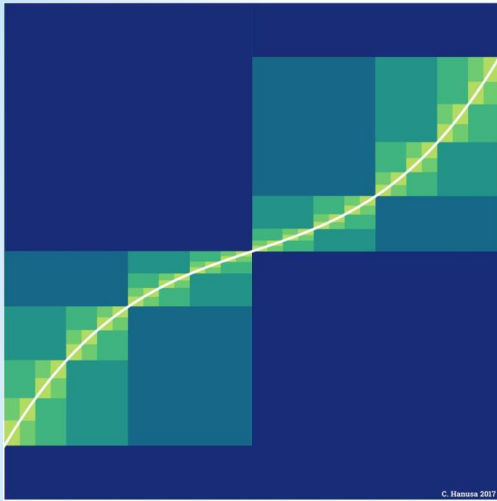
Riemann Valley (2017)



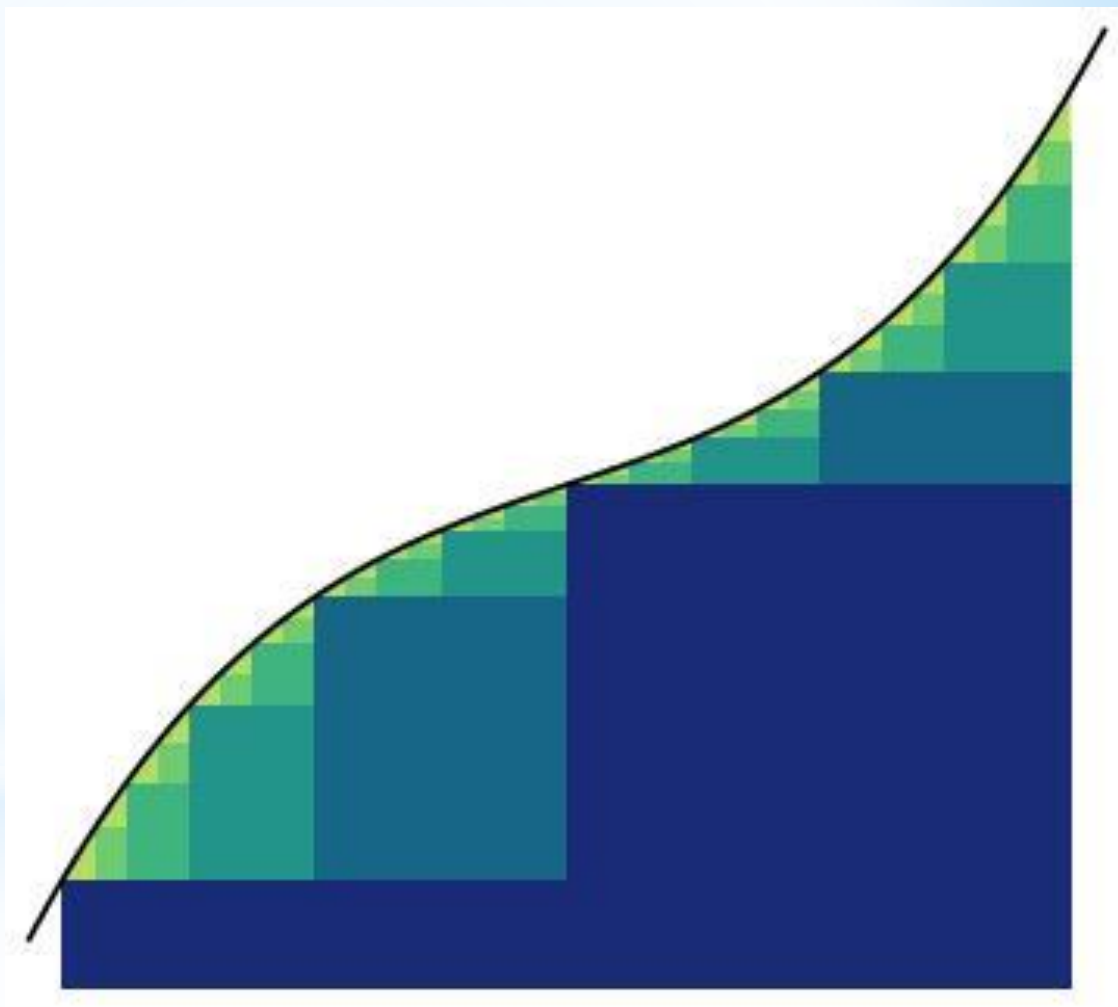
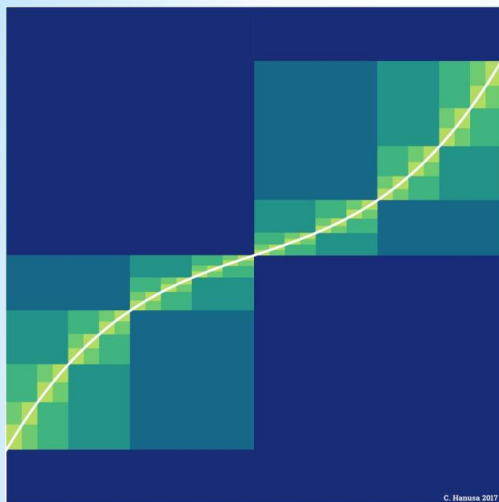
Riemann Valley (2017)



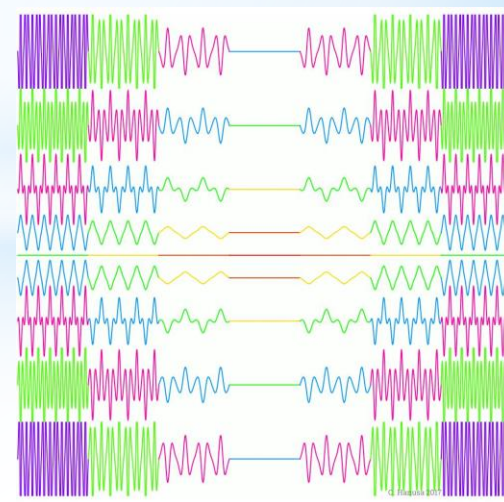
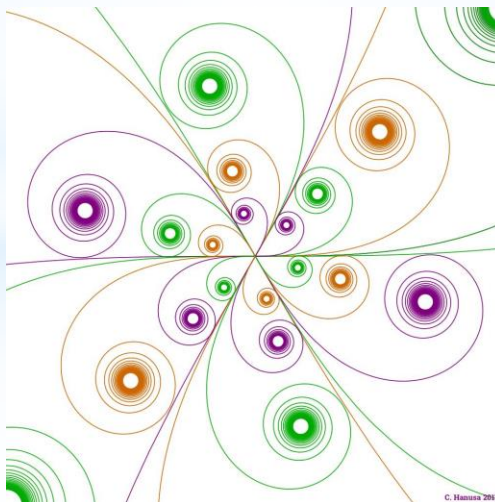
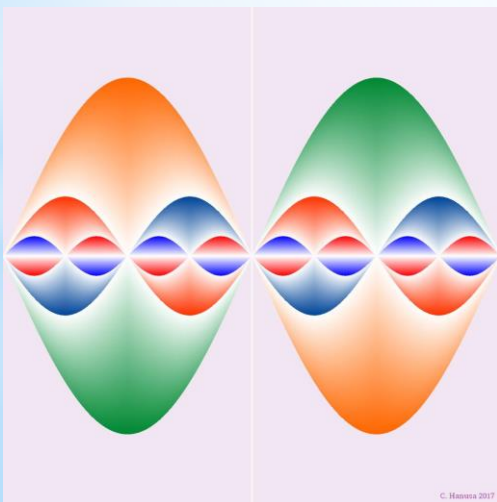
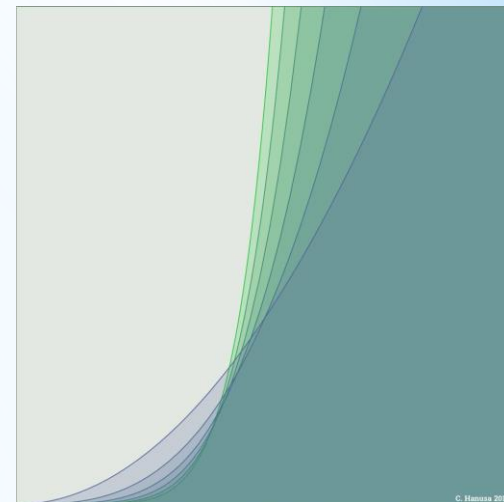
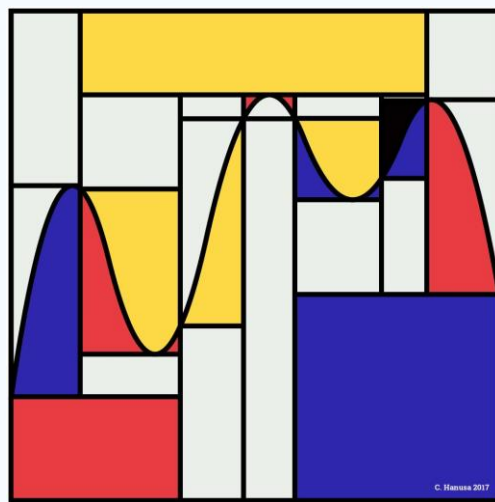
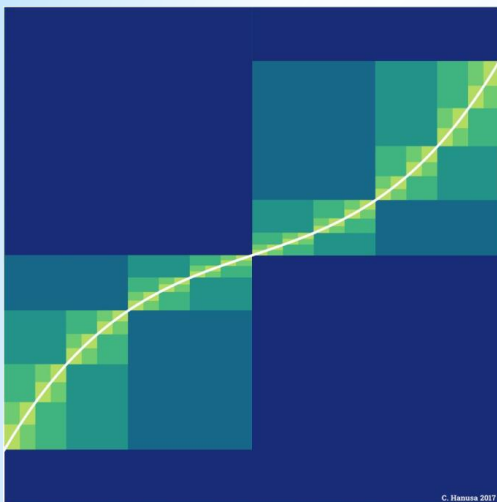
Riemann Valley (2017)



Riemann Valley (2017)



Calculus Art (2017)



Generative Art

That's Random

A **random number** is a number chosen by chance.

Key property: Each choice is independent of previous choices.

That's Random

A **random number** is a number chosen by chance.

Key property: Each choice is independent of previous choices.

Which feels more random?

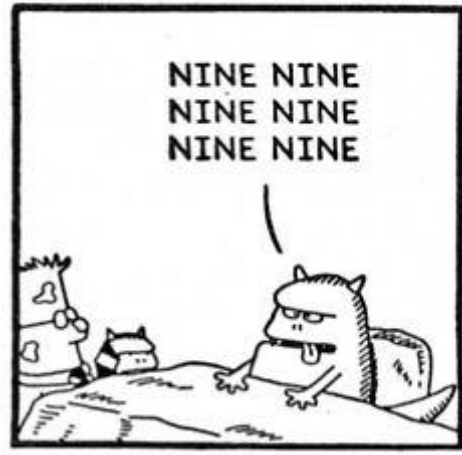
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List B:

1, 3, 4, 2, 1, 1, 3, 3, 2, 4, 1, 2, 3, 1, 3, 4, 4, 2, 1, 4, 2, 3,
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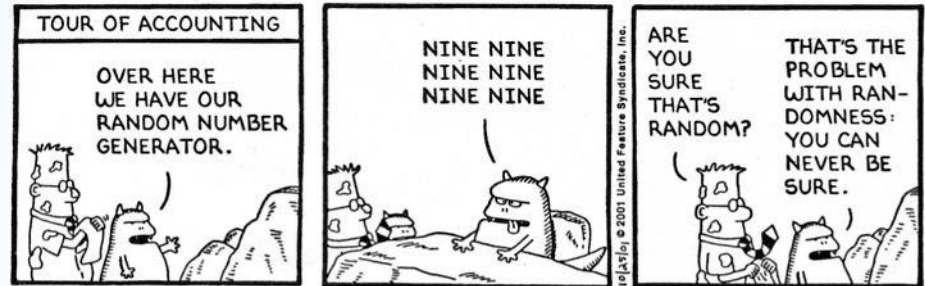
Generating Random Numbers



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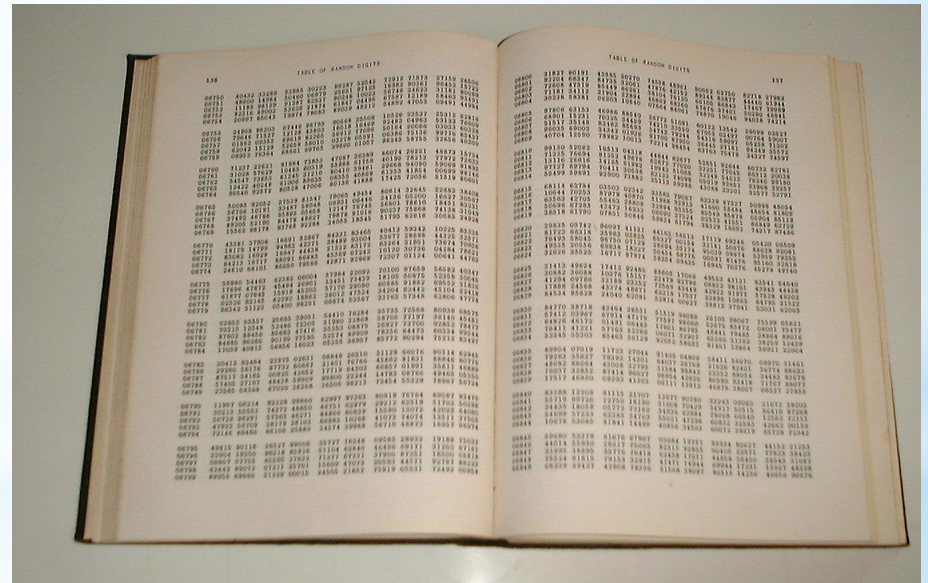
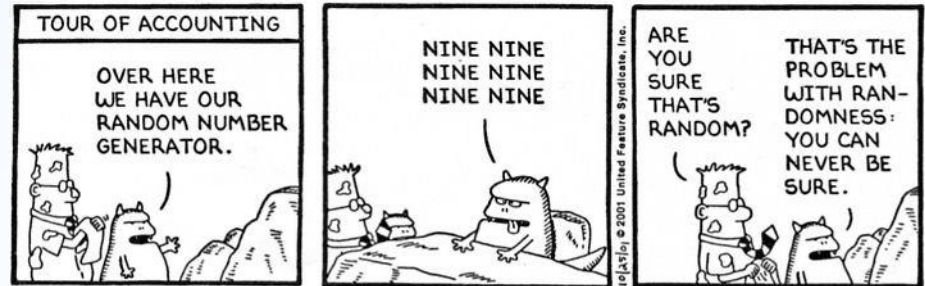
Generating Random Numbers

- Flip a coin
- Roll a die



Generating Random Numbers

- Flip a coin
- Roll a die
- Tables in books



Generating Random Numbers

TABLE OF RANDOM DIGITS

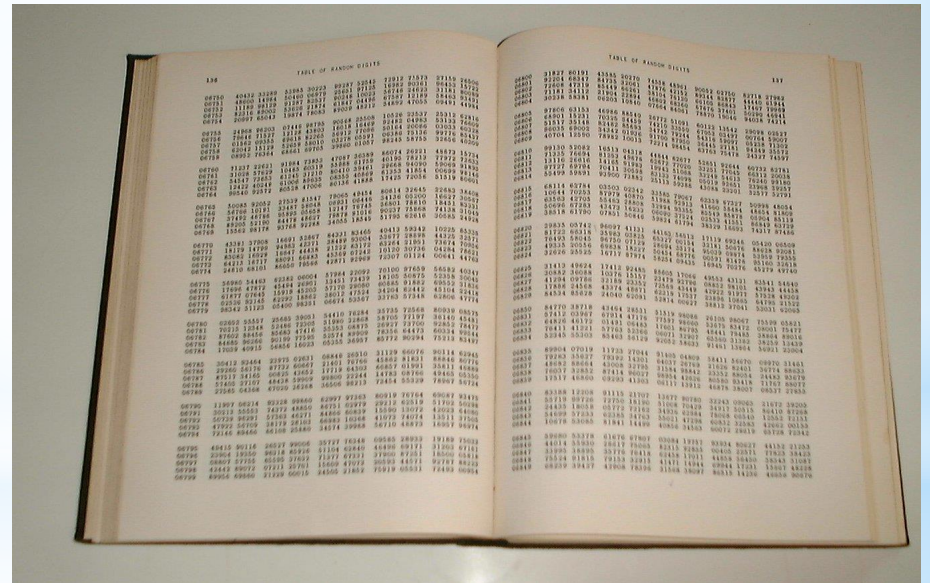
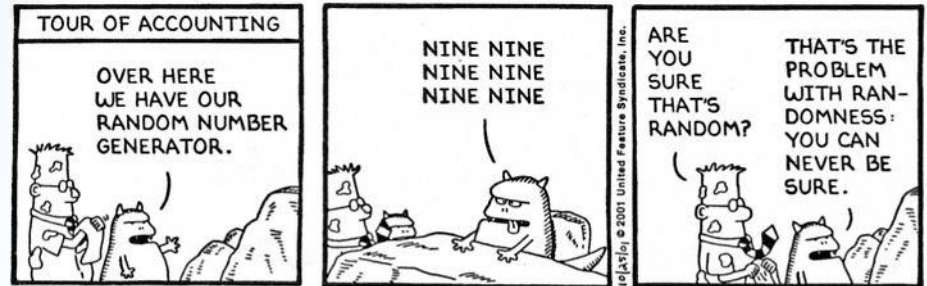
40432 33289	53985 30223	89287 52545	22912 71573	27159 26505
48600 14984	50460 06979	23651 87125	16982 90361	96453 15722
11189 98129	91287 82537	90248 10023	56746 34623	31181 80089
82216 89002	53626 21874	81847 04496	67587 12189	58463 93491
20997 85043	19874 76053	89039 48217	34892 47055	09491 44984
24968 96203	07446 98795	90568 25508	10526 23537	25912 62816
79646 71527	32128 43803	16018 16469	92482 04983	53133 76609
01862 09355	69618 82265	56912 77096	50164 20086	03033 60328
62042 15129	52659 58010	03278 05591	06389 79136	99776 85457
08952 76364	84661 69705	39860 01057	98245 58755	32656 40299
71237 22621	91984 73833	47087 36389	86074 26221	48873 15734
31028 57629	10485 60319	55985 81759	40193 78213	77972 72632
54547 73653	61245 31210	80410 39461	29668 94090	59069 91893
12422 40249	81006 89635	08355 40869	61353 41854	00699 98146
98540 92577	80528 47006	80136 41888	17425 72056	51319 80601
50085 92052	27539 81547	78065 49454	80614 32645	22683 38408
56766 10191	33487 38048	06831 06446	34136 05200	16627 30587
37492 46786	95895 05658	12147 78745	36501 78810	18451 83331
89205 52190	84478 48637	79879 91016	90337 75868	74138 31045
15362 98178	93768 92288	34055 18545	51793 62010	30585 24928
43382 37808	16691 52867	84331 83465	40413 58342	10225 85338
18179 14799	94983 42371	38489 93004	33677 28898	44325 32571
80042 16929	18647 44438	21222 63172	63264 21951	73674 70934
64213 16717	86091 66883	45369 07242	10120 30736	04284 78621
24810 68101	86656 79588	42871 82989	73307 01124	00641 44763
66980 54463	92382 06004	57964 22092	70100 87659	56582 40347
76996 47872	45484 24901	13451 73439	18105 50875	52358 30045
71877 07645	15918 45203	57170 29050	60885 01882	68552 31836
25220 83145	62292 18862	38012 47824	34204 82442	45104 22418
8342 51123	05400 98351	06674 53367	32783 57348	62860 47774
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7602 88456	85683 47416	55353 08873	26927 73700	92852 78477
1685 96266	90199 77593	52574 89909	78356 84473	60334 98344
	44846 16923	05355 36997	85772 90394	75213 83497

TABLE OF RANDOM DIGITS

04600	31827 80191	43585 20270	74558 48961	90052 02750	82718 27982
04601	92204 68347	84735 32061	47876 42152	89344 83877	44440 61944
04602	72608 47319	85449 56261	38104 76120	66105 86843	17467 79969
04603	71181 34112	21904 22824	46802 68260	67676 37401	50290 46941
04604	30238 58381	06203 10940	07664 84031	78870 19046	94038 74214
04605	97806 63153	46986 88540	26772 51091	60132 13542	25098 02527
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04611	71335 76694	81253 49678	62672 77020	33251 77045	68312 20038
04612	13116 26816	14165 91983	19943 51068	33249 54613	76240 98180
04613	97727 69794	70411 30598	83130 74098	05019 92651	23968 39257
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04616	10644 70253	87979 40870	51988 92913	41660 58484	48654 81809
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04619	38518 61790	07851 50840	38824 61794	38329 18693	74317 87486
04620	29835 03742	86097 41131	44163 56513	17119 68346	05420 06509
04621	61723 66318	35983 03825	68327 00194	32181 50676	88628 92061
04622	76493 58045	96750 07129	28694 33174	95039 09874	53559 79355
04623	49335 20556	69838 18227	30454 68776	00591 81426	85160 32518
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04630	84770 38718	43464 28531	51519 98086	26105 88067	75509 05882
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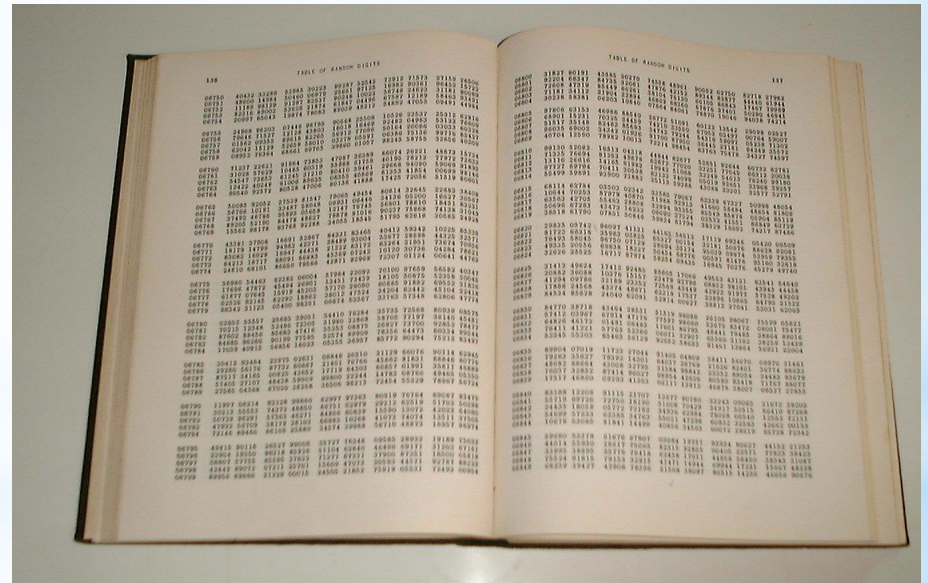
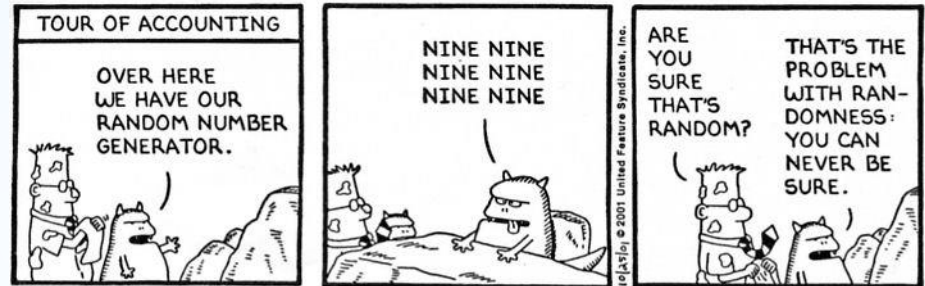
Generating Random Numbers

- Flip a coin
- Roll a die
- Tables in books
- Noise from outer space (random.org)



Generating Random Numbers

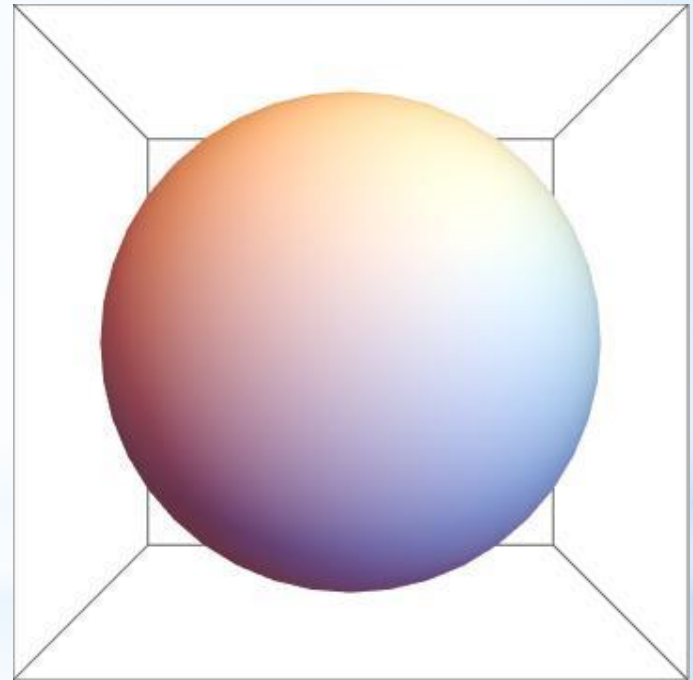
- Flip a coin
- Roll a die
- Tables in books
- Noise from outer space (random.org)
- Use a computer?



Generative Art / Creative Coding

Use a computer to program an **algorithm**:

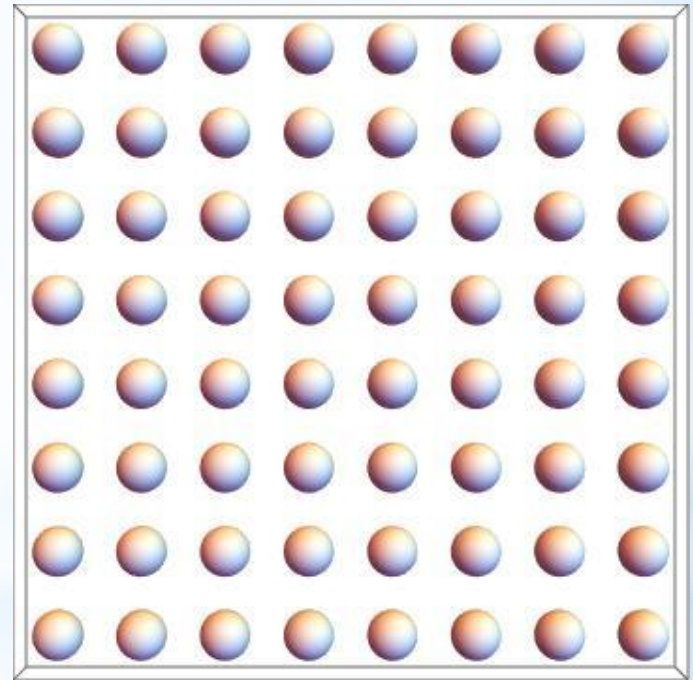
- Specify **objects**



Generative Art / Creative Coding

Use a computer to program an **algorithm**:

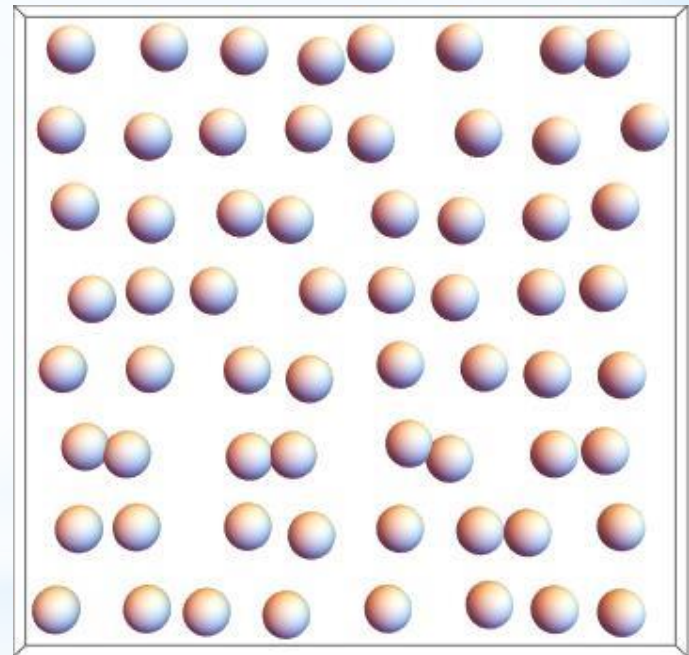
- Specify **objects**
- Give **rules** for placement



Generative Art / Creative Coding

Use a computer to program an **algorithm**:

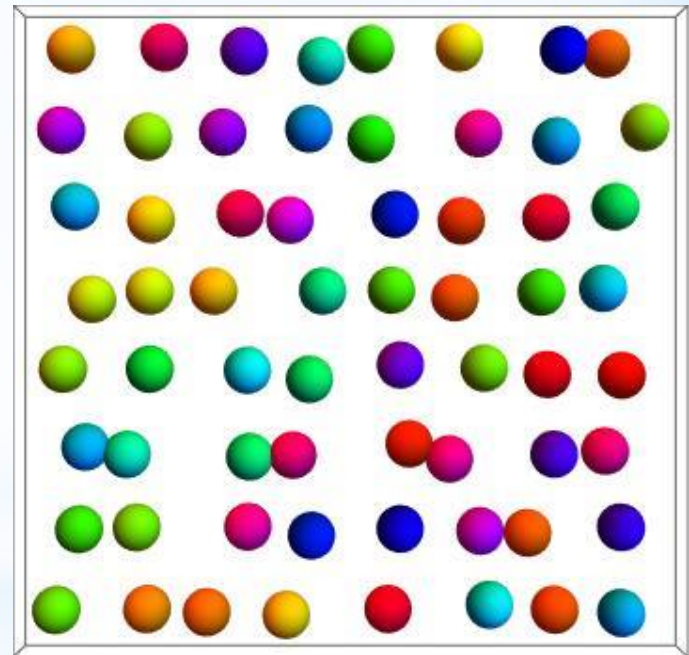
- Specify **objects**
- Give **rules** for placement
- Add **randomness**



Generative Art / Creative Coding

Use a computer to program an **algorithm**:

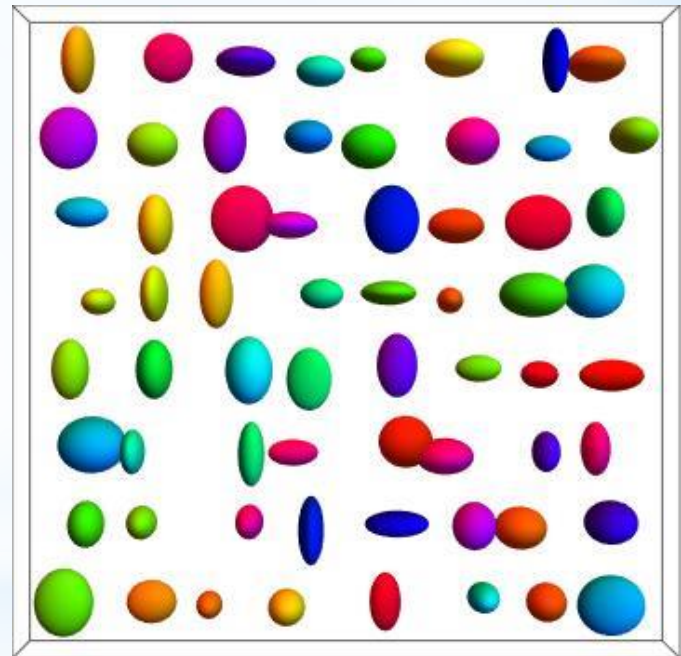
- Specify **objects**
- Give **rules** for placement
- Add **randomness**



Generative Art / Creative Coding

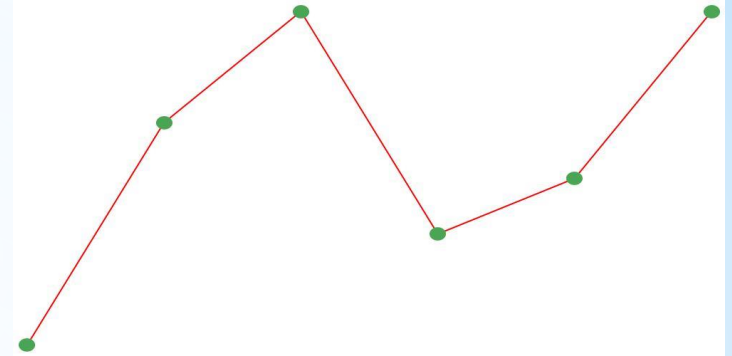
Use a computer to program an **algorithm**:

- Specify **objects**
- Give **rules** for placement
- Add **randomness**



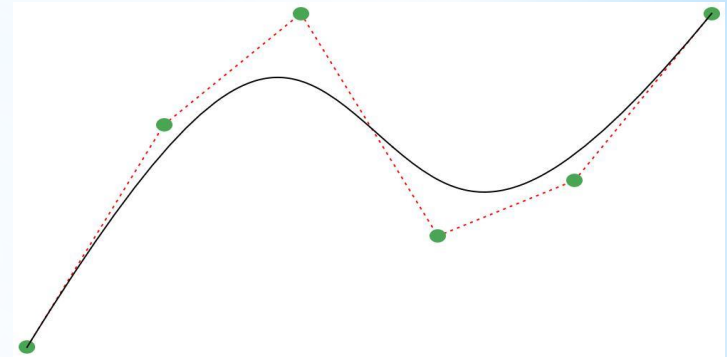
Random Splines

A **spline** is a **piecewise function** that is a **smooth curve** and approximates given data points.



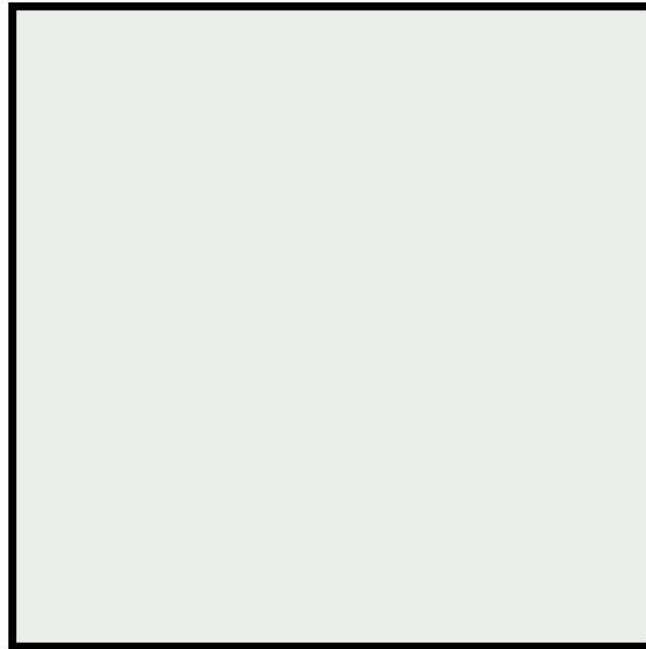
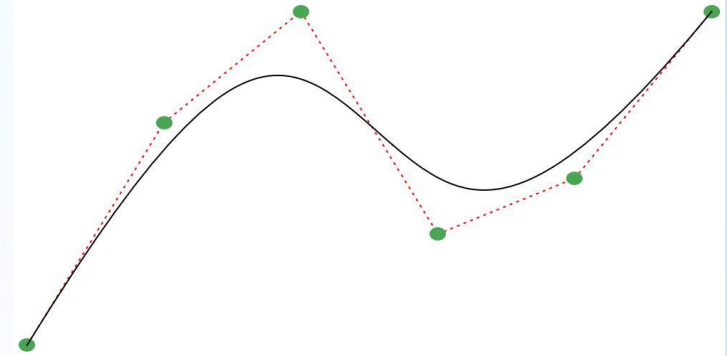
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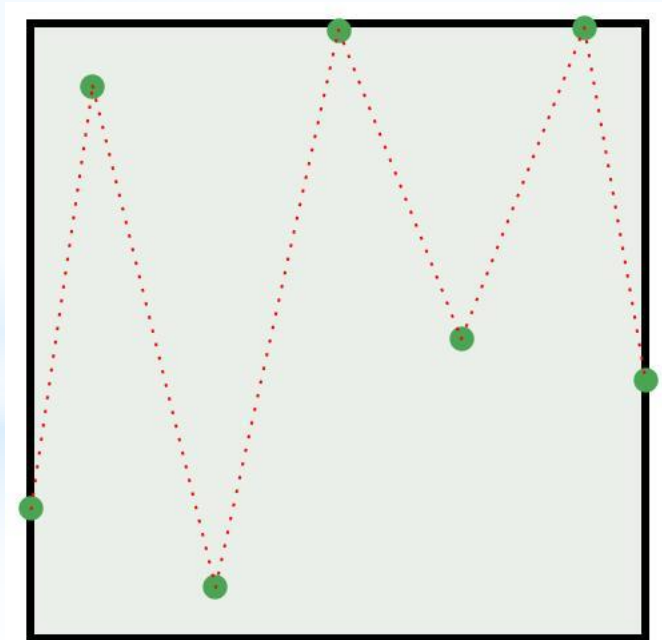
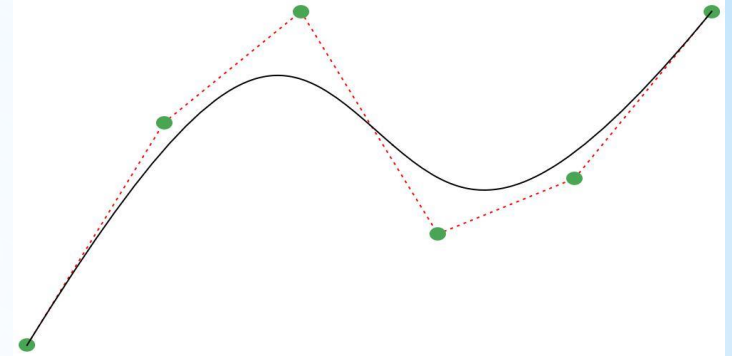
Riemondrian (2017)

A **spline** is a **piecewise function** that is a **smooth curve** and approximates given data points.



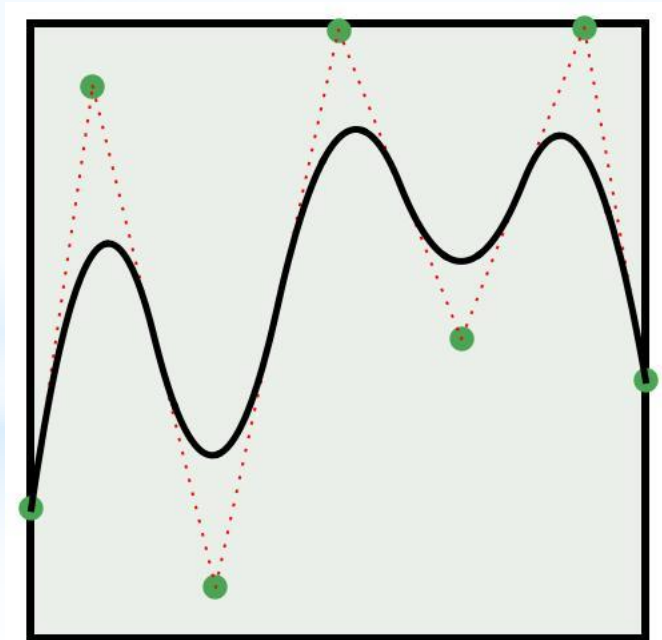
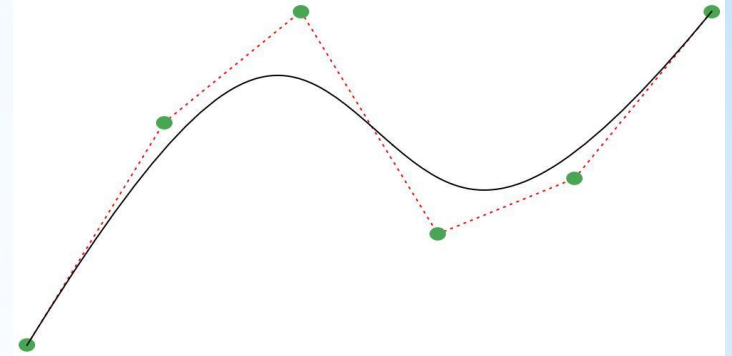
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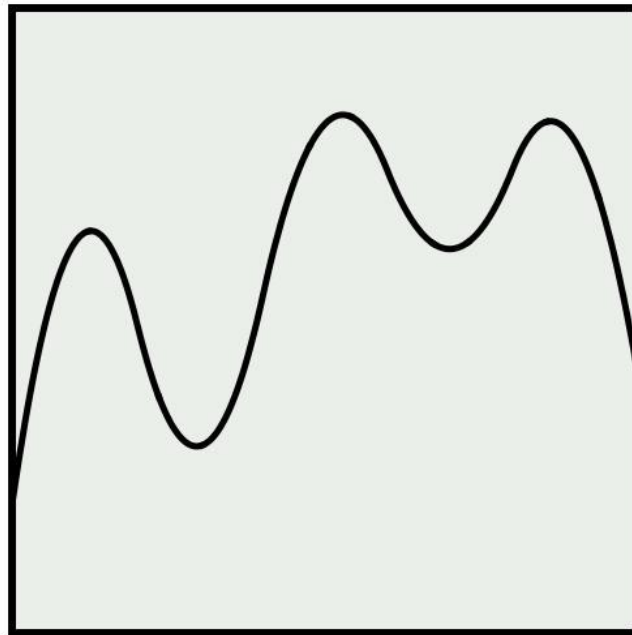
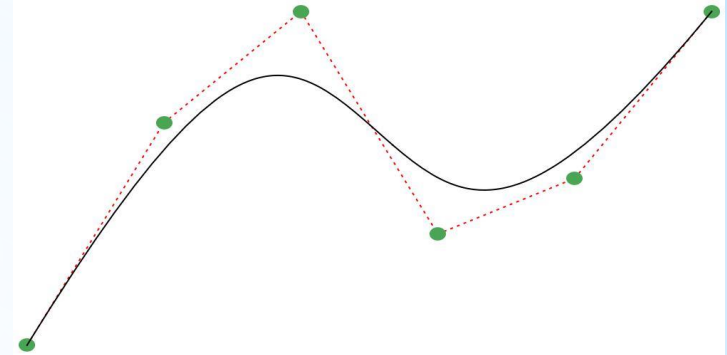
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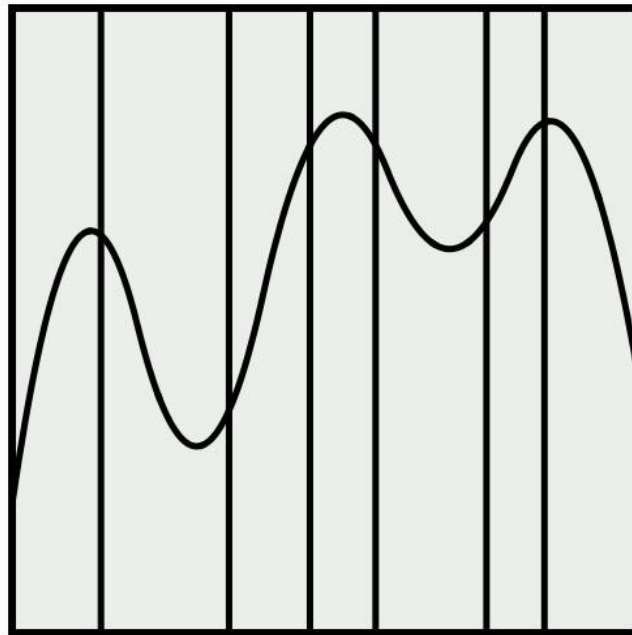
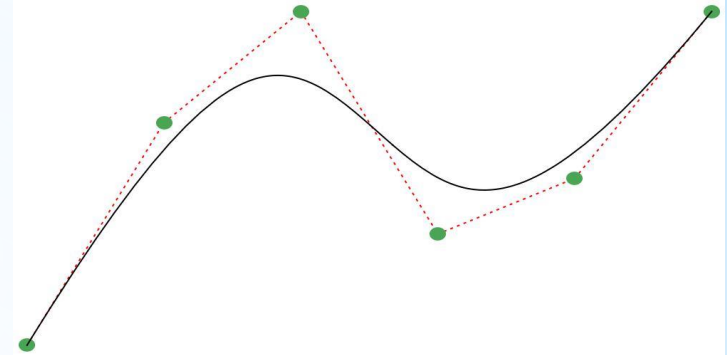
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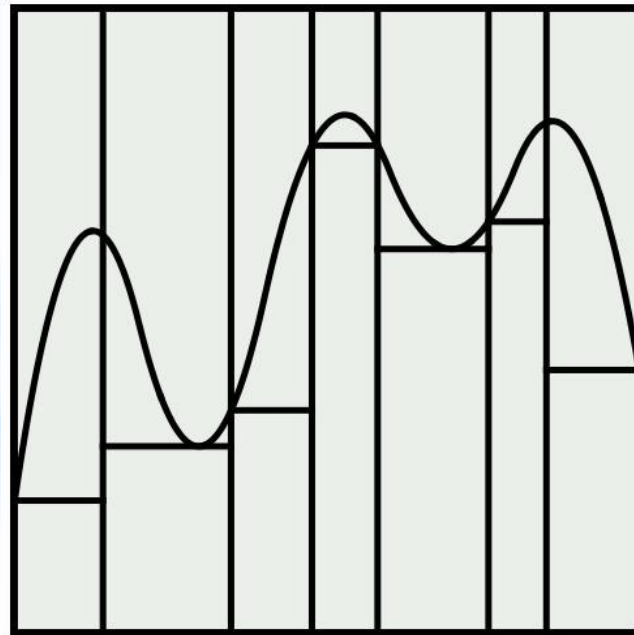
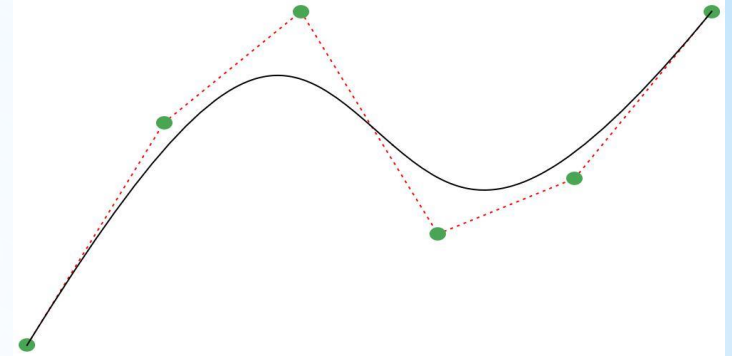
Riemondrian (2017)

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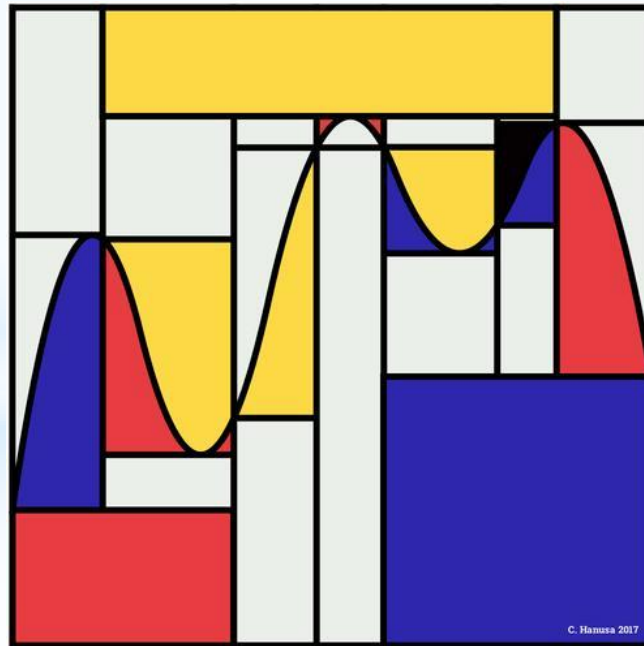
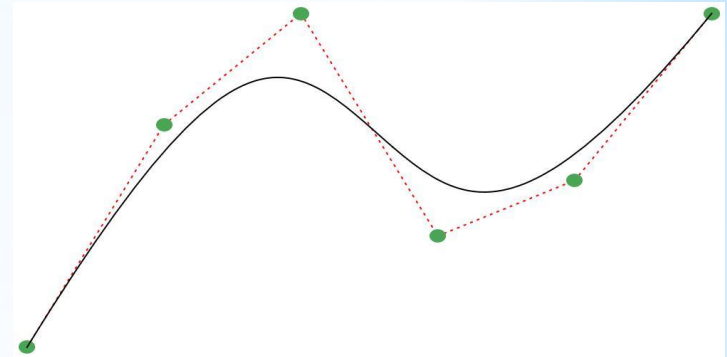
Riemondrian (2017)

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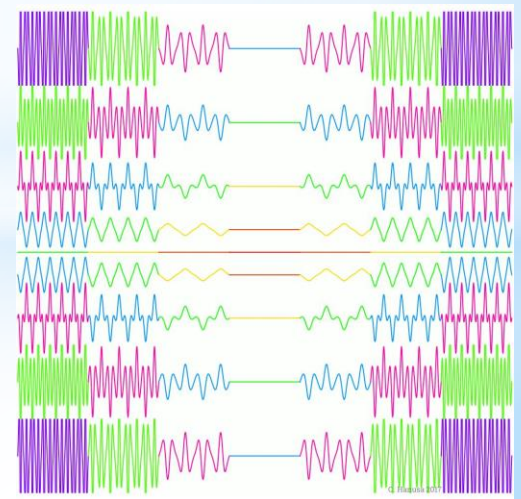
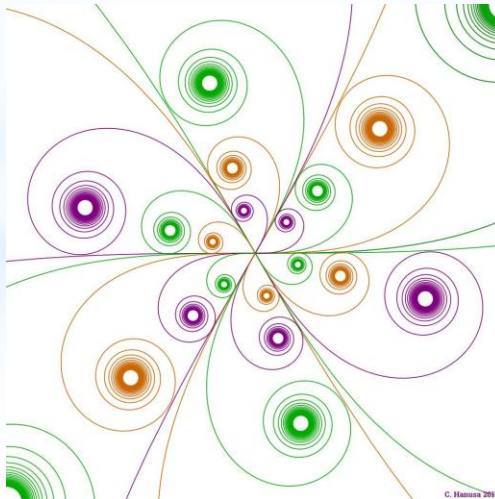
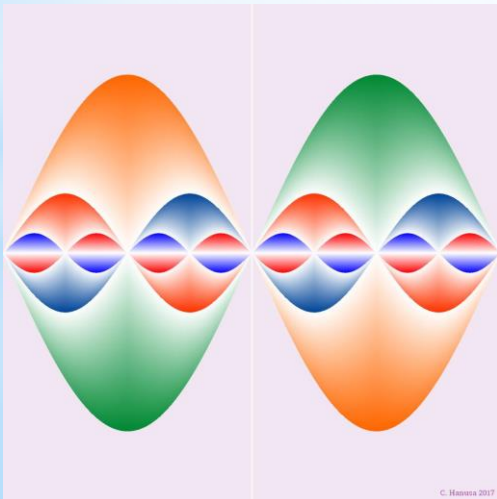
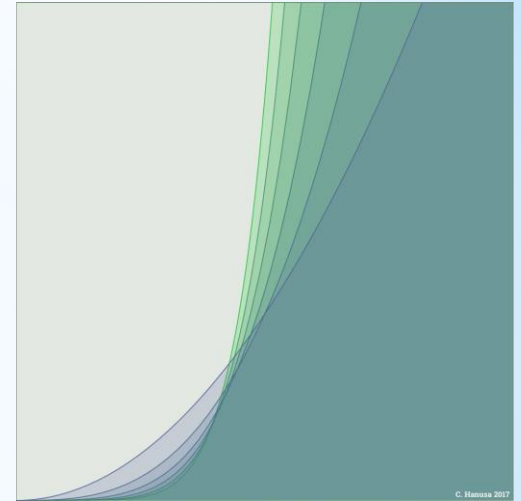
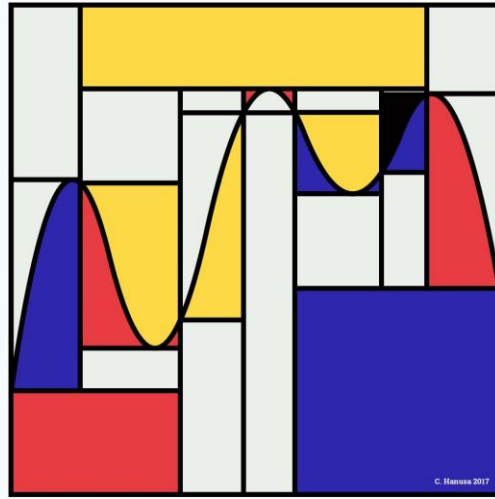
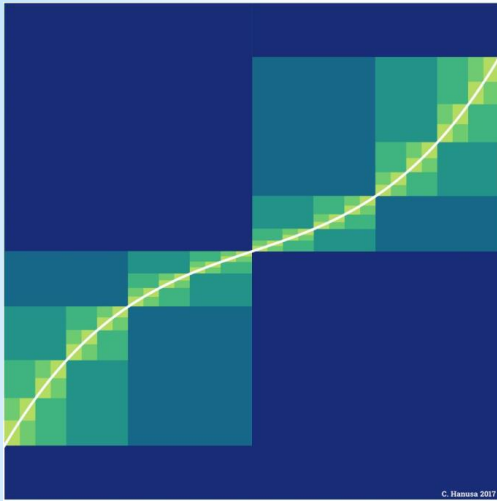


Riemondrian (2017)

A **spline** is a **piecewise function** that is a **smooth curve** and approximates given data points.



Calculus Art (2017)



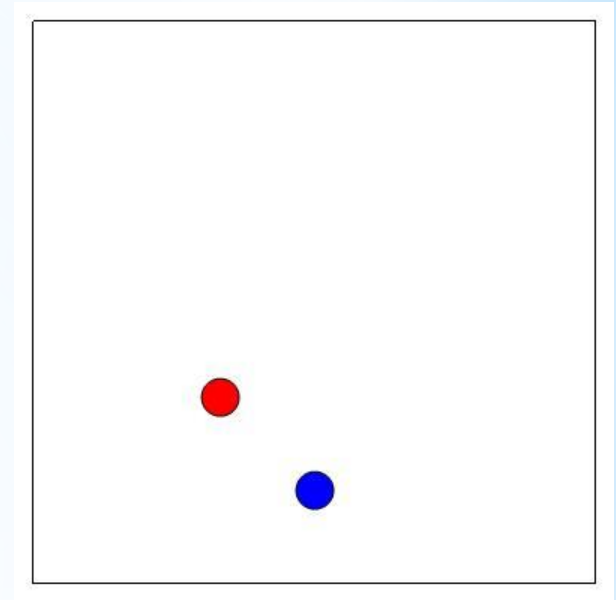
Mathematical Sculptures

The New Normal (2017)



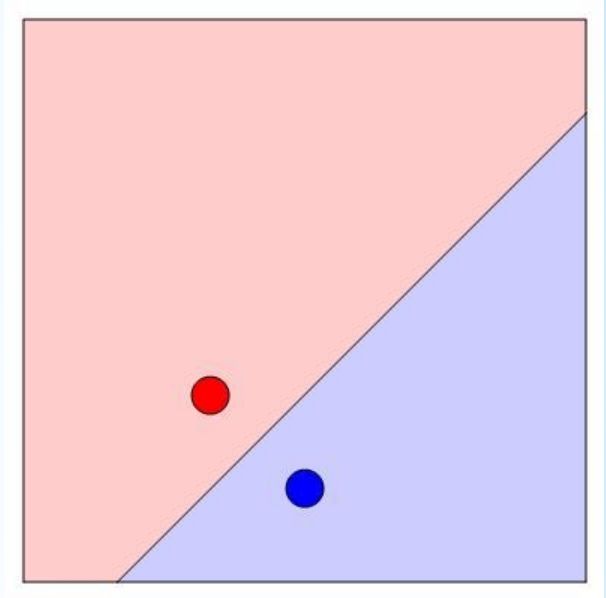
Voronoi Diagrams

The **Voronoi Diagram** for a **set of points** is the **division of the region** into pieces based on **closeness**.



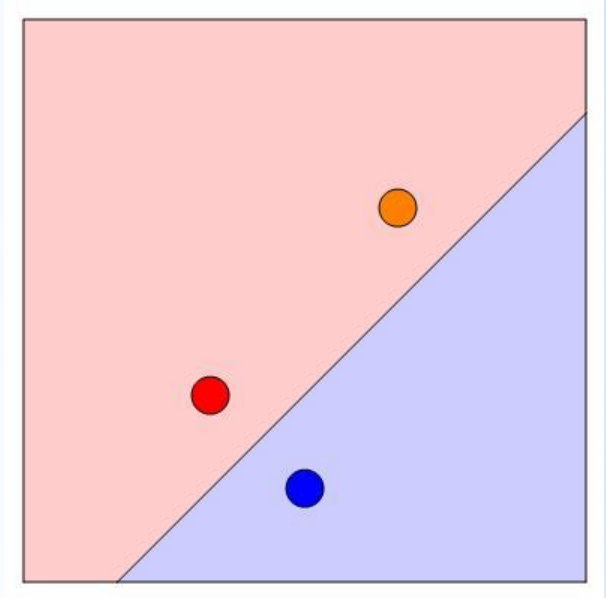
Voronoi Diagrams

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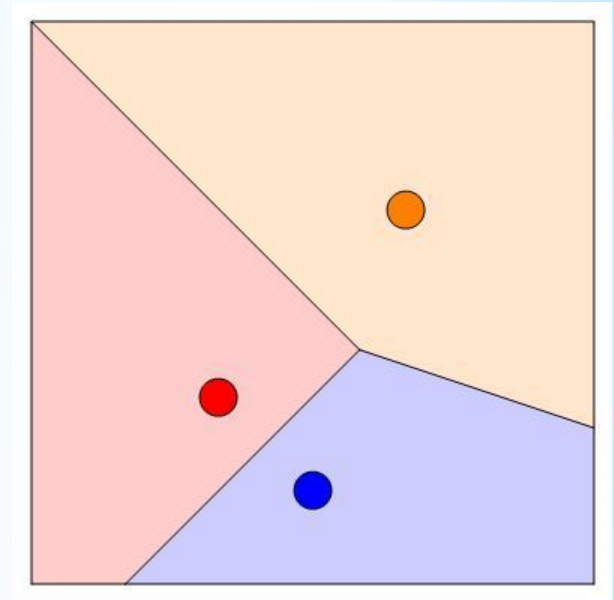
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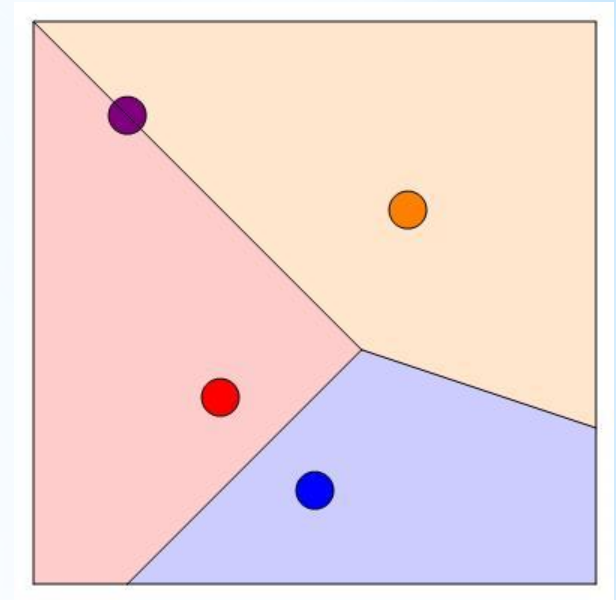
Voronoi Diagrams

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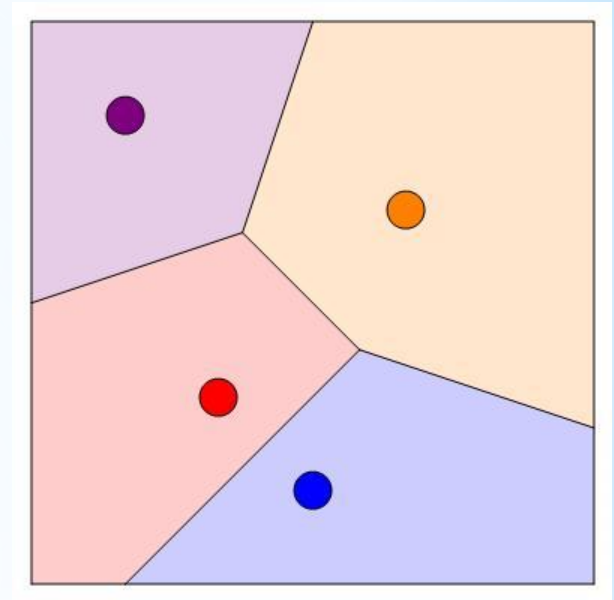
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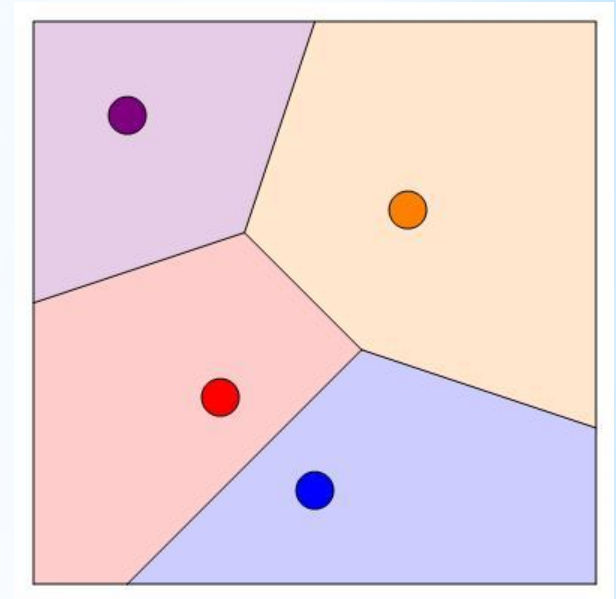
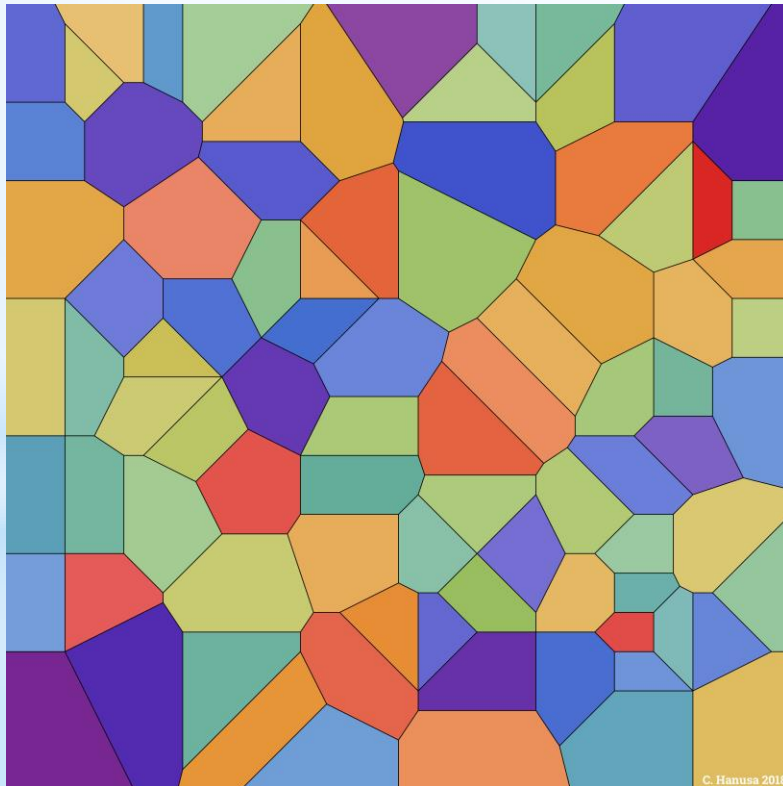
Voronoi Diagrams

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Voronoi Diagrams

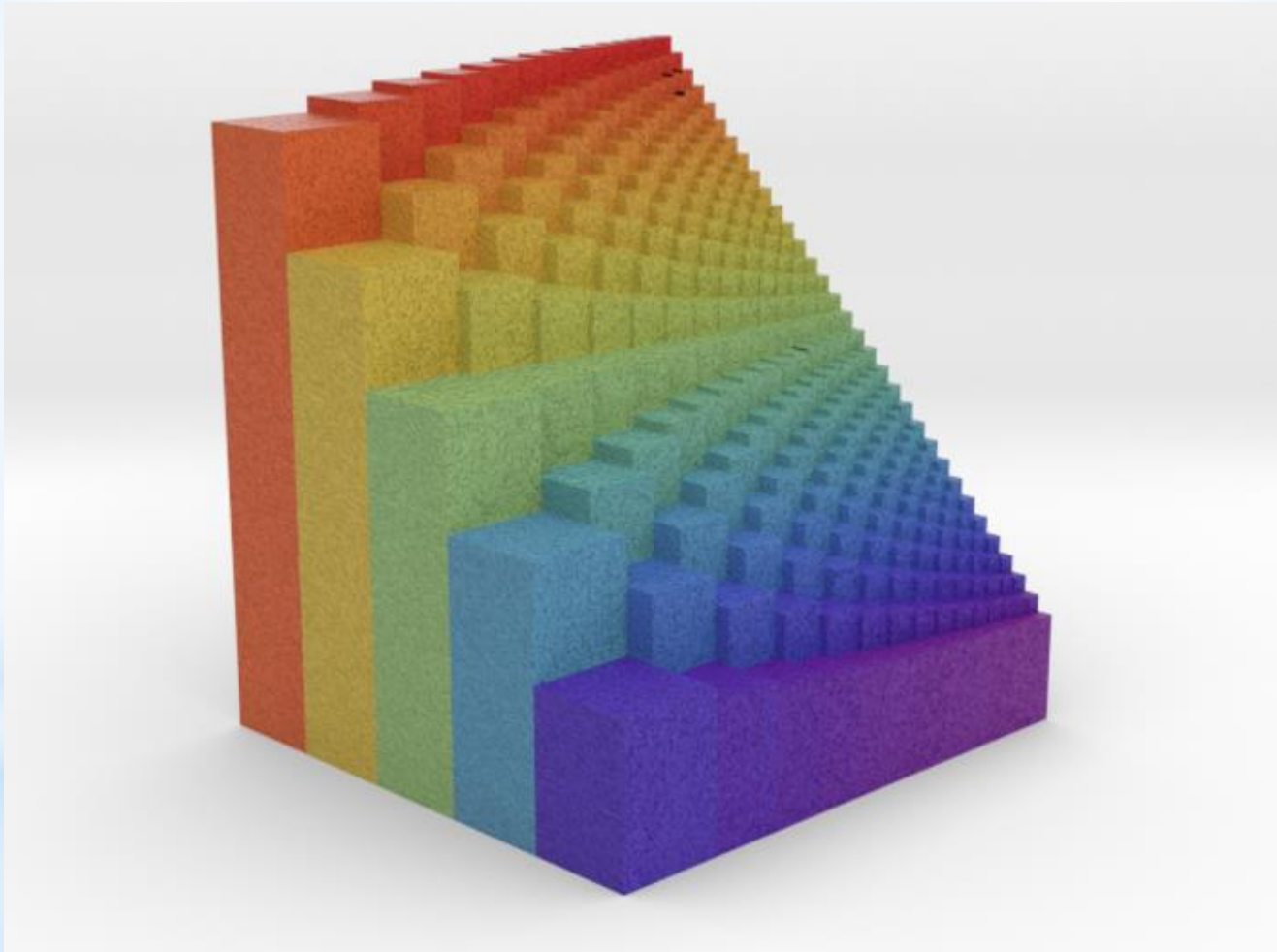
The **Voronoi Diagram** for a **set of points** is the **division of the region** into pieces based on **closeness**.



The New Normal (2017)



Rainbow Staircase (2017)

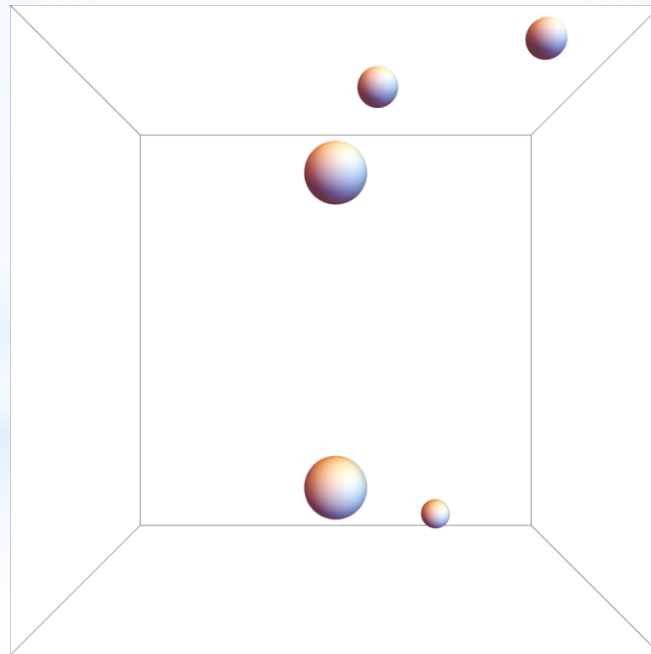
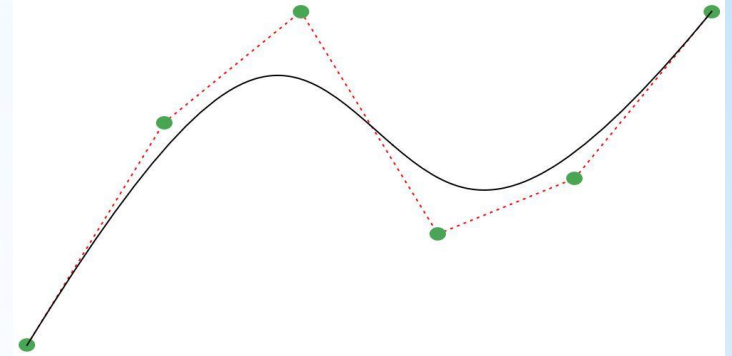


Tortoise Torus (2017)



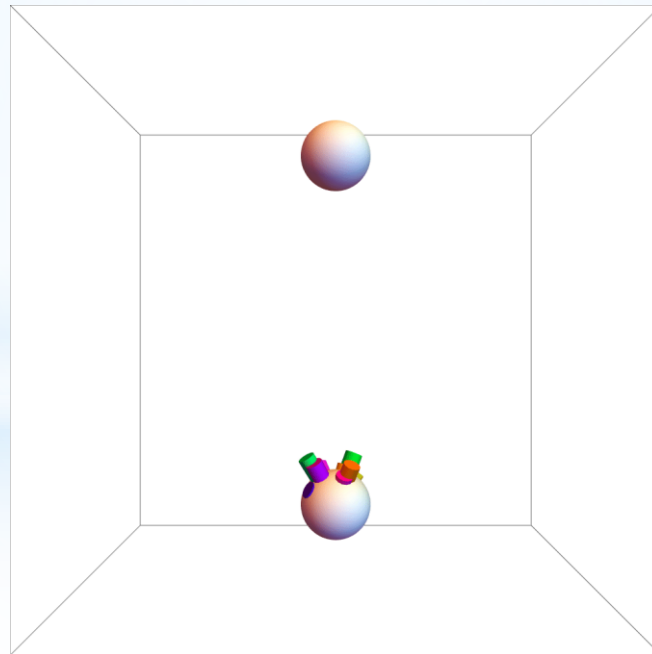
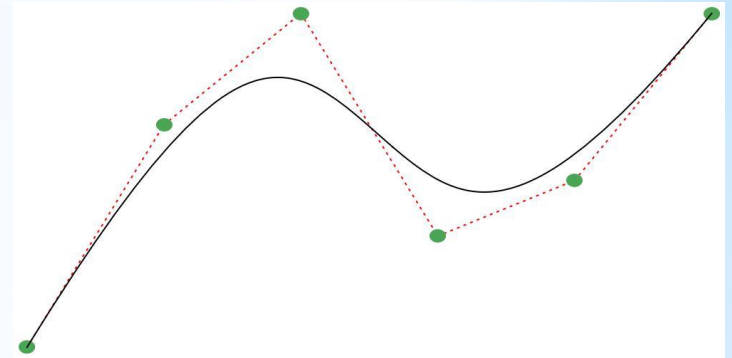
Spaghetti

A **spline** is a **piecewise function** that is a **smooth curve** and approximates given data points.



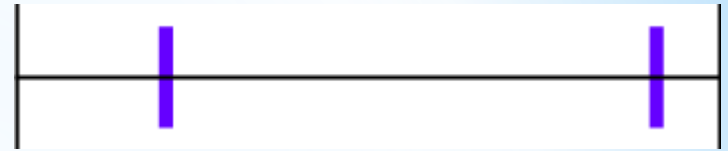
Spaghetti

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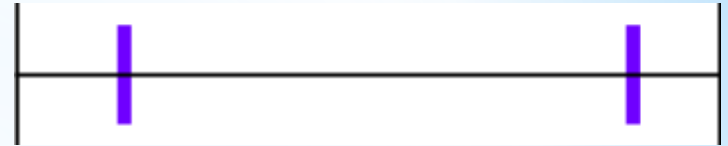
Random Growth

Create blips at random places



Random Growth

Create blips at random places



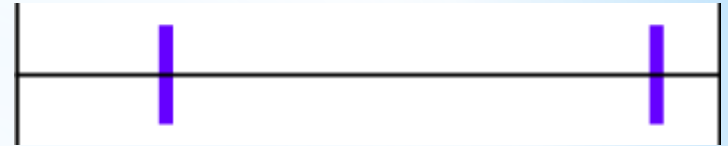
Random Growth

Create blips at random places



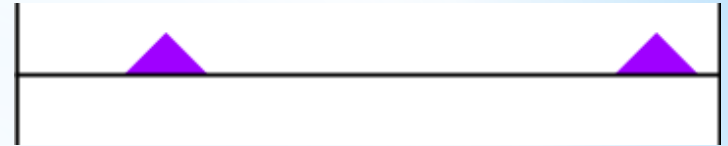
Random Growth

Create blips at random places



Random Growth

Create bumps at random places

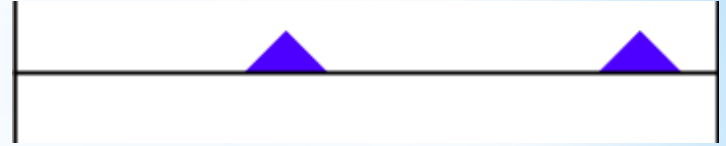


Random Growth

Create bumps at random places



Add bumps together

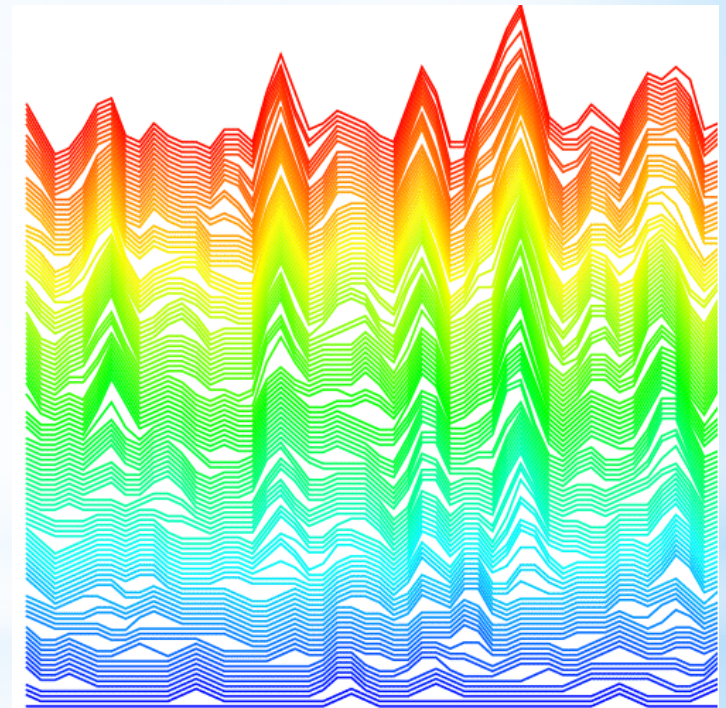
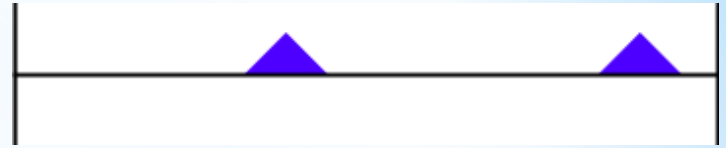


Random Growth

Create bumps at random places

Add bumps together

Wrap around a cylinder

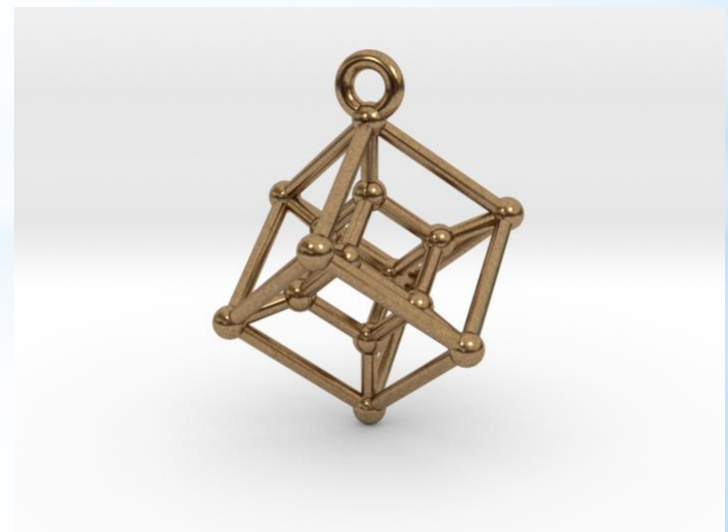
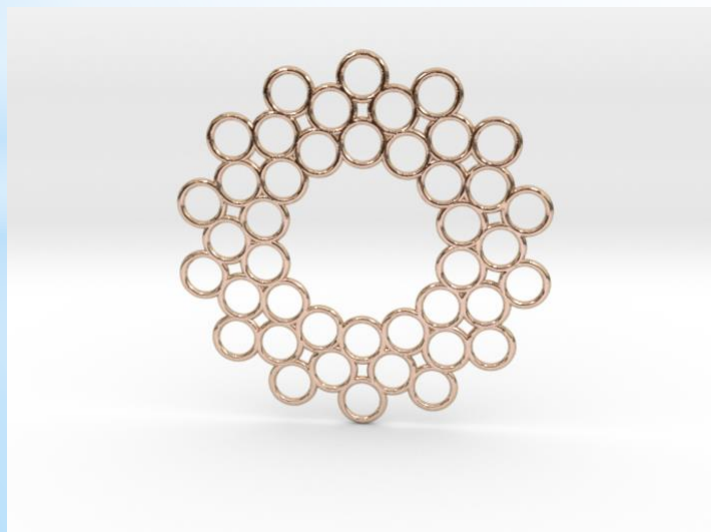


Mathematical Jewelry

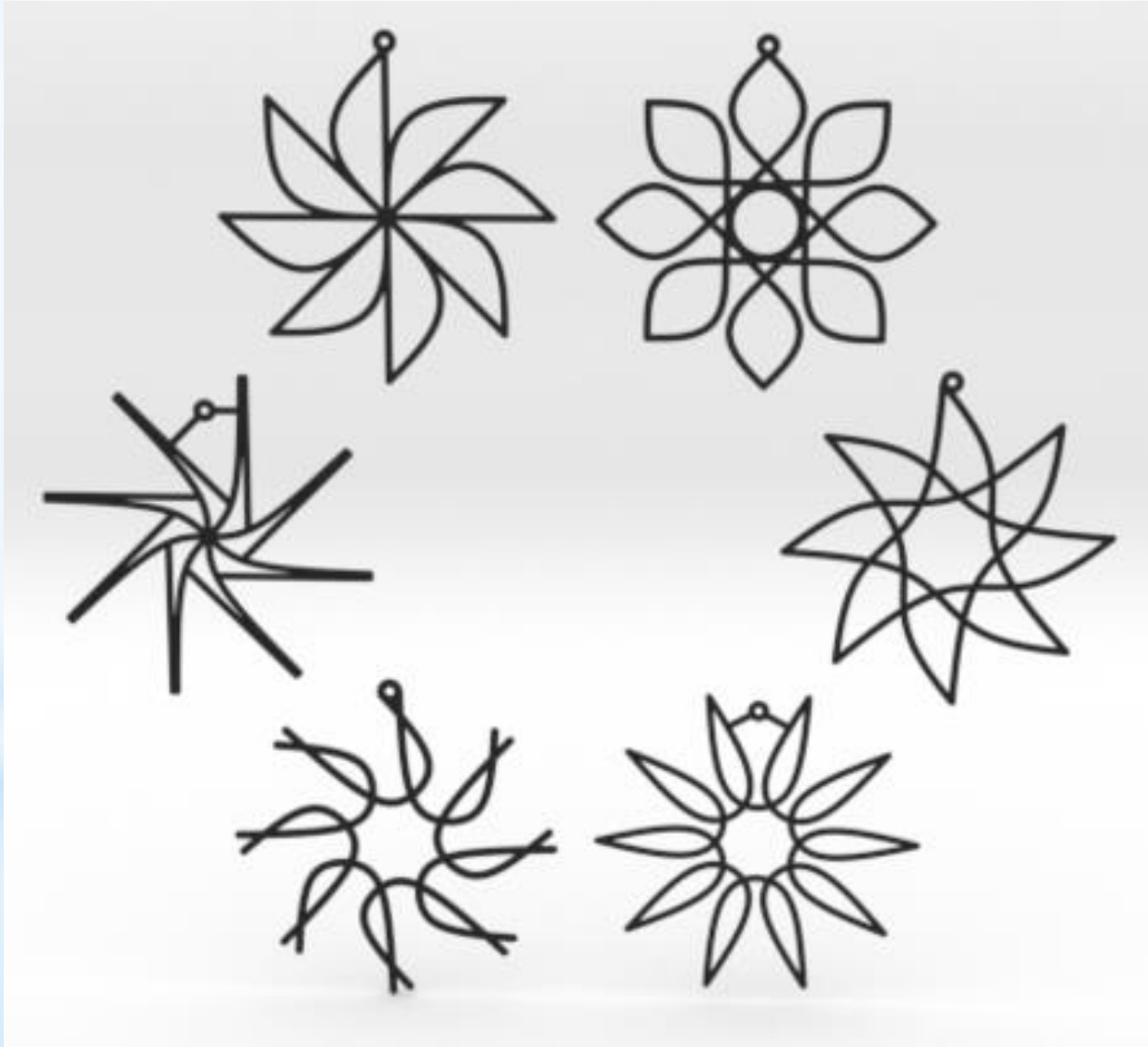
Voronoi Jewelry



Geometric Jewelry



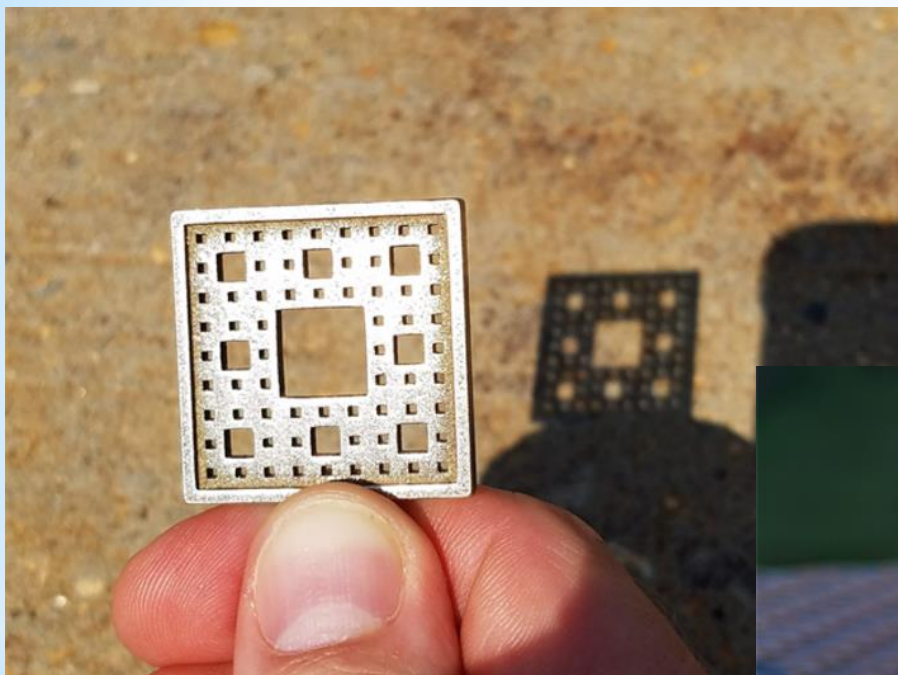
Trigonometry Jewelry



Rotini Earrings



Fractal-inspired



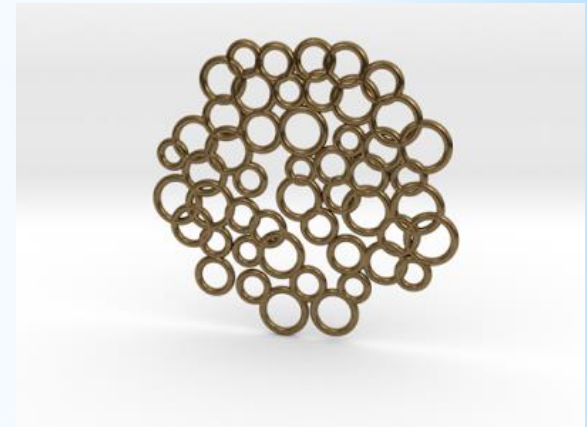
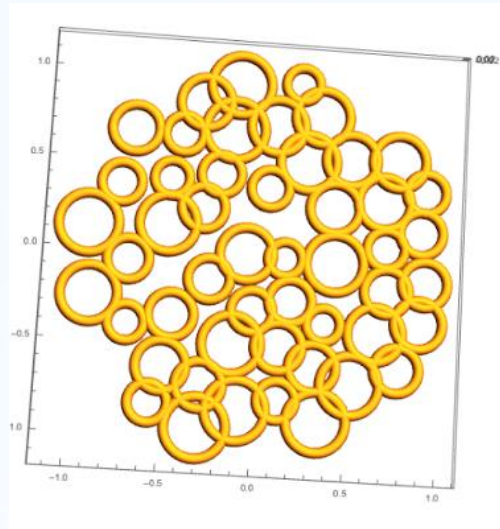
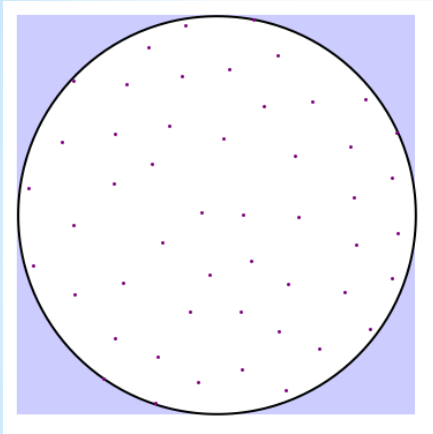
Graph Theory inspired



Golden Ratio inspired



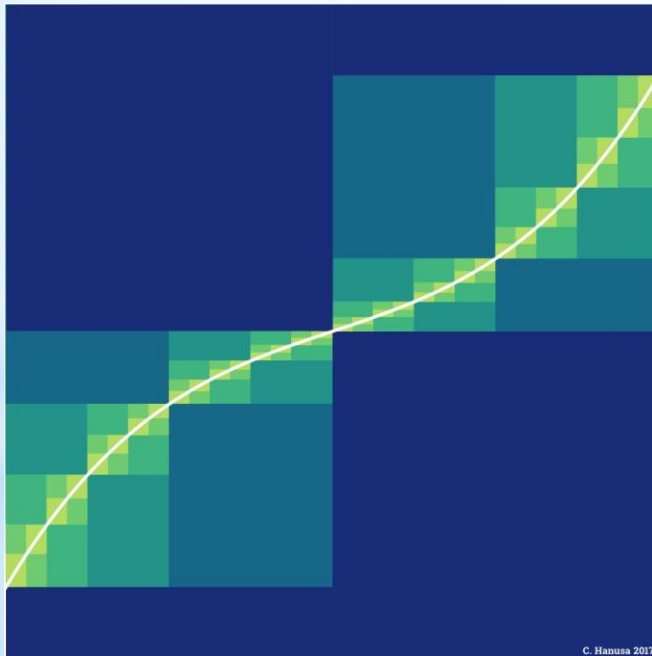
Generative Jewelry



- Choose random points that are not too close
- Choose random size tori
- Export and print on a 3D printer

Thanks! Questions? Real-time Art!?

qc.edu/~chanusa
> Research > Talks



@hanusadesign
hanusadesign.com

Real-time Art

Art that's never
been seen before