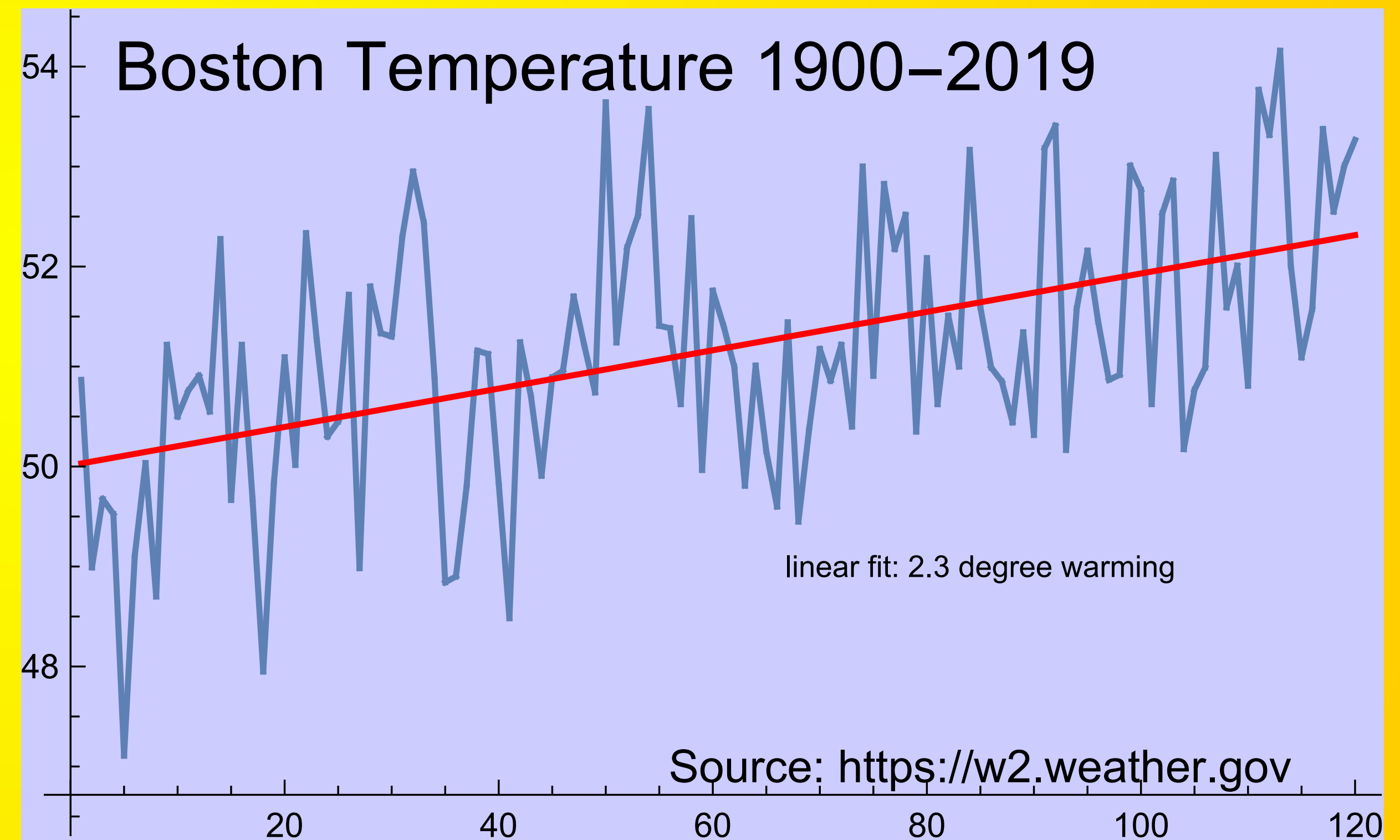


34

Data

```
{2000,27.5,34.2,43.3,47.3,57.2,67.3,70.0,70.3,63.5,53.9,43.8,29.2,50.6},  
{2001,30.0,31.7,35.3,48.7,59.5,71.1,69.9,73.9,65.3,56.2,48.3,40.5,52.5},  
{2002,36.7,36.3,40.2,49.7,57.7,66.5,75.2,75.2,68.4,52.4,42.9,33.1,52.9},  
{2003,24.1,26.3,37.6,44.5,55.1,65.4,74.3,74.2,65.7,53.0,45.9,36.0,50.2},  
{2004,20.7,33.0,39.4,49.5,58.8,66.5,71.0,72.0,65.2,53.8,44.3,35.0,50.8},  
{2005,26.7,31.1,35.2,49.7,52.2,68.3,73.3,74.4,67.9,54.7,45.9,32.5,51.0},  
{2006,36.5,31.0,38.7,49.8,57.0,68.1,75.9,71.4,64.6,54.3,49.1,41.0,53.1},  
{2007,32.7,26.1,37.4,45.2,61.4,68.5,72.9,72.7,67.6,59.2,43.0,32.4,51.6},  
{2008,33.4,32.5,38.2,49.3,57.7,70.3,75.0,70.0,65.3,53.3,43.4,35.7,52.0},  
{2009,24.8,32.9,37.5,50.5,59.5,63.3,70.5,73.6,63.2,51.9,48.8,33.2,50.8},  
{2010,29.6,33.2,43.9,53.0,62.8,70.3,77.2,73.4,68.7,55.6,44.8,32.7,53.8},  
{2011,27.6,30.5,38.9,50.1,59.2,67.1,77.3,73.9,67.3,57.5,50.4,40.0,53.3},  
{2012,34.1,37.3,46.7,53.1,60.3,66.8,75.3,74.6,64.7,56.5,42.1,38.4,54.2},  
{2013,31.5,31.1,37.7,48.9,58.8,69.6,77.1,72.1,64.7,56.6,42.7,33.3,52.0},  
{2014,27.4,28.9,33.5,48.1,58.7,68.3,74.1,70.8,66.2,56.4,42.5,38.2,51.1},  
{2015,26.1,19.0,33.2,48.0,62.3,64.7,73.9,74.6,69.2,54.0,48.6,45.3,51.6},  
{2016,32.5,34.7,42.5,47.1,58.6,68.4,76.1,76.4,67.5,55.3,46.2,35.2,53.4},  
{2017,35.1,36.6,34.0,51.7,56.3,69.5,72.5,72.0,67.1,61.4,43.7,30.7,52.6},  
{2018,28.6,38.1,37.2,45.3,62.1,67.7,76.1,77.4,69.0,54.4,42.9,37.3,53.0},  
{2019,30.7,33.5,39.1,51.7,57.8,68.2,78.7,74.1,68.0,57.4,42.8,37.2,53.3}
```



PLAN

1. Poll

2. Data examples

3. Models

4) Presentation of data

5. Benford's law

6. Beyond 1A

POLL

Which was your favorite data story ?

1) Primes

2) Polyhedra

3) Chaos

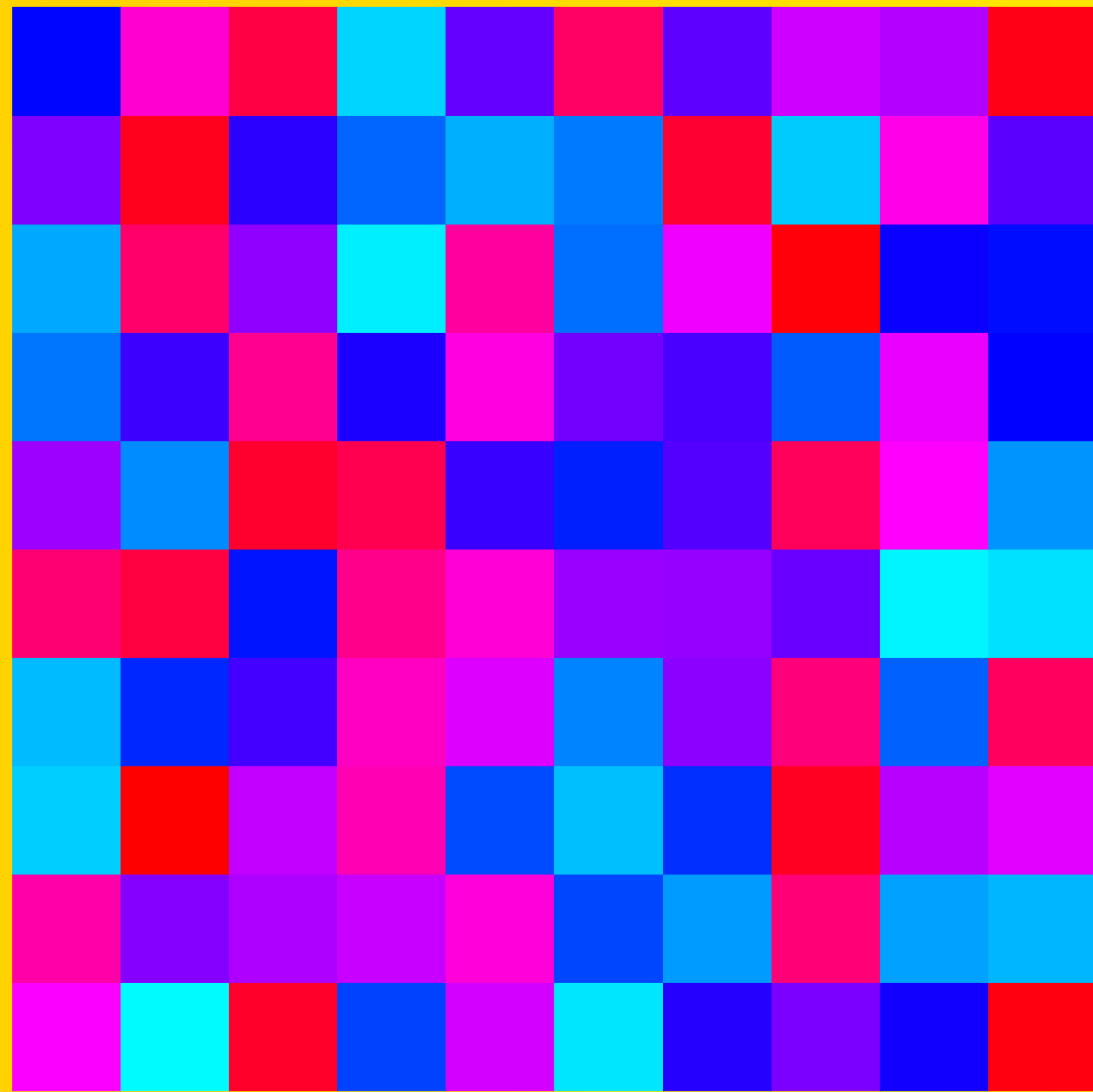
4) Beyond 1A

Reminder:

data project is due today

A) What are data?

Turing's picture



also multi-dimensional data can be written down as a string of numbers and eventually to a sequence of 0 or 1s



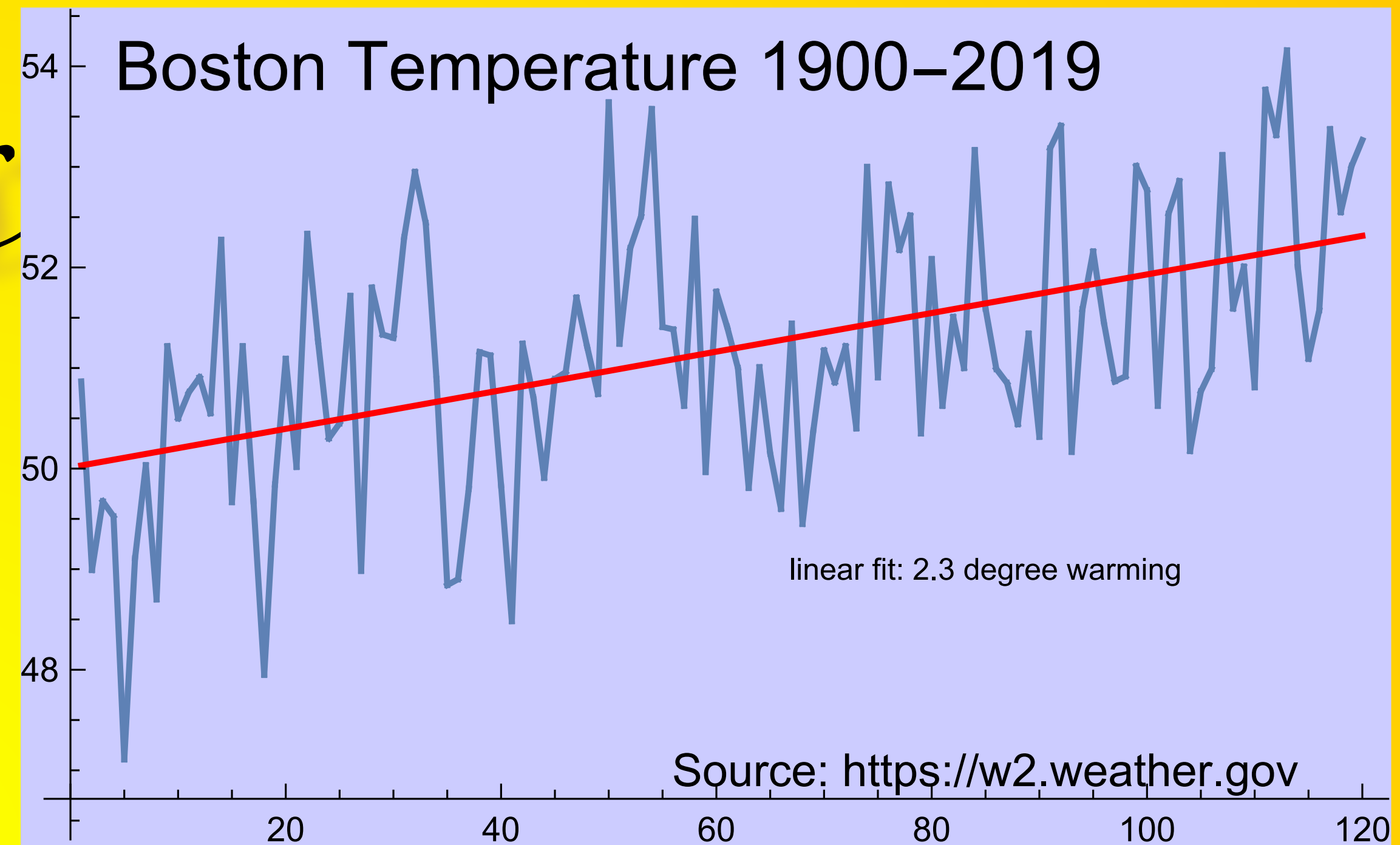
0

$n = 10^{13}$ for a TByte of data

n

Examples of data

1. Temperatures



National Weather Service Forecast Office
Boston, MA

Home News Organization

Local forecast by "City, St"
City, St Go

More Information
Our Main Webpage
Local Data / Records
Ask Questions

USA.gov
Government Made Easy

Observed Weather | Climate Locations | Climate Prediction | Climate Resources | Local Data/Records | Astronomical | NOWData

NOWData - NOAA Online Weather Data

1. Location » View map Boston Area Hartford Area Milton Area Providence Area Worcester Area Westfield Area Amherst COOP, MA Ashburnham COOP, MA Ashburnham N COOP, Barre Falls COOP, MA	2. Product » <input type="radio"/> Daily data for a month <input type="radio"/> Daily almanac <input checked="" type="radio"/> Monthly summarized data <input type="radio"/> Calendar day summaries <input type="radio"/> Daily/monthly normals <input type="radio"/> Climatology for a day <input type="radio"/> First/last dates <input type="radio"/> Temperature graphs <input type="radio"/> Accumulation graphs	3. Options » Year range: <input type="text" value="1900"/> - <input type="text" value="2020"/> Variable: <input type="text" value="Avg temp"/> Summary: <input type="text" value="Mean"/>	4. View » <input type="button" value="Go"/>
---	---	---	---

Product Description:
MONTHLY SUMMARIZED DATA - calculates averages, totals, daily extremes or frequencies for the selected variable for each month of the year for the selected range of years. Note: trace precipitation/snowfall/snow depth amounts are treated as zero in sums, mean, and number of days counts. Annual average temperatures are the average of the twelve monthly values. Temperatures are reported in degrees F; precipitation,

[- Common questions -](#)
[- Submit a question/comment -](#)

Powered by **ACIS**
NOAA Regional Climate Centers

The Applied Climate Information System (ACIS) is a joint project of the Regional Climate Centers, the National Centers for Environmental Information (NCEI) and the National Weather Service. Official data and data for additional locations are available from the Regional Climate Centers and NCEI.

120 years
of average
temperatures with best
linear fit.



National Weather Service Forecast Office

Boston, MA

[Home](#)[News](#)[Organization](#)[Search](#)

Local forecast by
"City, St"

[More Information](#)
[Our Main Webpage](#)
[Local Data /
Records](#)
[Ask Questions](#)

[Observed
Weather](#)[Climate
Locations](#)[Climate
Prediction](#)[Climate
Resources](#)[Local
Data/Records](#)[Astronomical](#)[NOWData](#)

NOWData - NOAA Online Weather Data

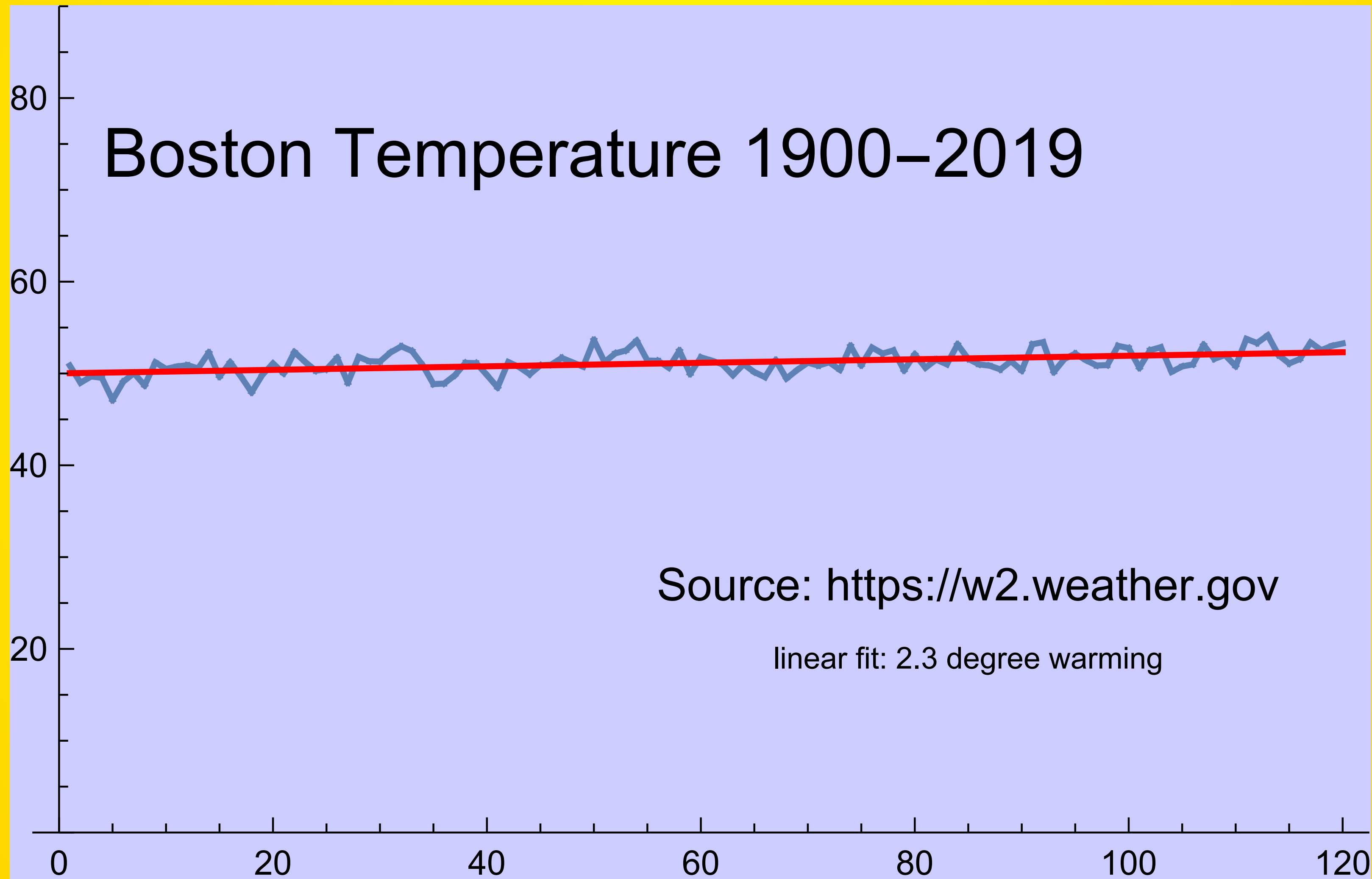
[Enlarge results](#)[Print](#)

Monthly Mean Avg Temperature for Boston Area, MA (ThreadEx)

Click column heading to sort ascending, click again to sort descending.

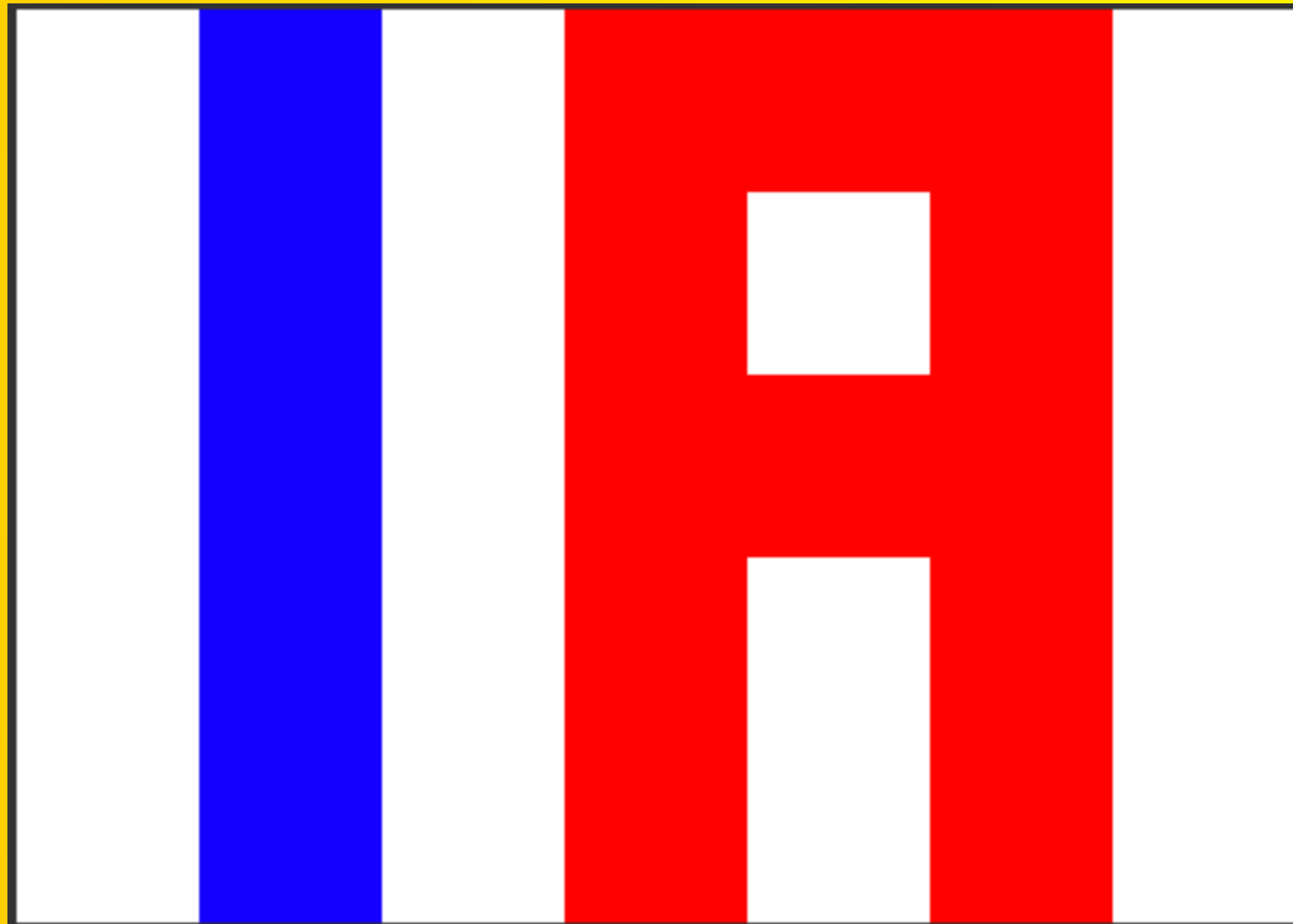
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1900	30.1	29.3	34.0	48.5	55.2	68.6	73.9	71.1	64.9	56.6	44.7	33.5	50.9
1901	27.6	24.3	36.2	43.5	54.3	68.2	73.5	70.7	65.4	54.4	37.3	32.5	49.0
1902	26.9	28.9	43.3	48.4	57.8	64.3	67.9	67.6	62.6	53.6	46.2	28.6	49.7
1903	28.6	31.4	44.4	47.9	58.5	59.8	71.4	65.0	64.4	53.9	40.0	29.0	49.5
1904	21.5	22.6	34.5	44.7	60.9	64.0	71.4	68.7	62.5	50.5	38.2	25.8	47.1
1905	25.1	23.4	37.1	46.8	57.6	65.2	73.2	68.6	62.0	53.6	41.6	35.1	49.1
1906	36.4	29.7	32.3	47.2	58.0	66.4	70.1	72.0	65.0	52.5	41.7	29.1	50.0
1907	27.0	21.7	37.0	43.4	52.5	65.1	72.4	69.7	64.4	49.8	43.3	37.2	48.7

Presentation matters!



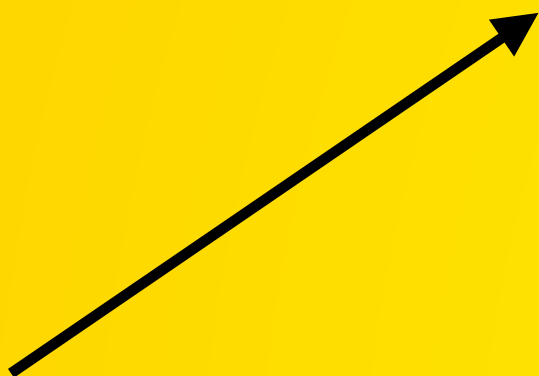
2. Pictures:

7 x 5 pixels
Each pixel has a red,
green and blue value
between 0 and 255
(3 Bytes per pixel)



```
knill — vi 1a.ppm — 62x16
P3
# CREATOR: XV version 3.10a-jumboFix+Enh of 20050501
# Created by GIMP version 2.10.8 PNM plug-in
7 5
255
255 255 255 0 0 255 255 255 255 255 0 0 255 0 0
255 0 0 255 255 255 255 255 255 0 0 255 255 255 255
255 0 0 255 255 255 255 0 0 255 255 255 255 255 255
0 0 255 255 255 255 255 0 0 255 0 0 255 0 0
255 255 255 255 255 255 0 0 255 255 255 255 255 0 0
255 255 255 255 0 0 255 255 255 255 255 255 0 0 255
255 255 255 255 0 0 255 255 255 255 0 0 255 255 255
~
~
```

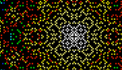
```
knill — vi 1a.ppm — 62x16
P3
# CREATOR: XV version 3.10a-jumboFix+Enh of 20050501
# Created by GIMP version 2.10.8 PNM plug-in
35 1
255
255 255 255 0 0 255 255 255 255 255 0 0 255 0 0
255 0 0 255 255 255 255 255 255 0 0 255 255 255 255
255 0 0 255 255 255 255 0 0 255 255 255 255 255 255
0 0 255 255 255 255 255 0 0 255 0 0 255 0 0
255 255 255 255 255 255 0 0 255 255 255 255 255 0 0
255 255 255 255 0 0 255 255 255 255 255 255 0 0 255
255 255 255 255 0 0 255 255 255 255 0 0 255 255 255
~
```



Now we have a one dimensional function

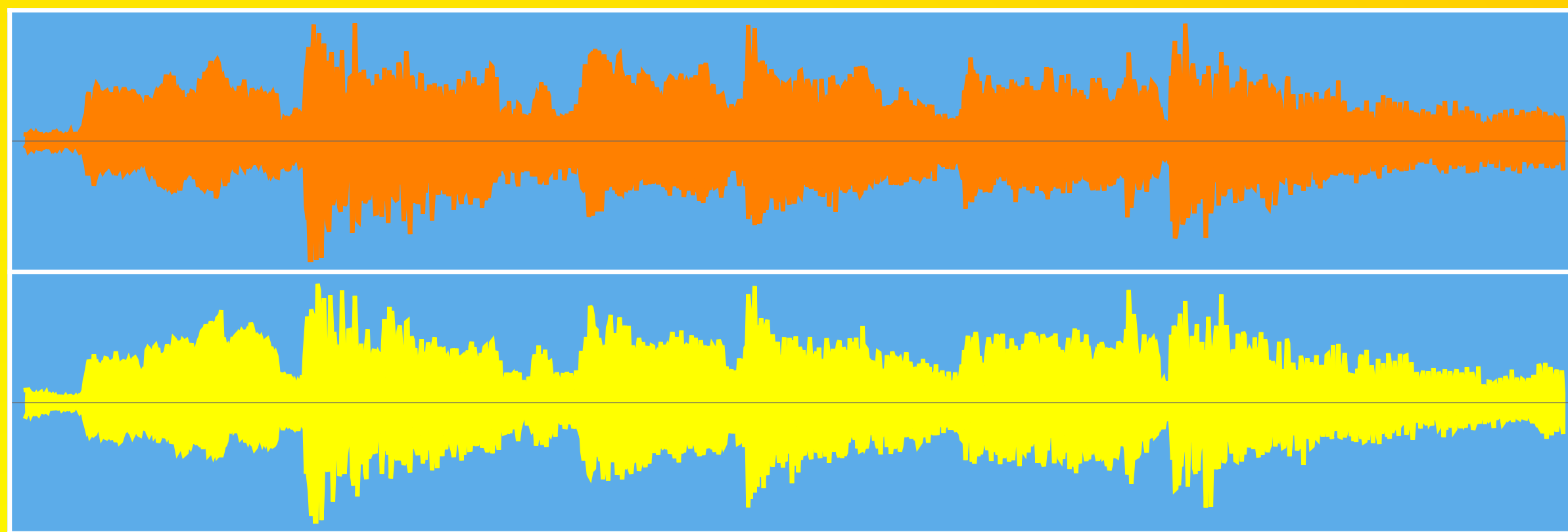


In the Homework



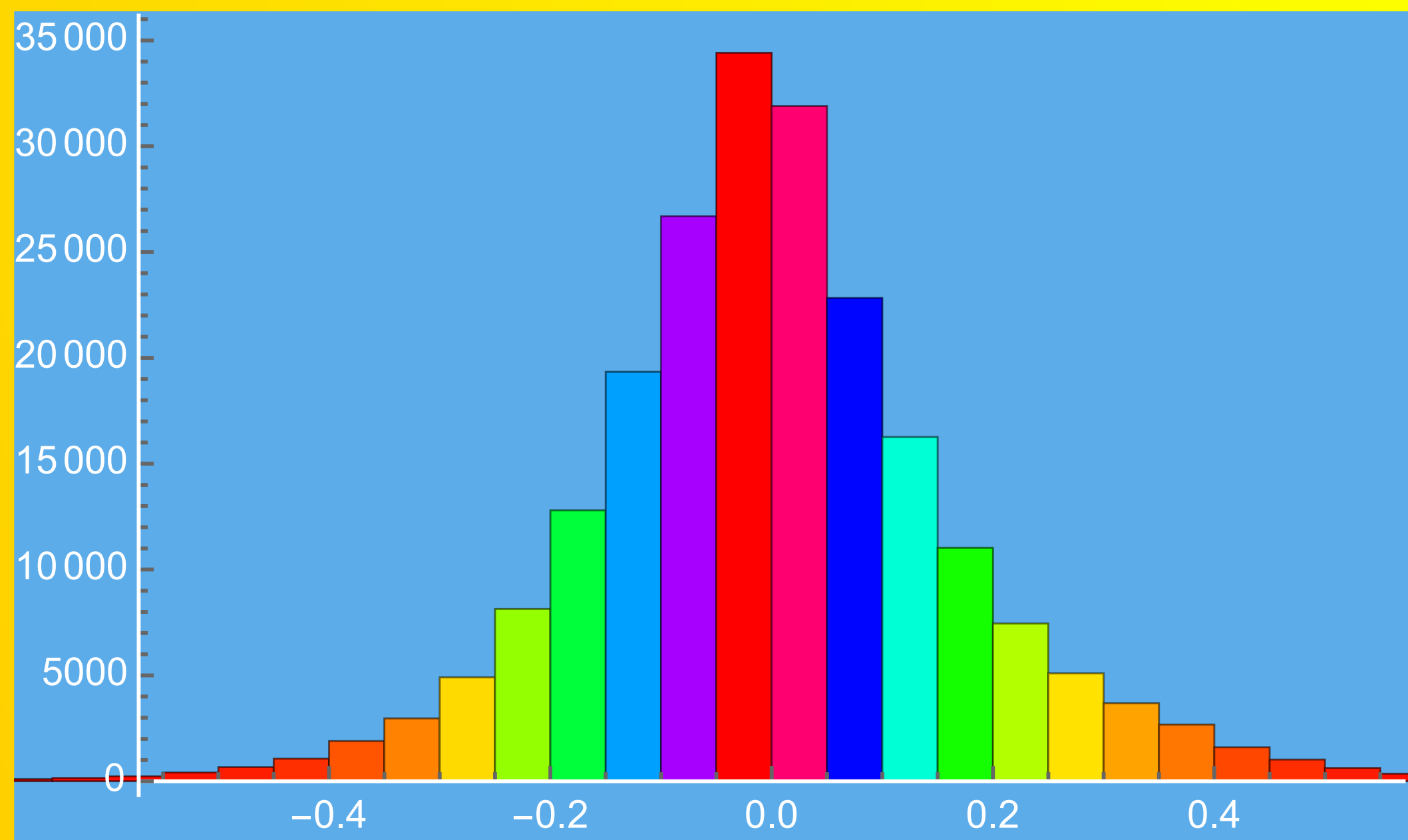
Gaussian
Primes.
Written directly as
a .PPM file

3. Music

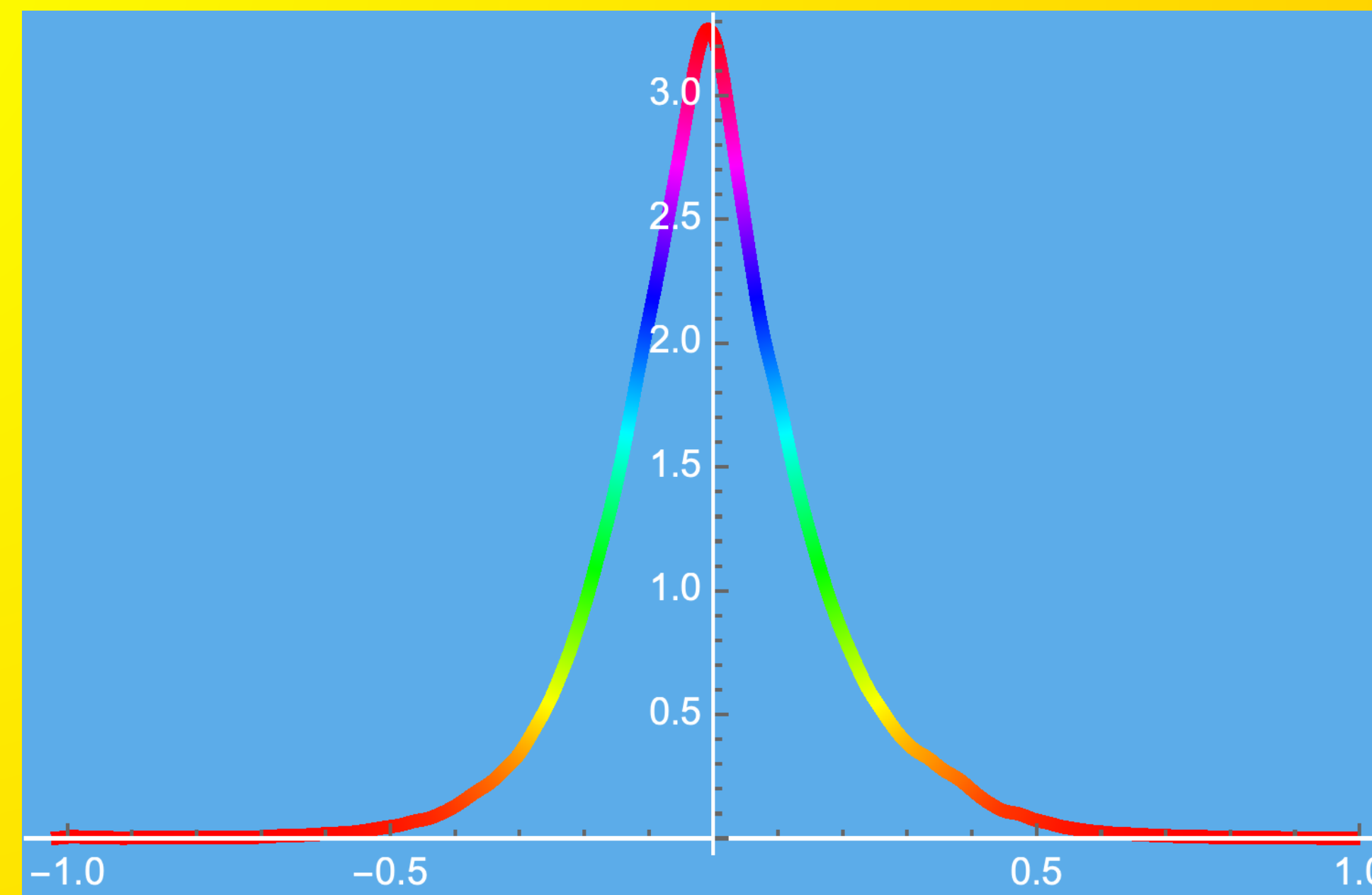


```
L=First[AudioData[A]]
```

```
Histogram[L]
```



```
SmoothHistogram[L]
```



4. Movies

183600 frames

Samsara, 2011



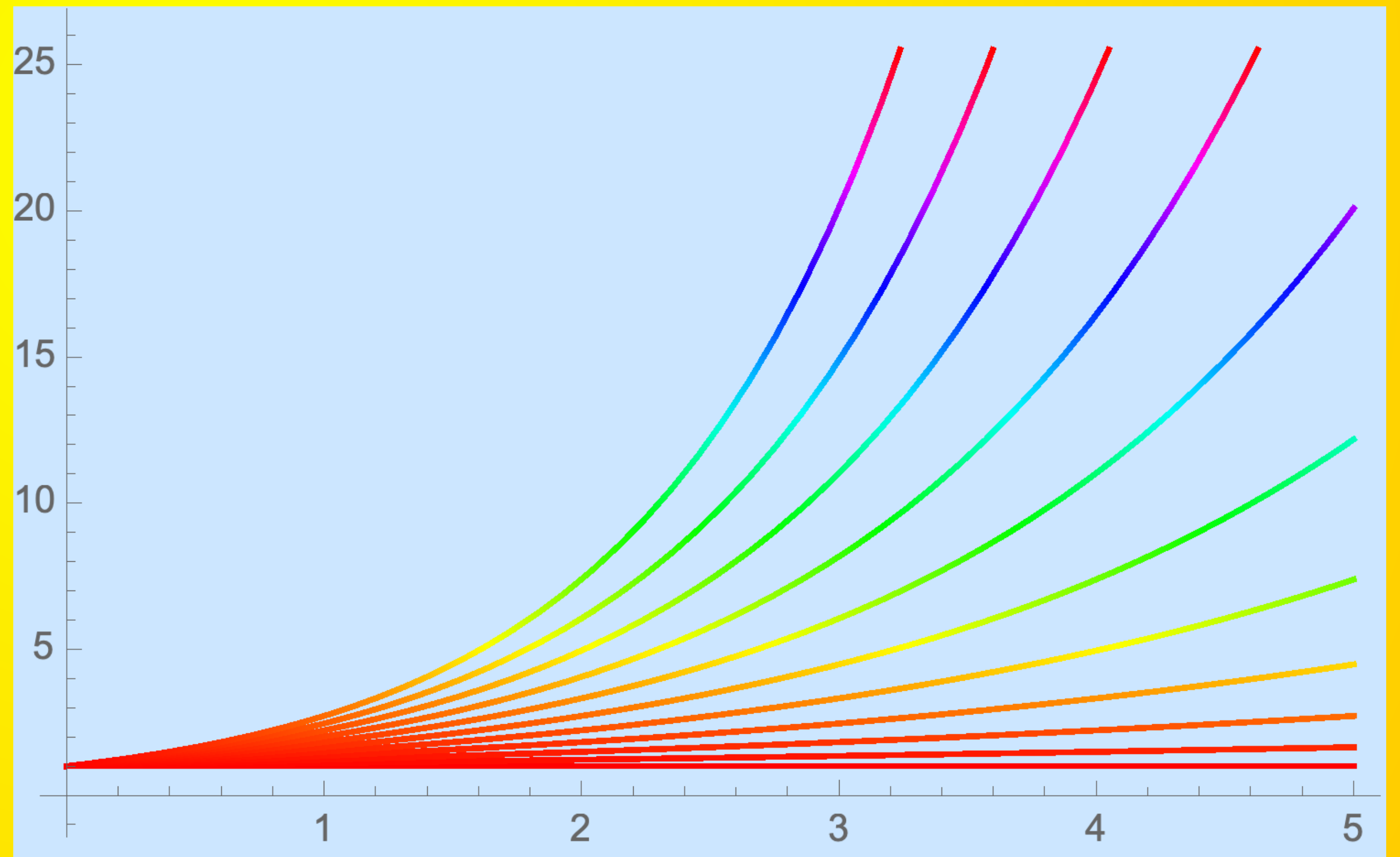
480x854 matrix, each pixel has 24 Bit



B) Models

Example: exp. growth

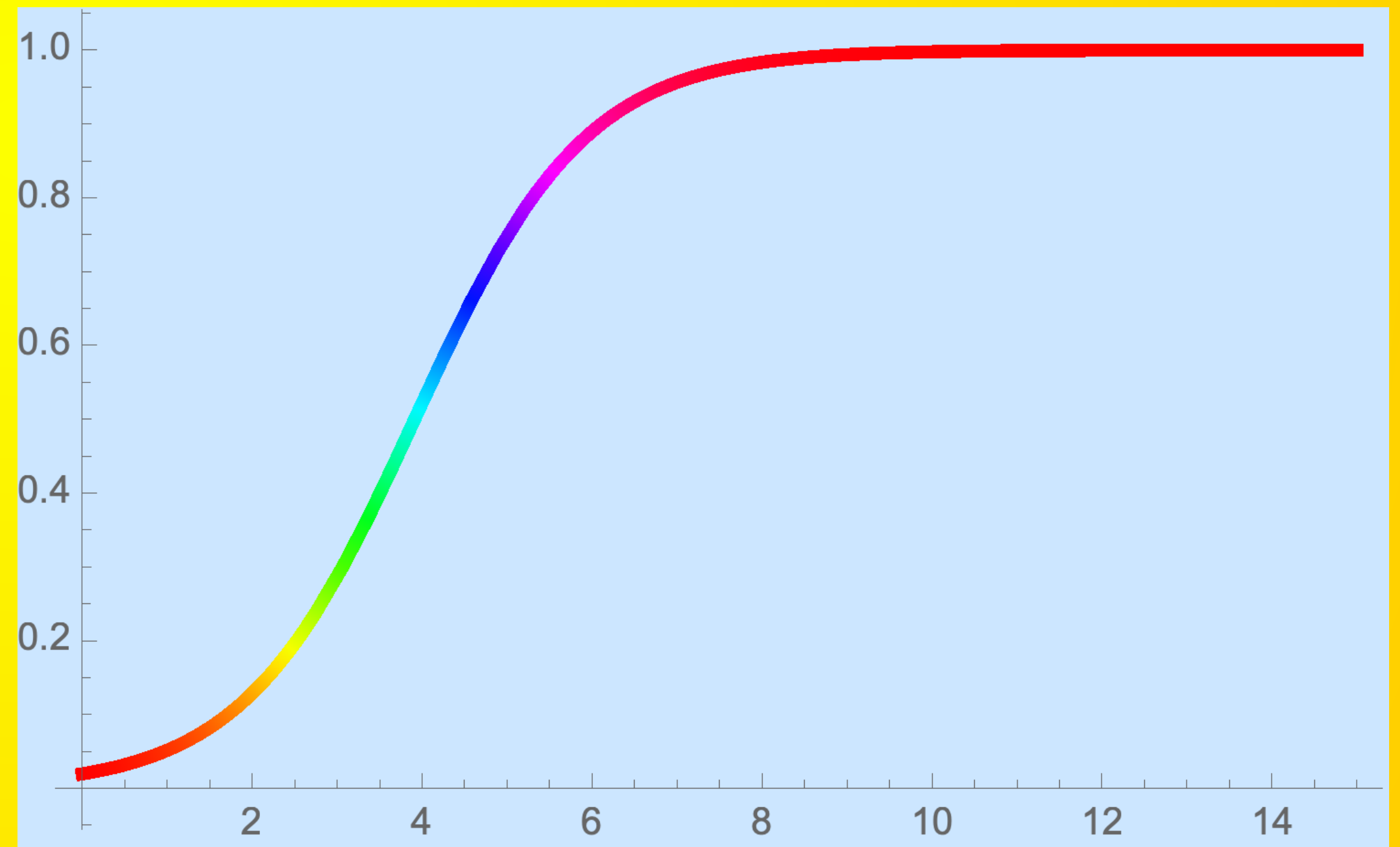
$$f(t) = Ce^{at}$$



In the Homework:

Logistic growth

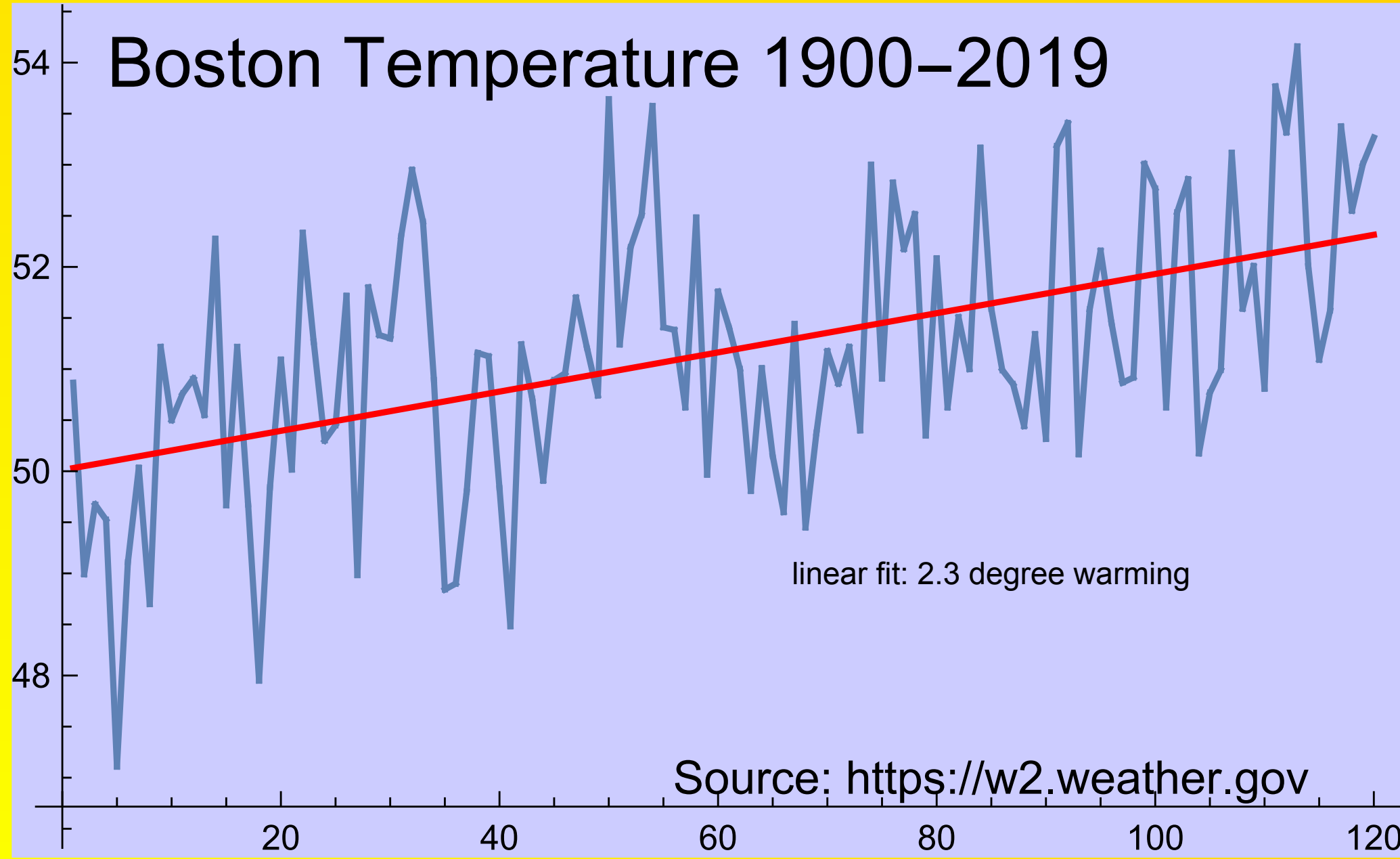
$$f(t) = \frac{e^{ct}}{A + e^{ct}}$$



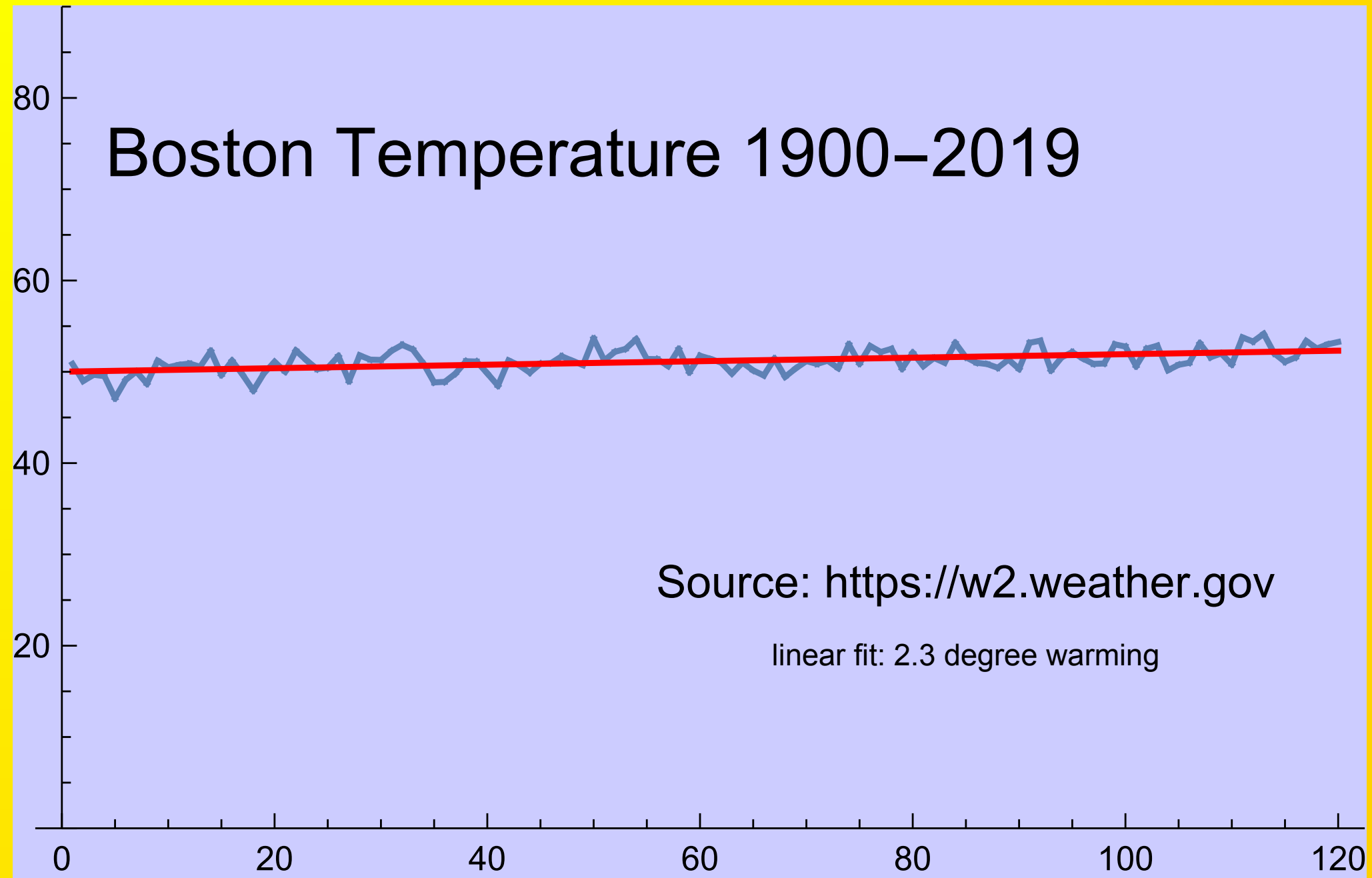
`DSolve[f'[t] == c f[t] (b - a f[t]), f[t], t]`

C) Presentation

dramatic
climate
change



no significant
increase

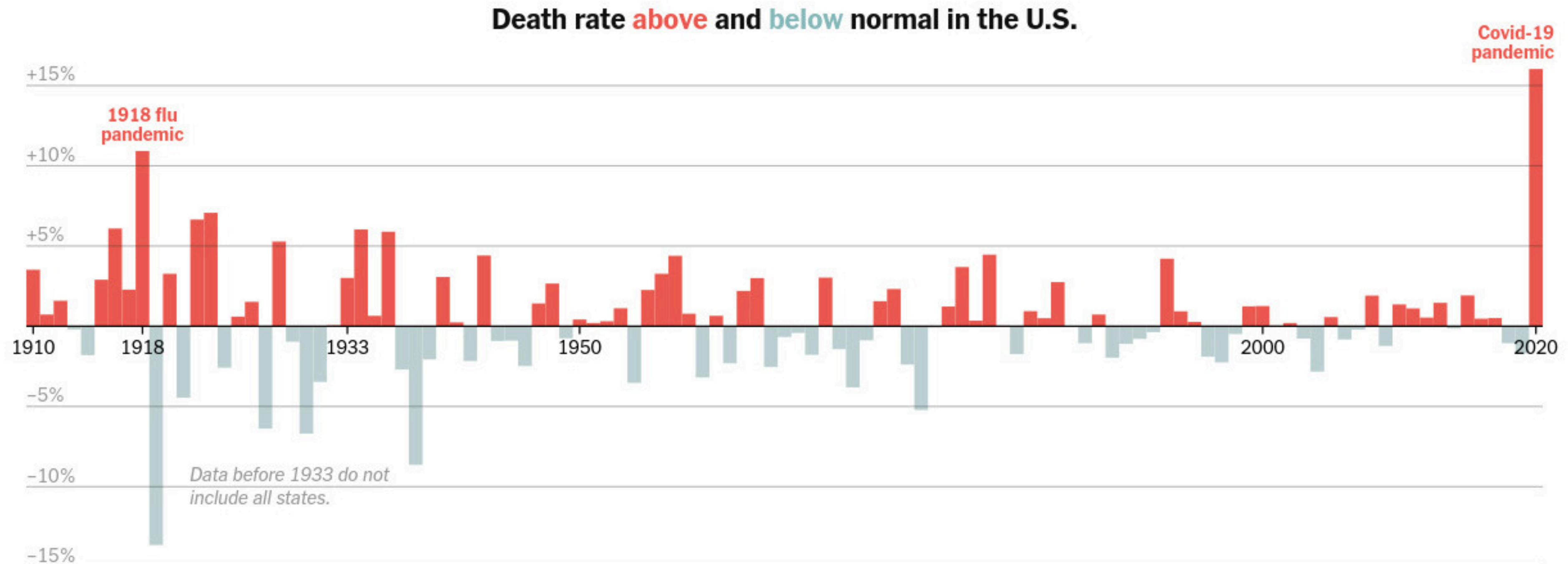


just
appeared
today

How Covid Upended a Century of Patterns in U.S. Deaths

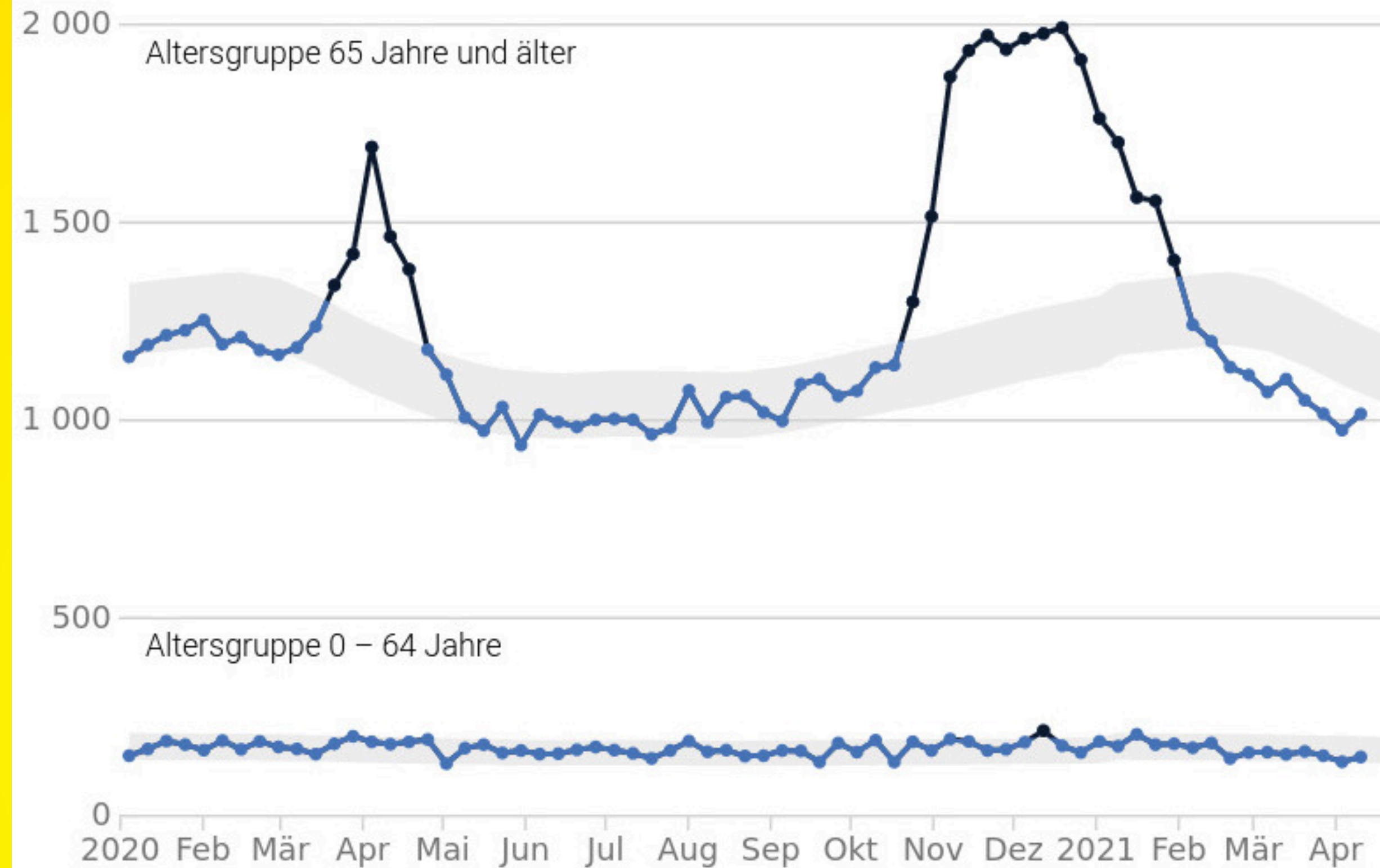
By Denise Lu April 23, 2021

The U.S. death rate in 2020 was the highest above normal ever recorded in the country — even surpassing the calamity of the 1918 flu pandemic.



Switzerland

Anzahl Todesfälle pro Kalenderwoche



■ Obere und untere Grenze des statistisch zu erwartenden Werts

● Anzahl Todesfälle (Hochrechnung)

Die Anzahl Todesfälle wird anhand der bis zum Vortag gemeldeten Fälle für die aktuelle Periode hochgerechnet, unter Berücksichtigung der zeitlichen Verzögerung für die Erstattung einer Meldung.

Die Daten der letzten zwei Wochen sind teilweise unvollständig, es werden noch Nachmeldungen erwartet.

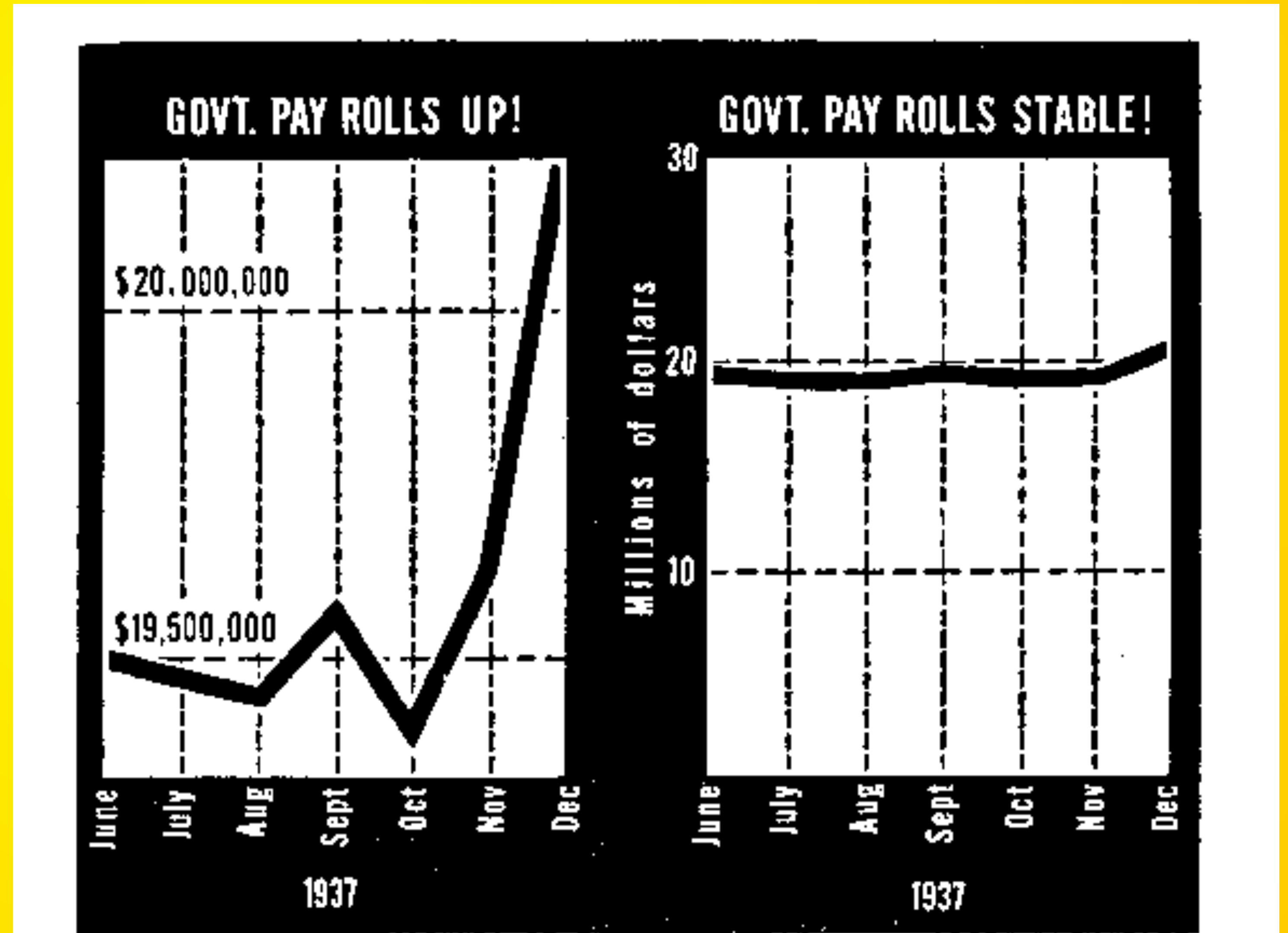
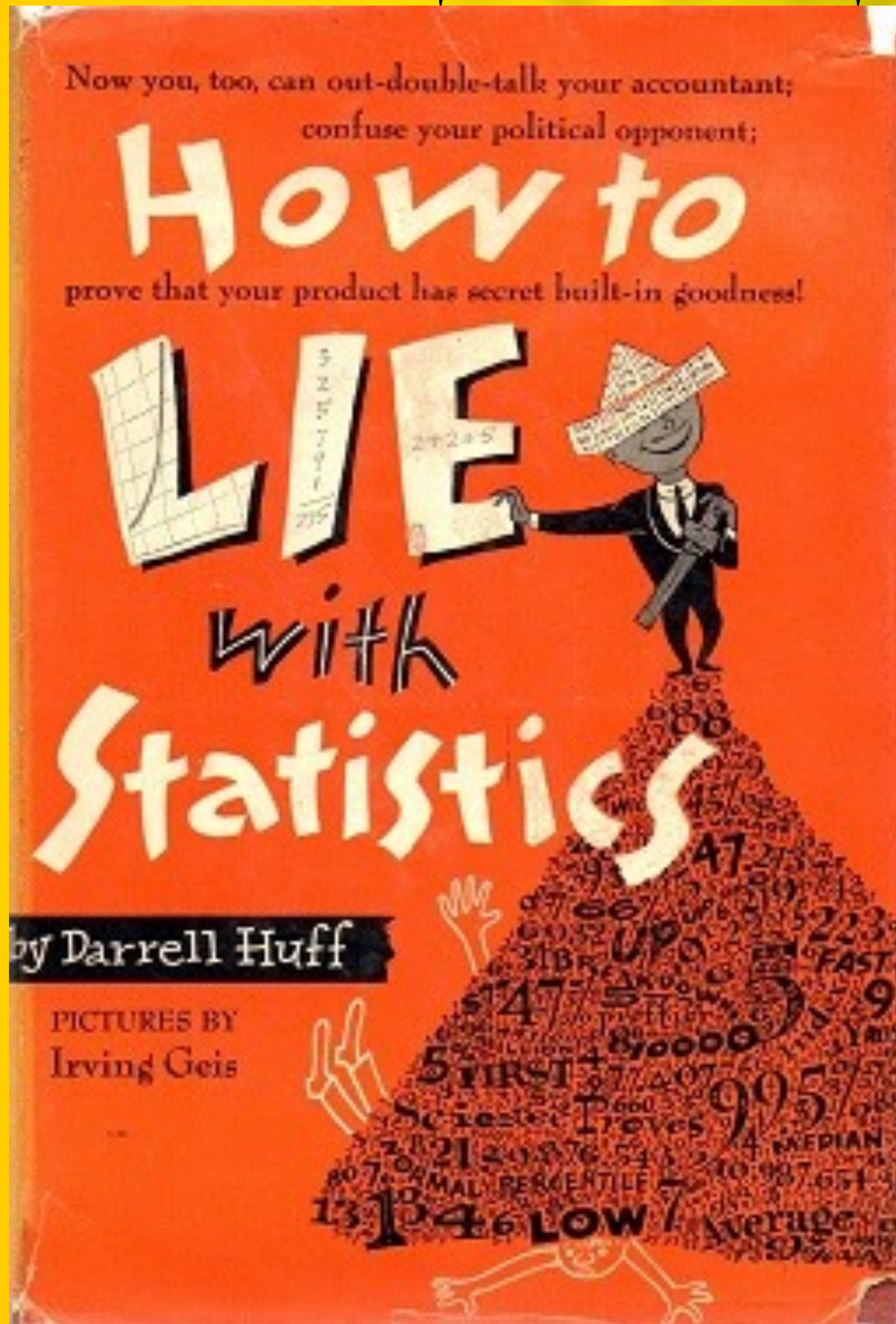
Stand der Datenbank: 19.04.2021

1954

Darrell Huff

1913-2001

A CLASSIC BOOK



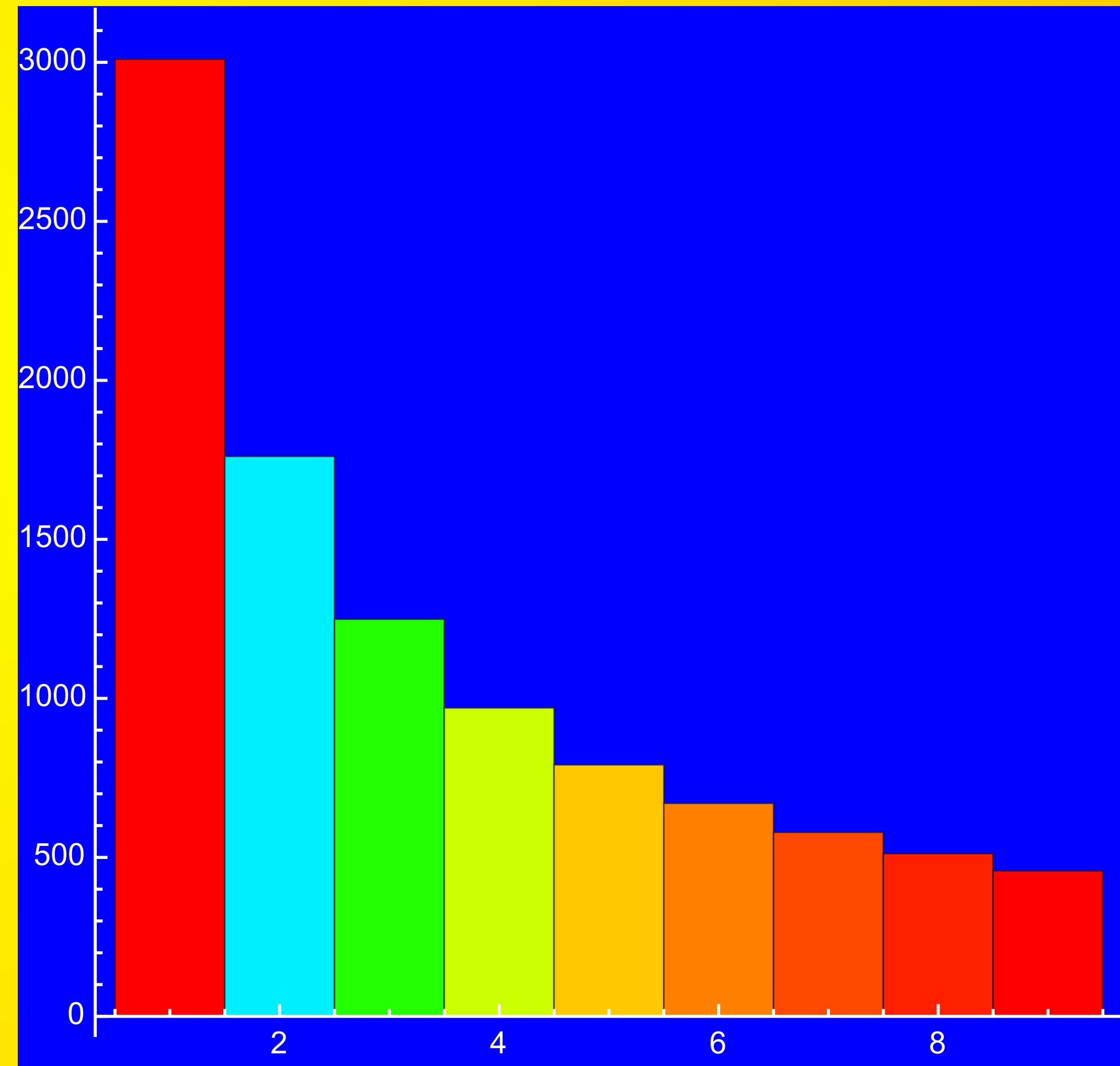
D) Benford's law

An experiment:

*2, 4, 8, 16, 32, 64, 128, 256, 512,
1024, 2048, 4096, 8192,
16384, 32768, 65536, 131072,
262144, 524288, 1048576, 2097152,
4194304, 8388608, 16777216,
33554432, 67108864, 134217728,
268435456, 536870912, 1073741824*

An experiment:

```
Histogram[  
  Table[First[IntegerDigits[2^n]],  
  {n, 1, 10000}], 10]
```

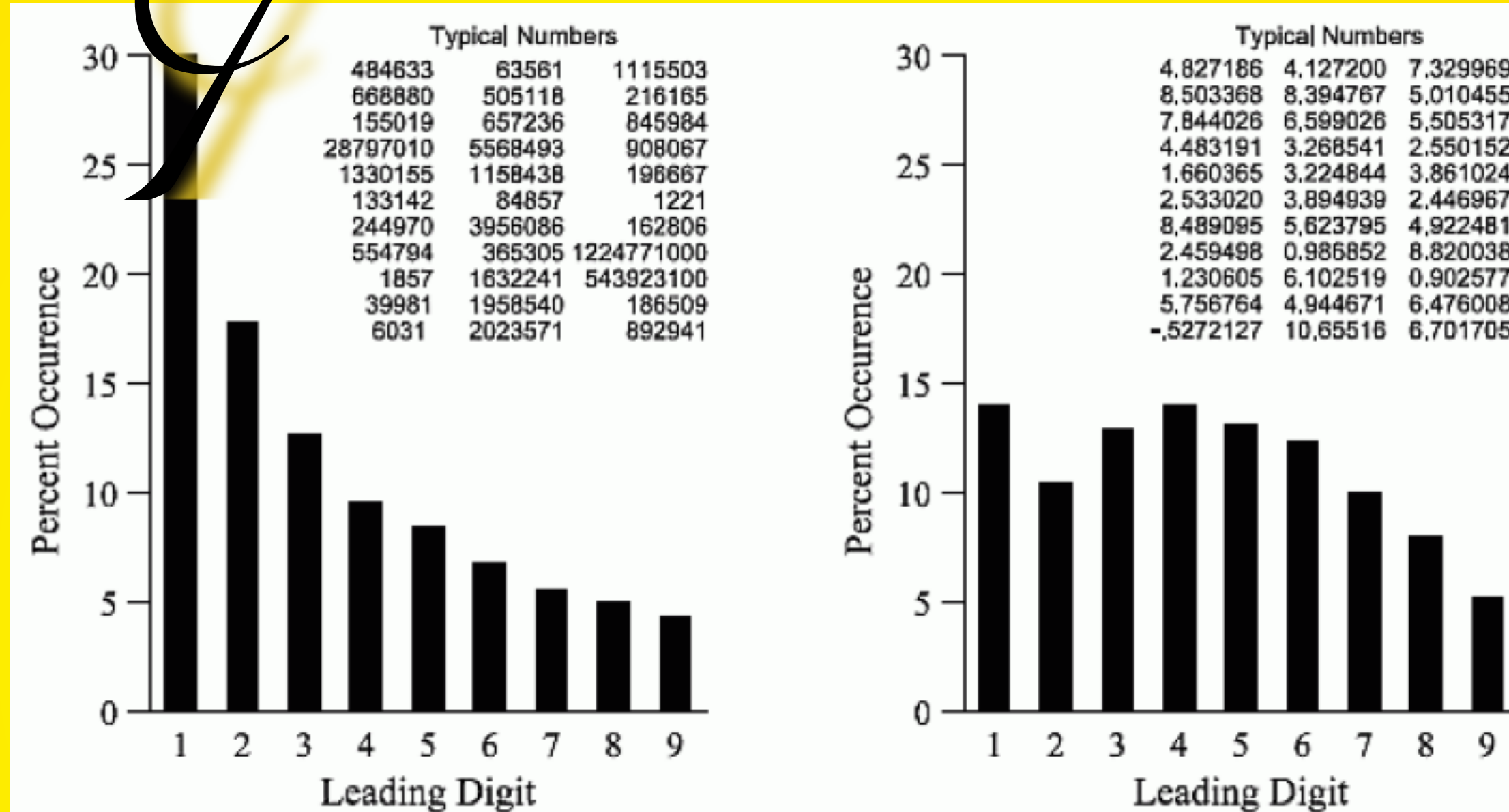


Explanation



Frank Benford

1883-1948

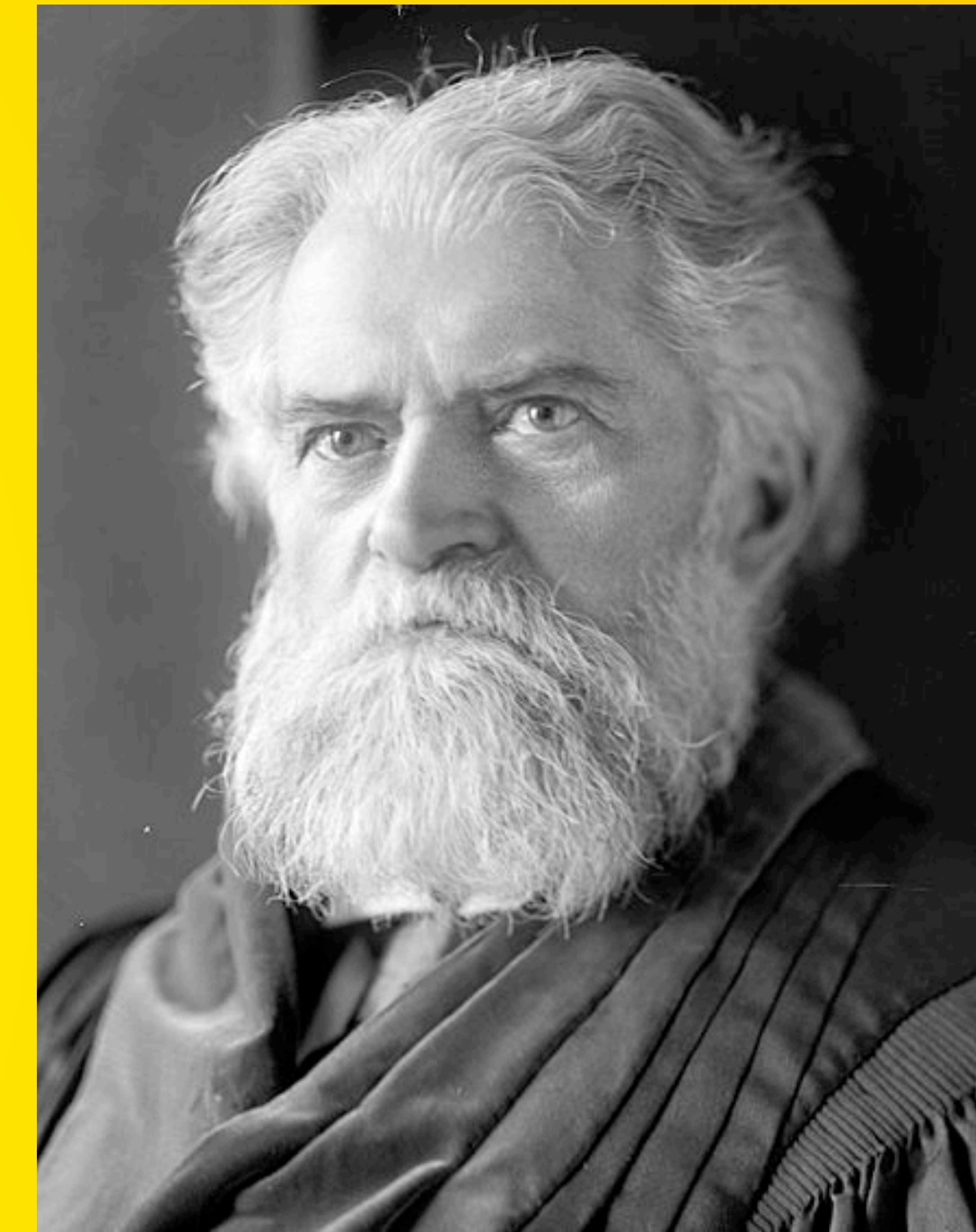


a. Tax return numbers, *Benford's law*

b. RNG numbers, *not Benford's law*

FIGURE 34-2

Two examples of leading-digit histograms. The left figure shows the leading-digit distribution for 14,414 numbers taken from U.S. Federal income tax returns. The figure on the right is for numbers produced by a computer random number generator (RNG). This shows one of the longstanding mysteries of Benford's law— Why do some sets of numbers follow the law (such as tax returns), while others (such as this RNG) do not? Many have claimed that this is some sort of secret code hidden in the fabric of Nature.



Simon

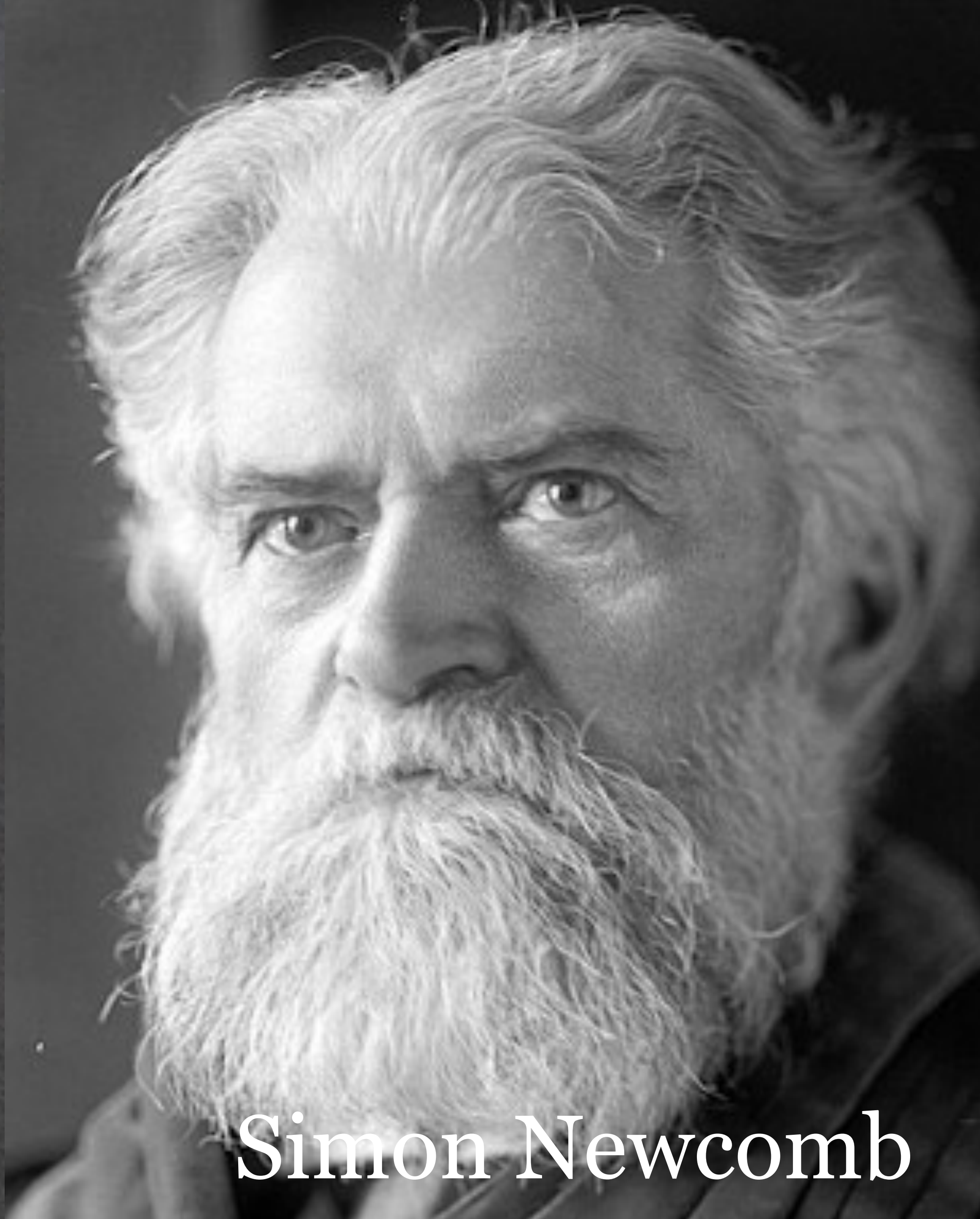
Newcomb
1835-1909

1931

1881

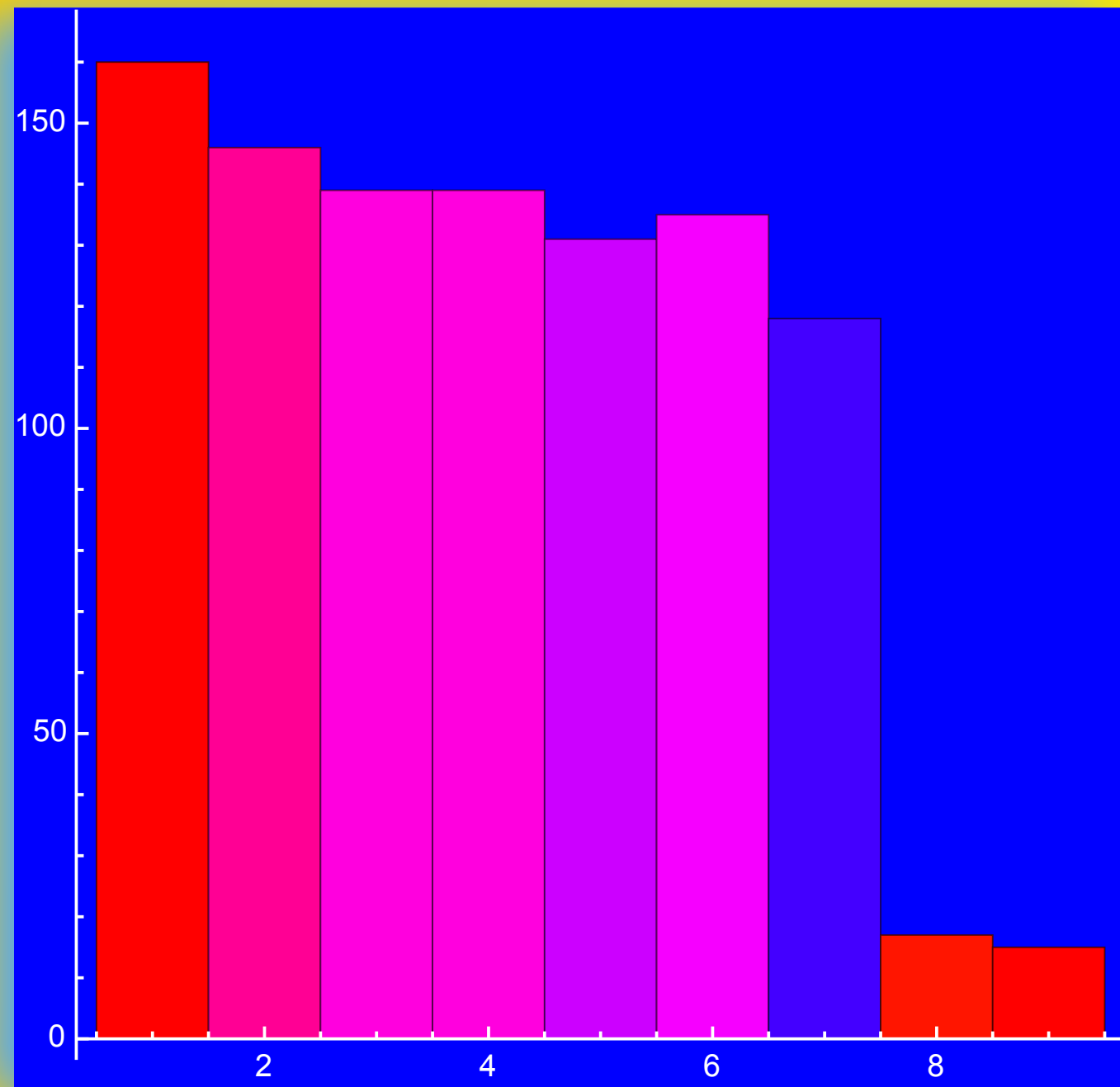


Frank Benford

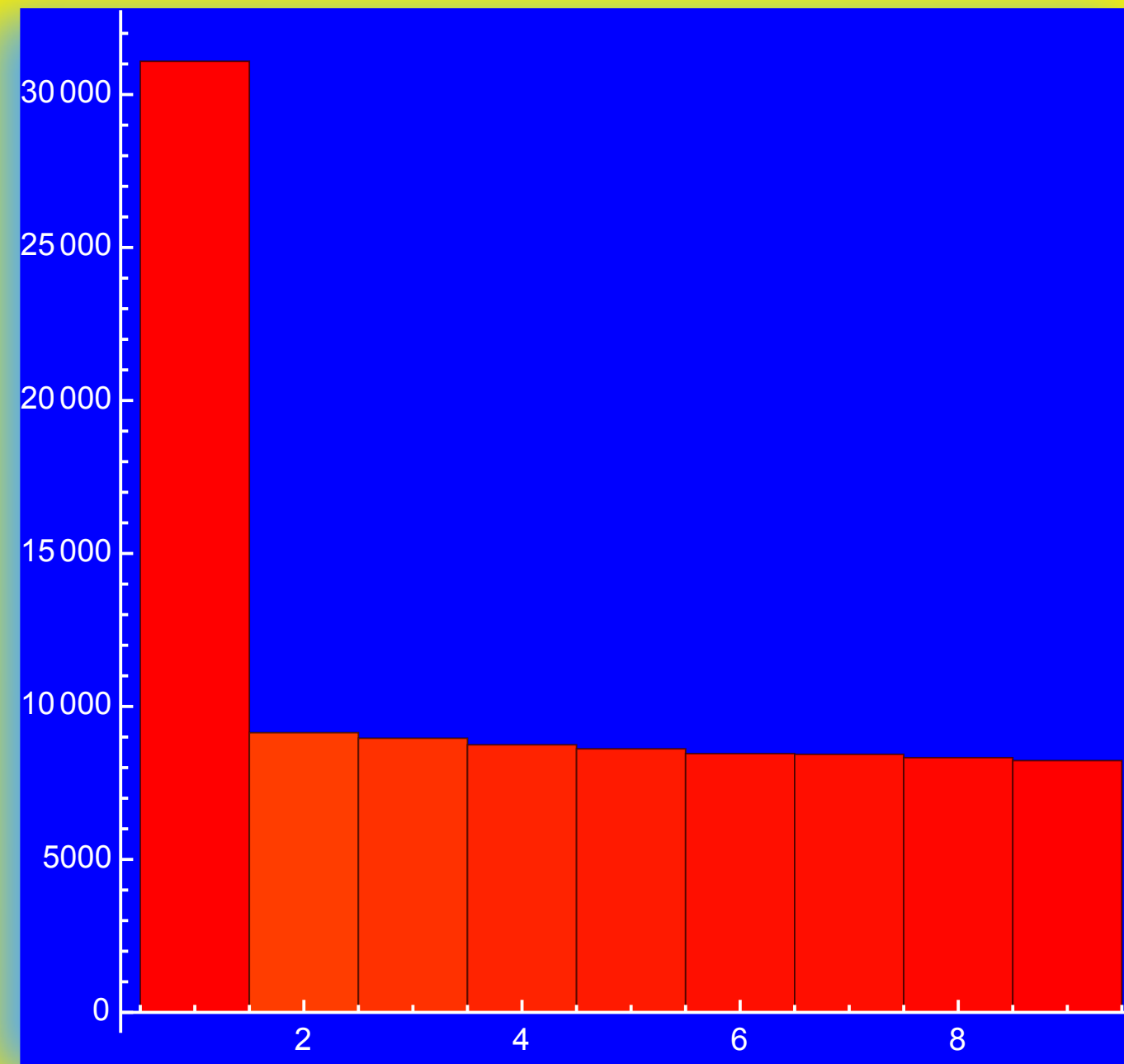


Simon Newcomb

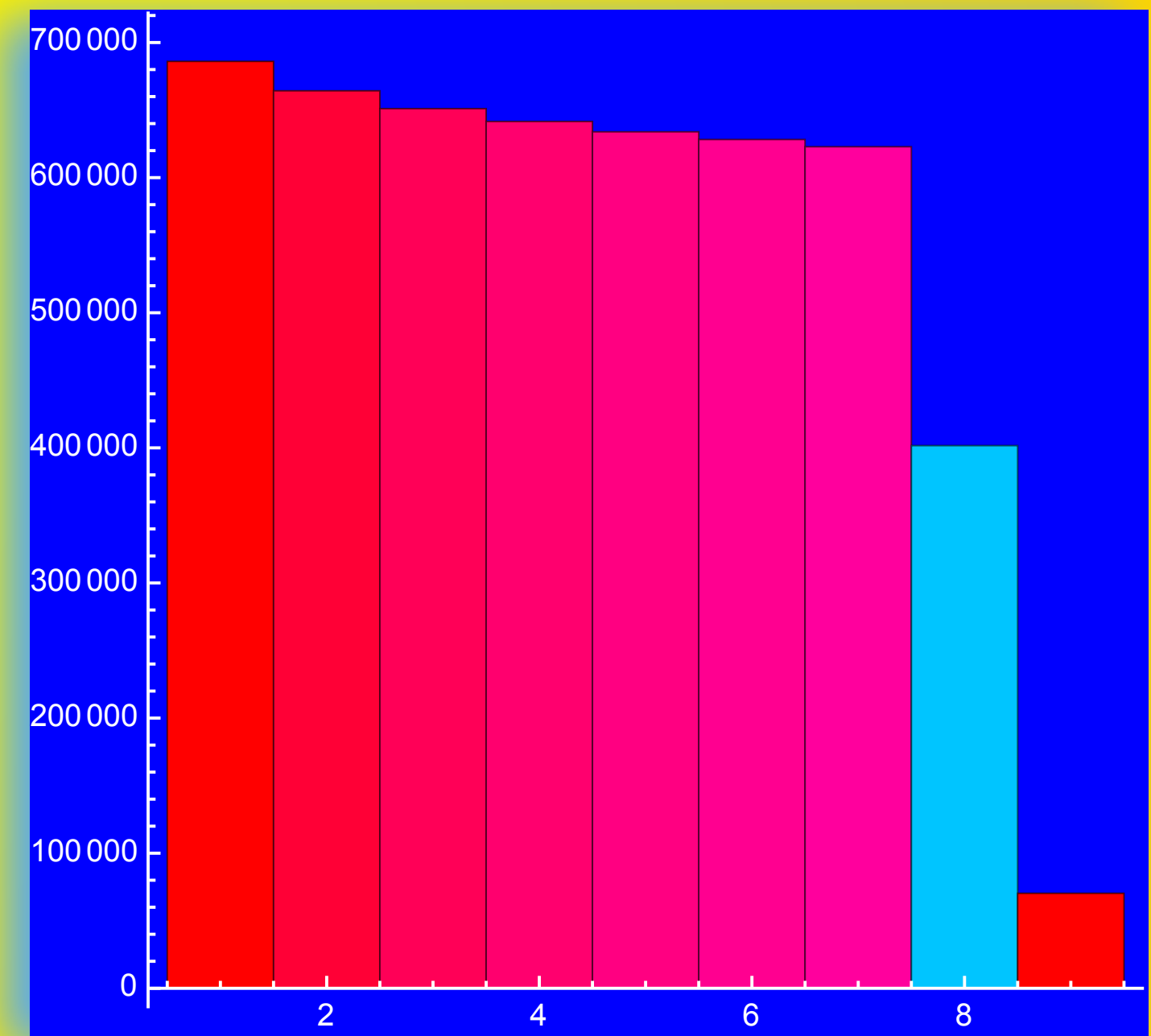
Primes



1000

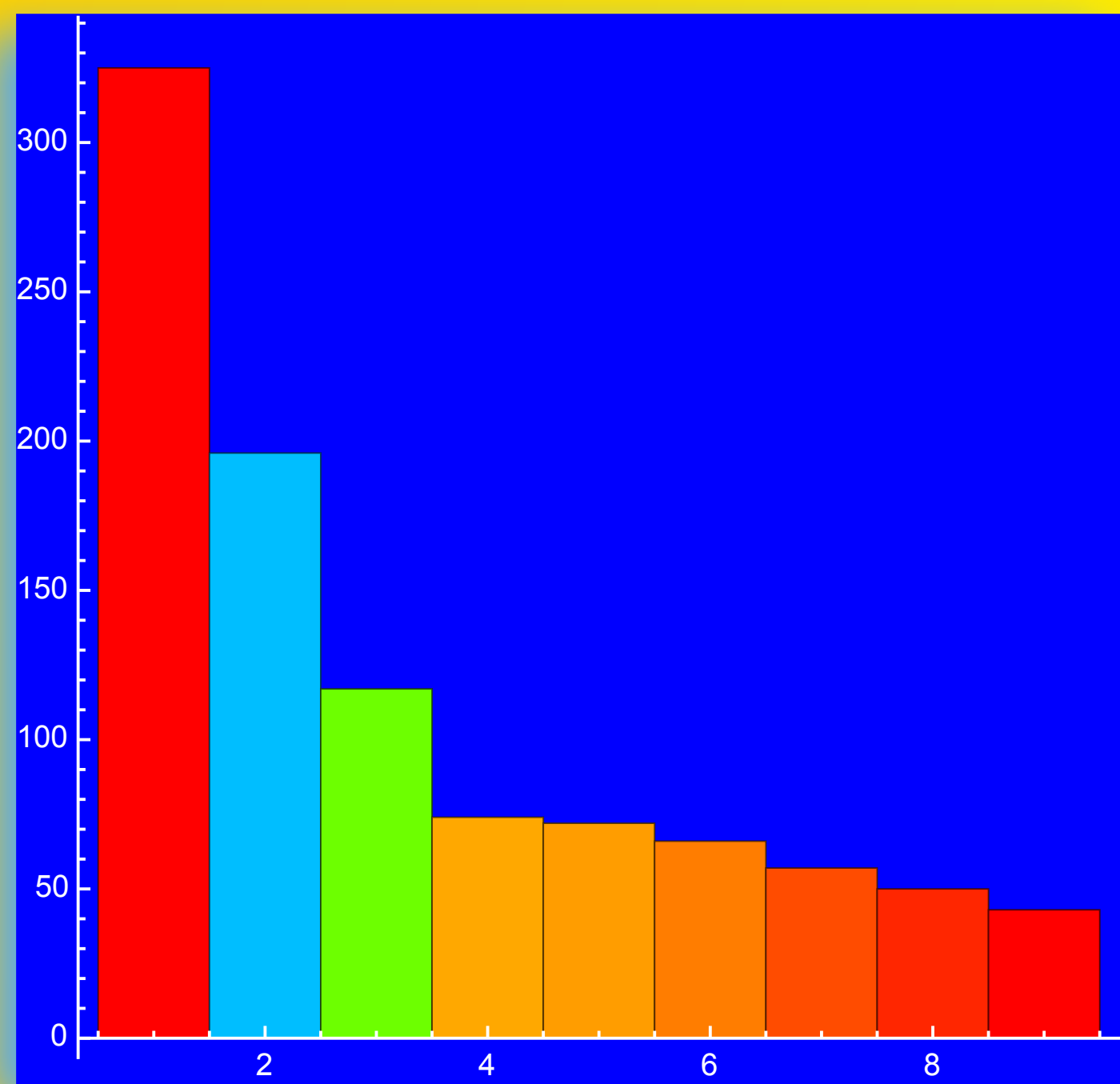


100000

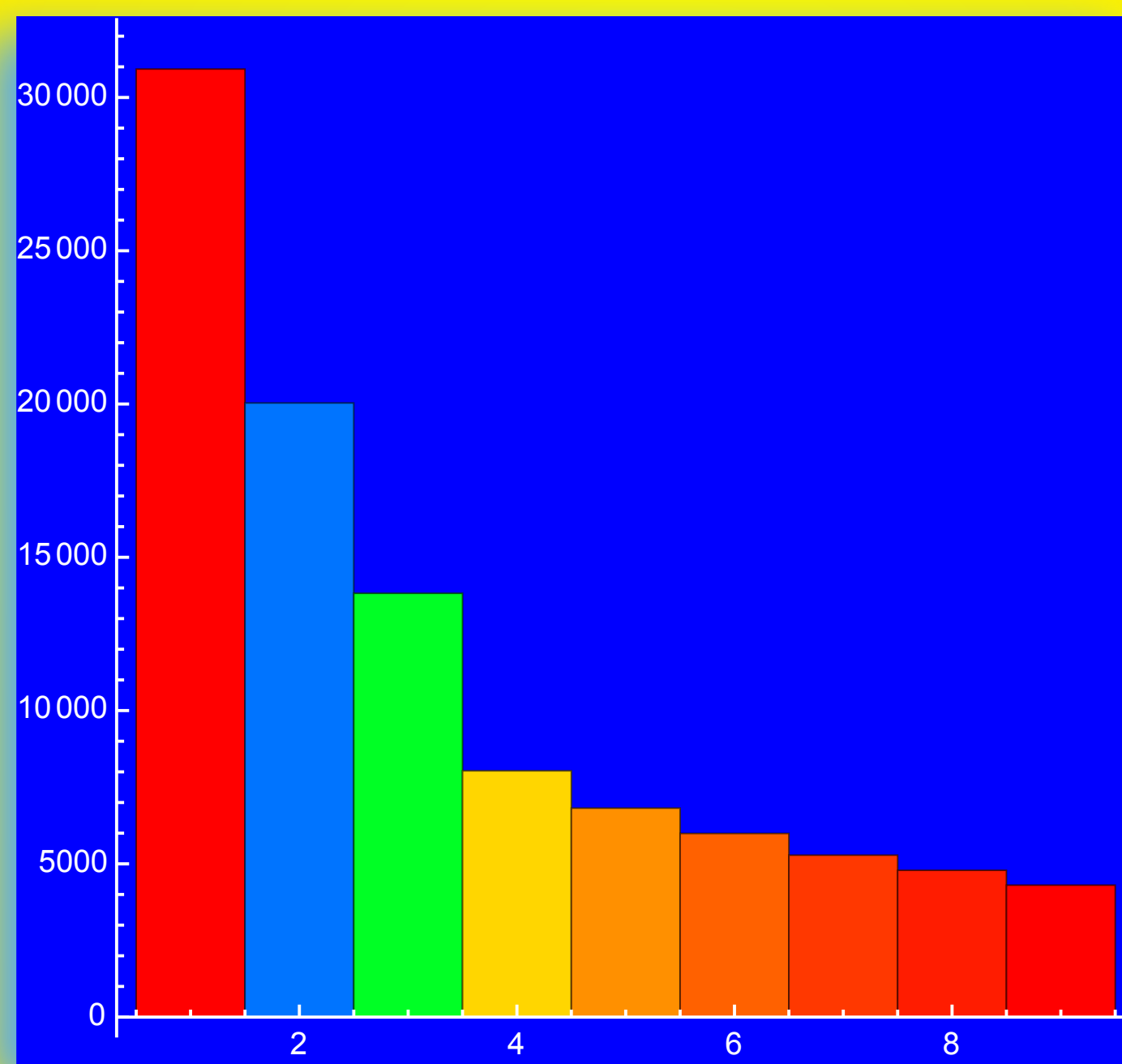


50000000

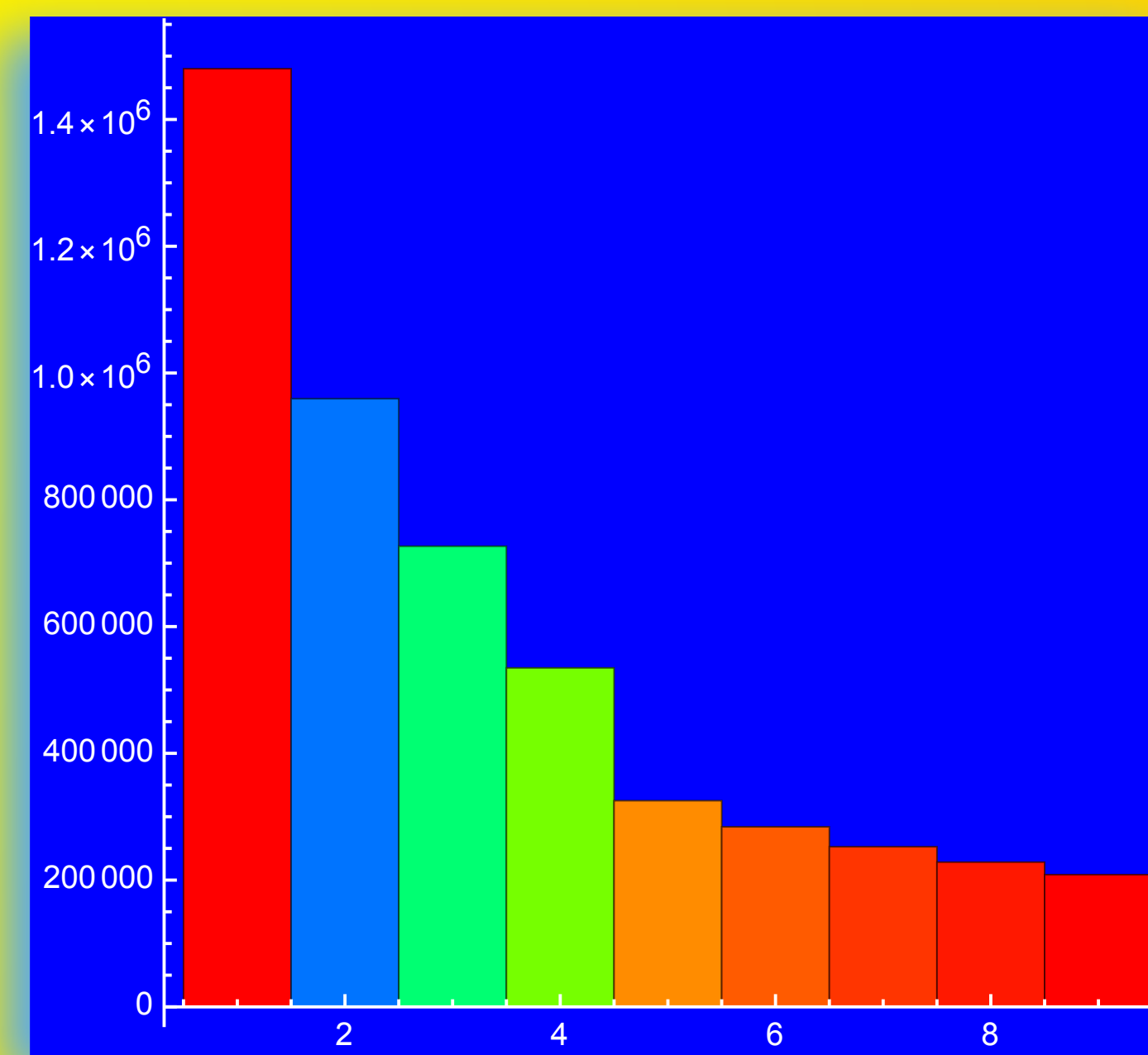
Experiment



1000

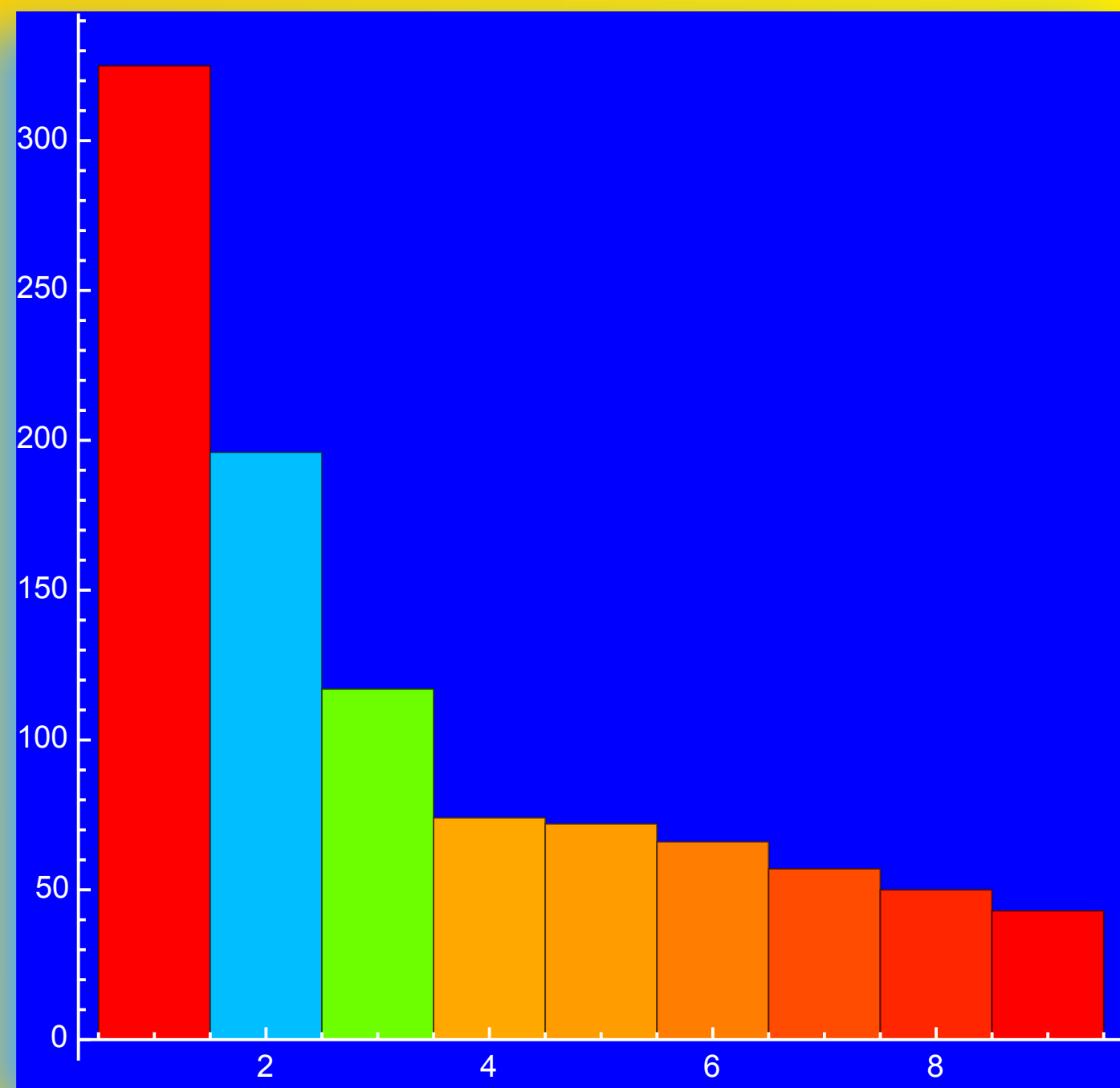


100000

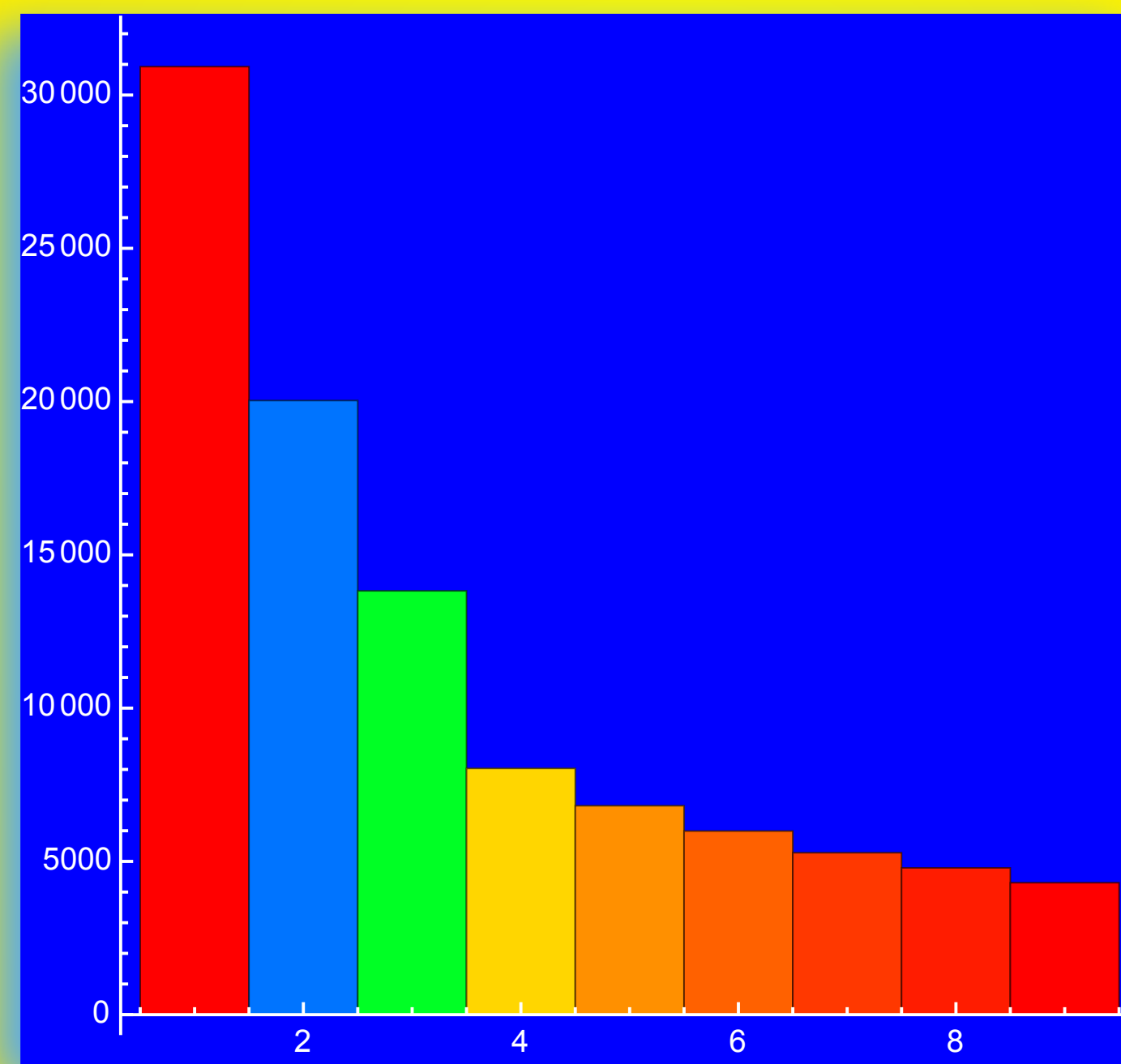


5000000

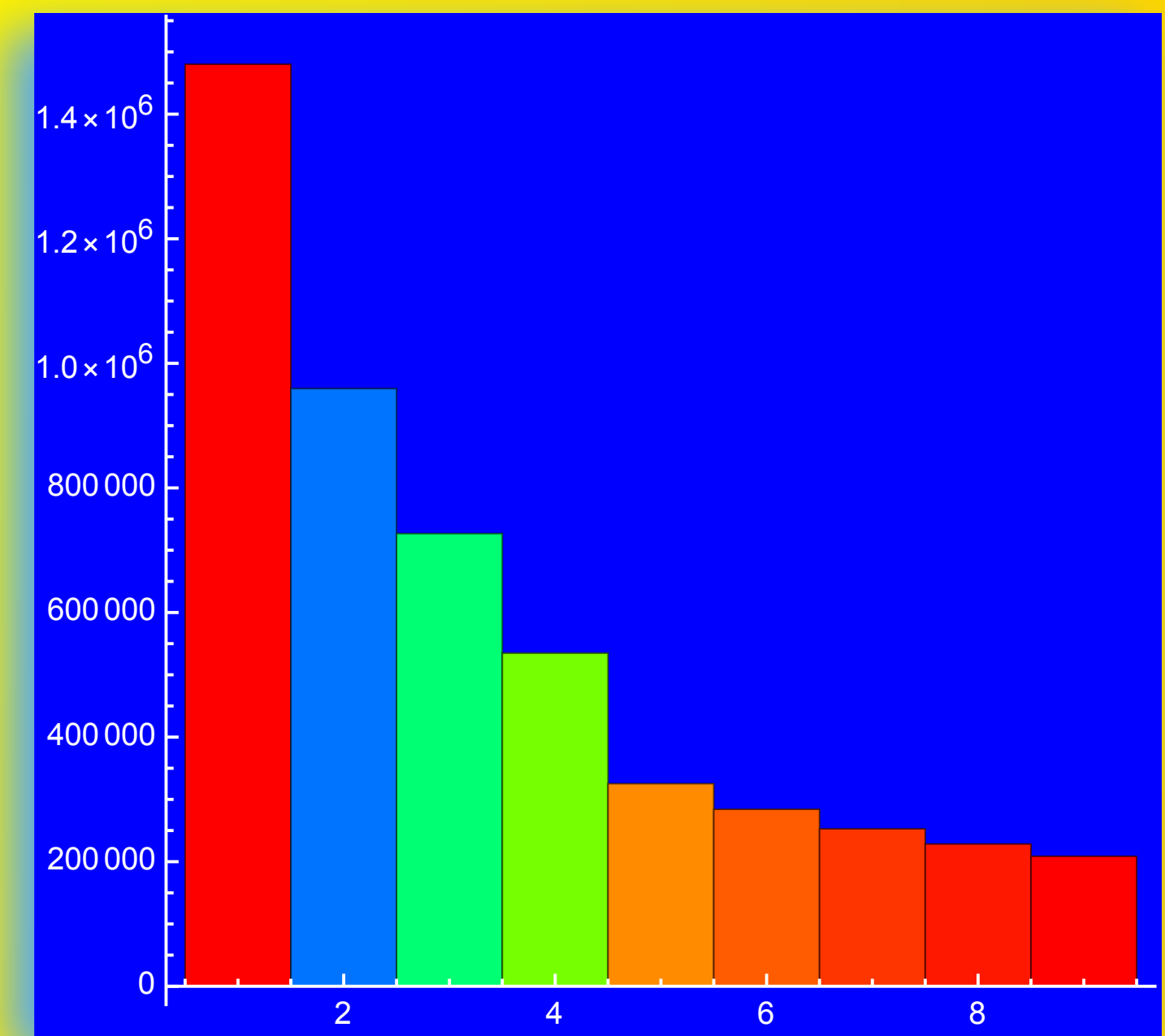
Primes Powers



1000

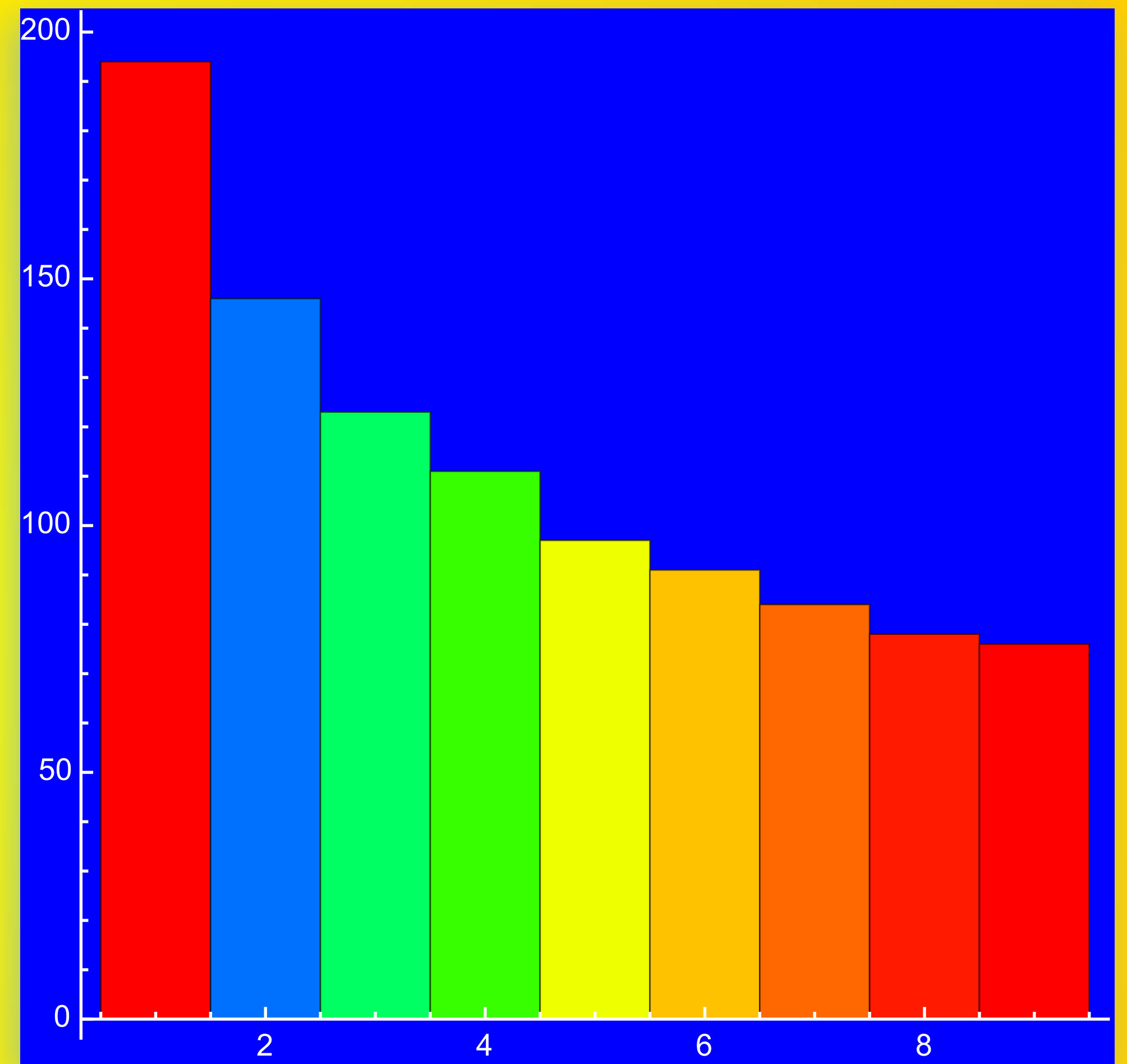


100000



5000000

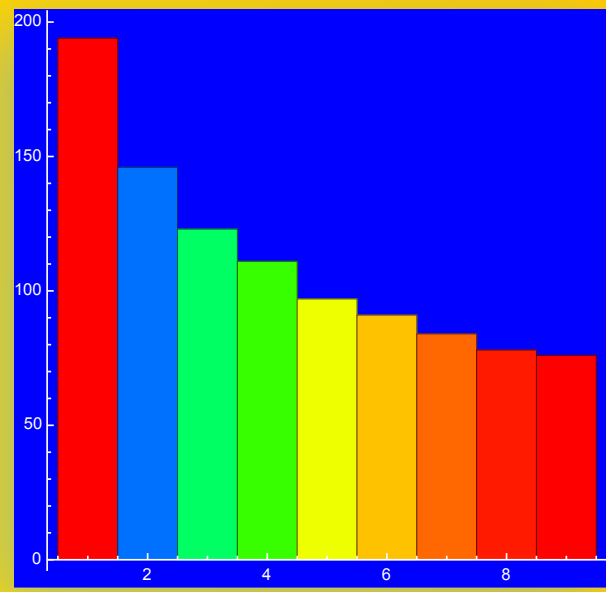
Experiment



```
data = Table[First[IntegerDigits[n^2]], {n, 1, 1000}];
```

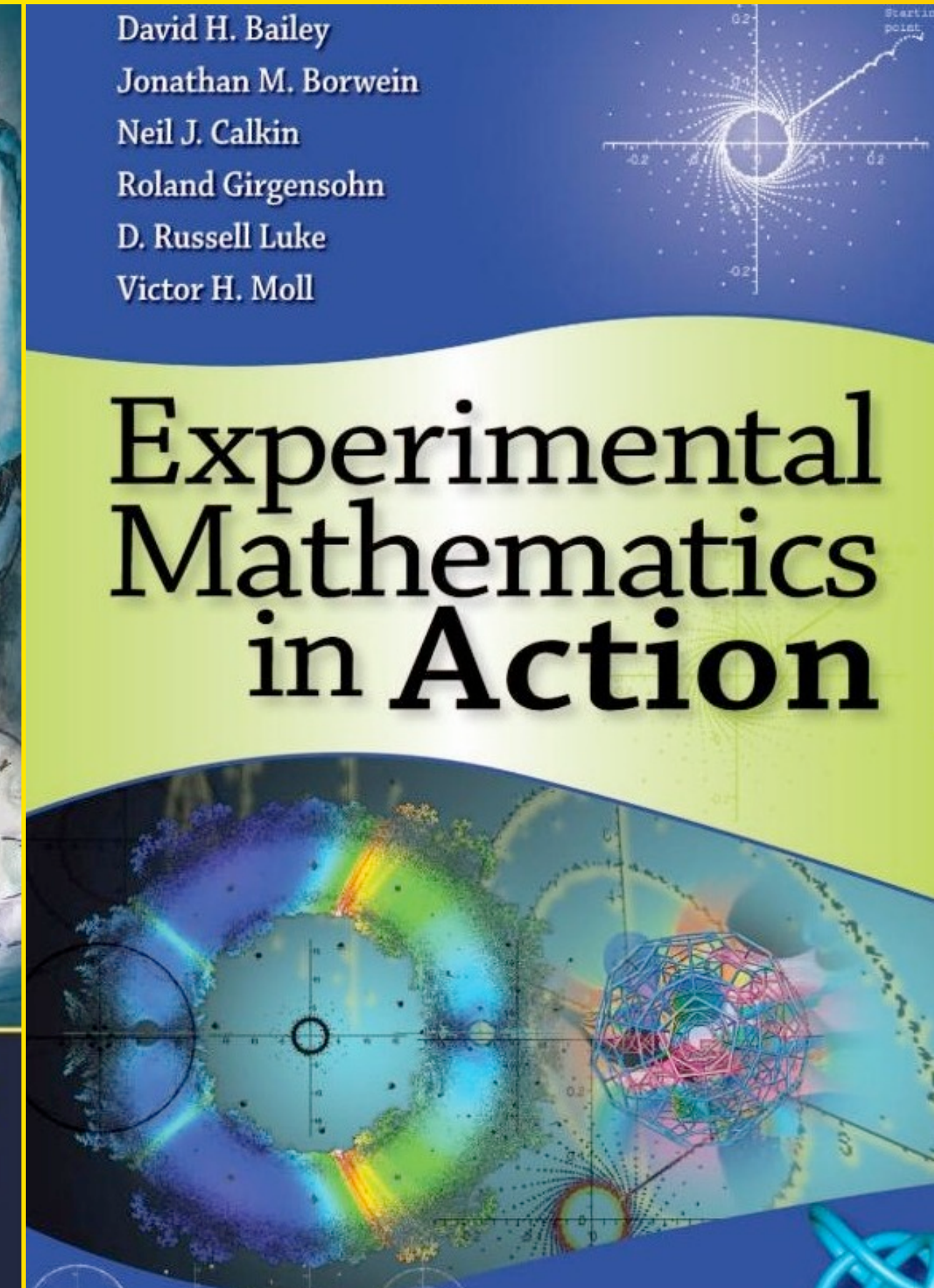
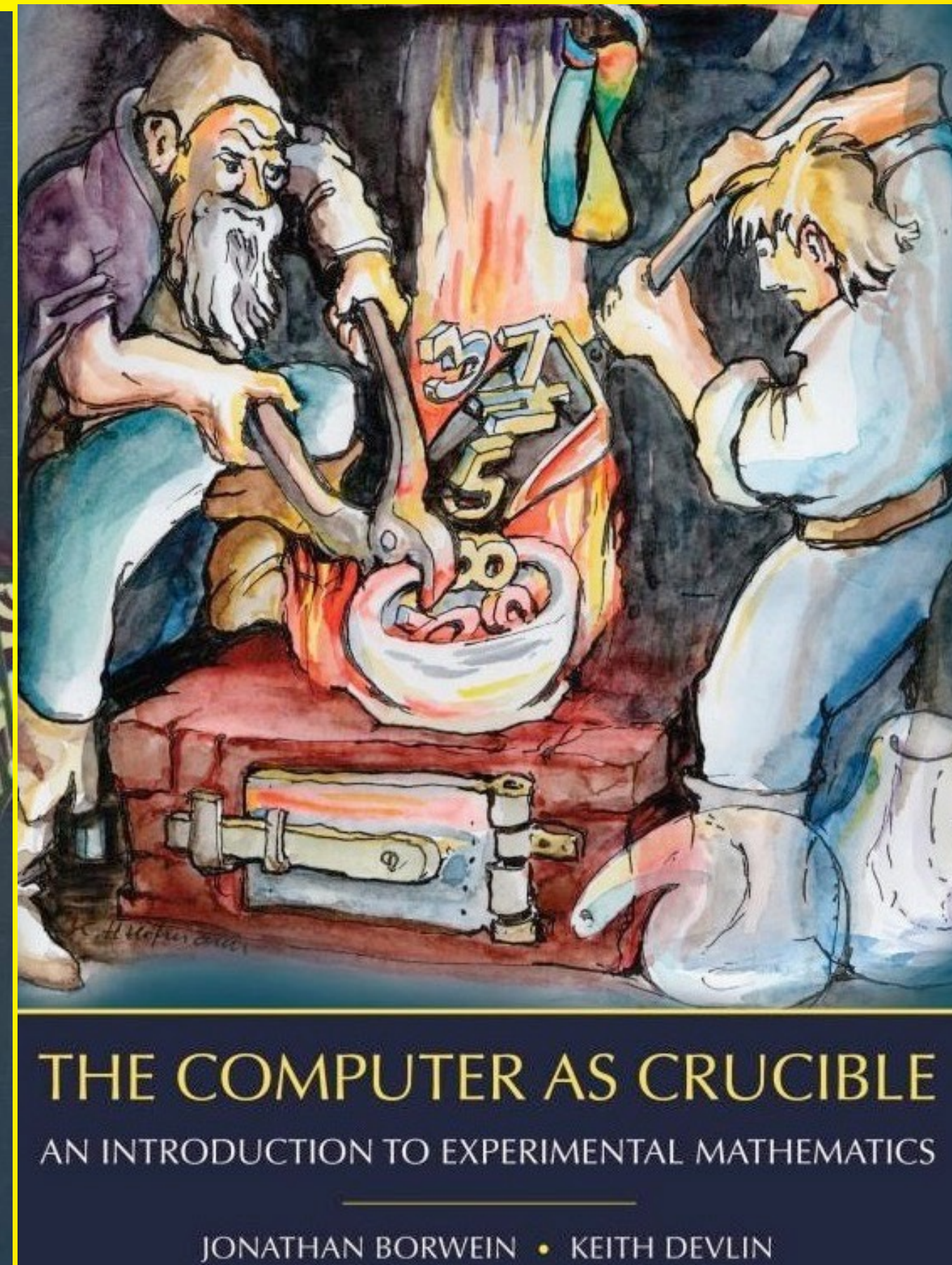
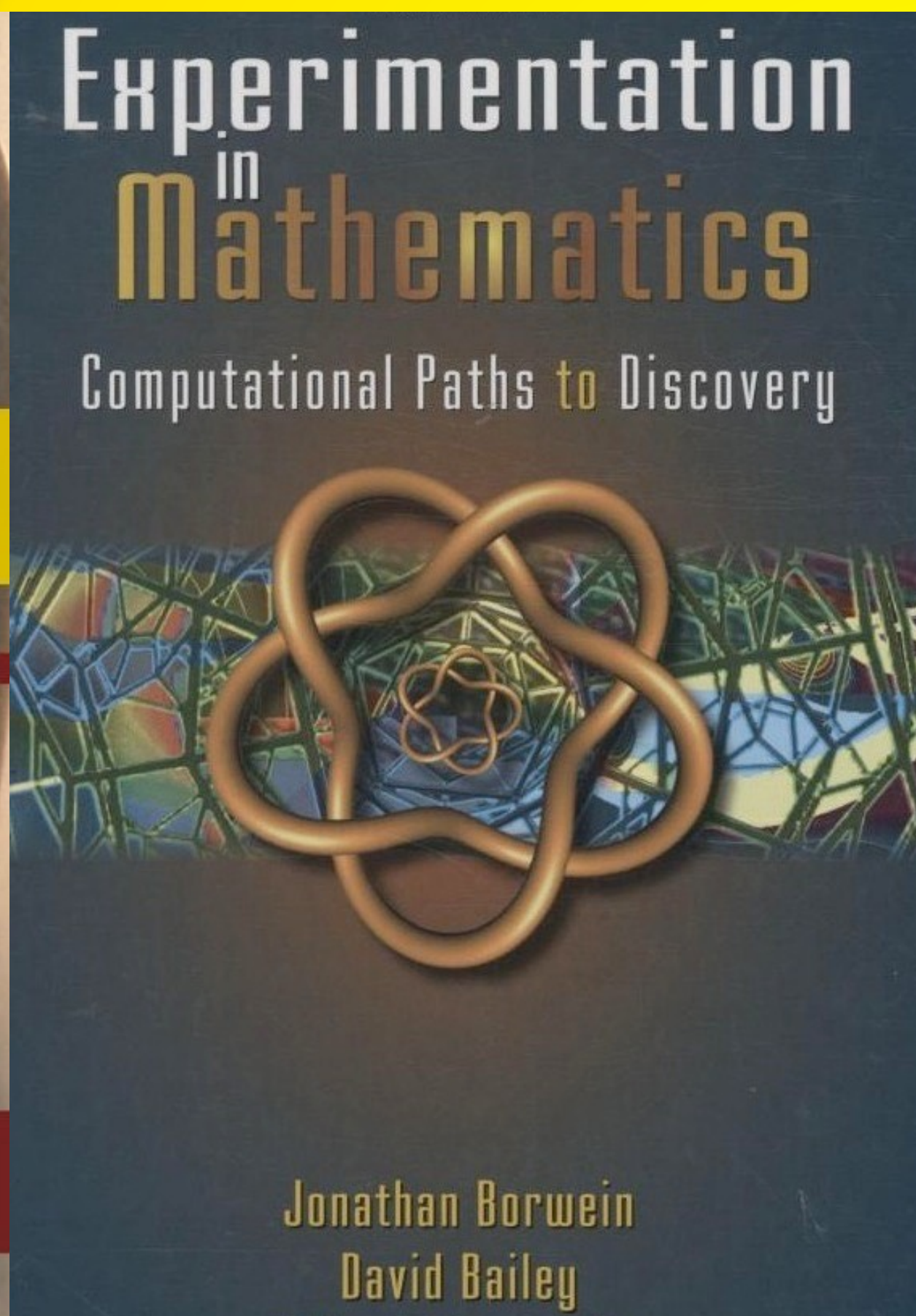
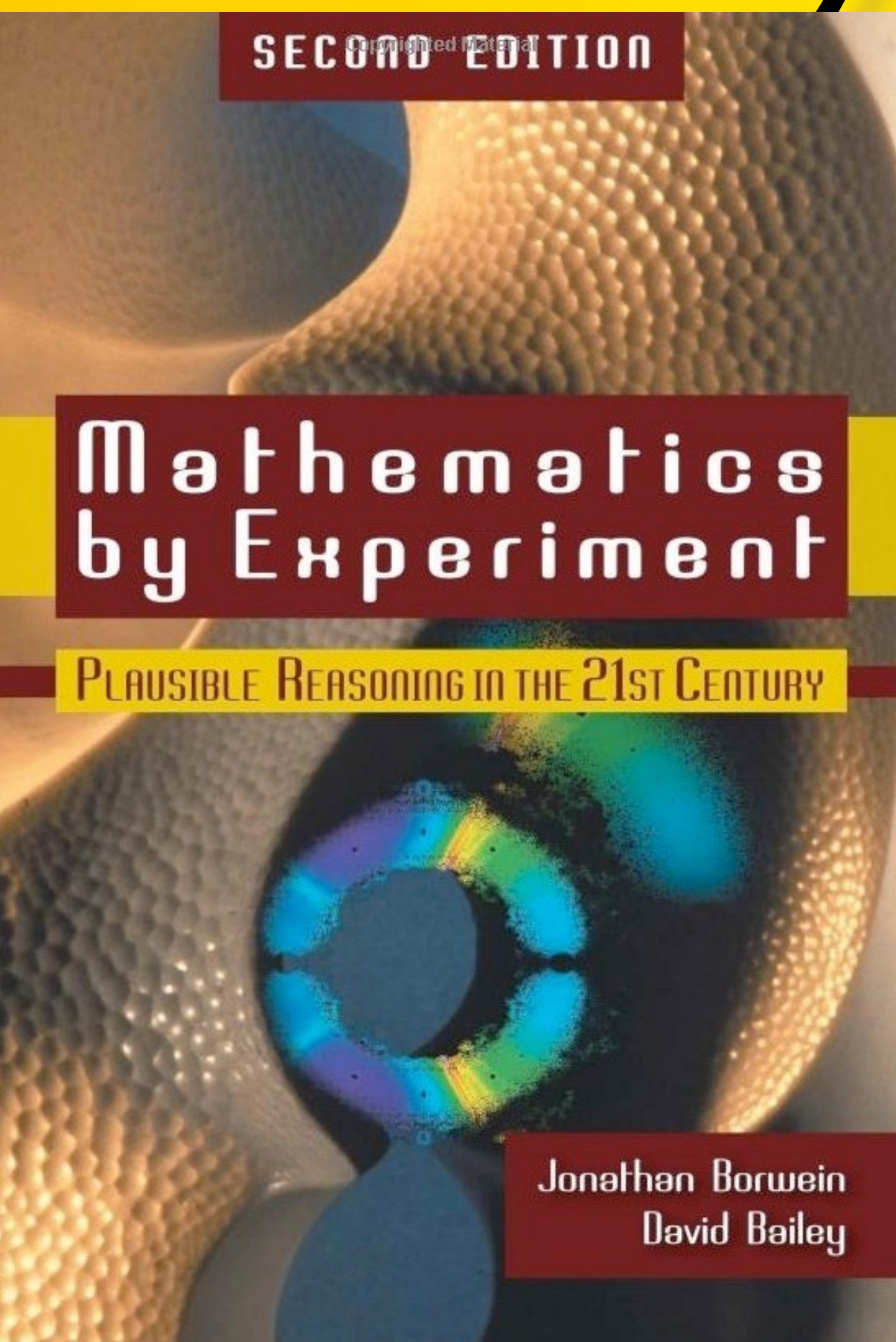
```
S = Histogram[data, 10, ColorFunction -> Hue, AspectRatio -> 1]
```

Jam



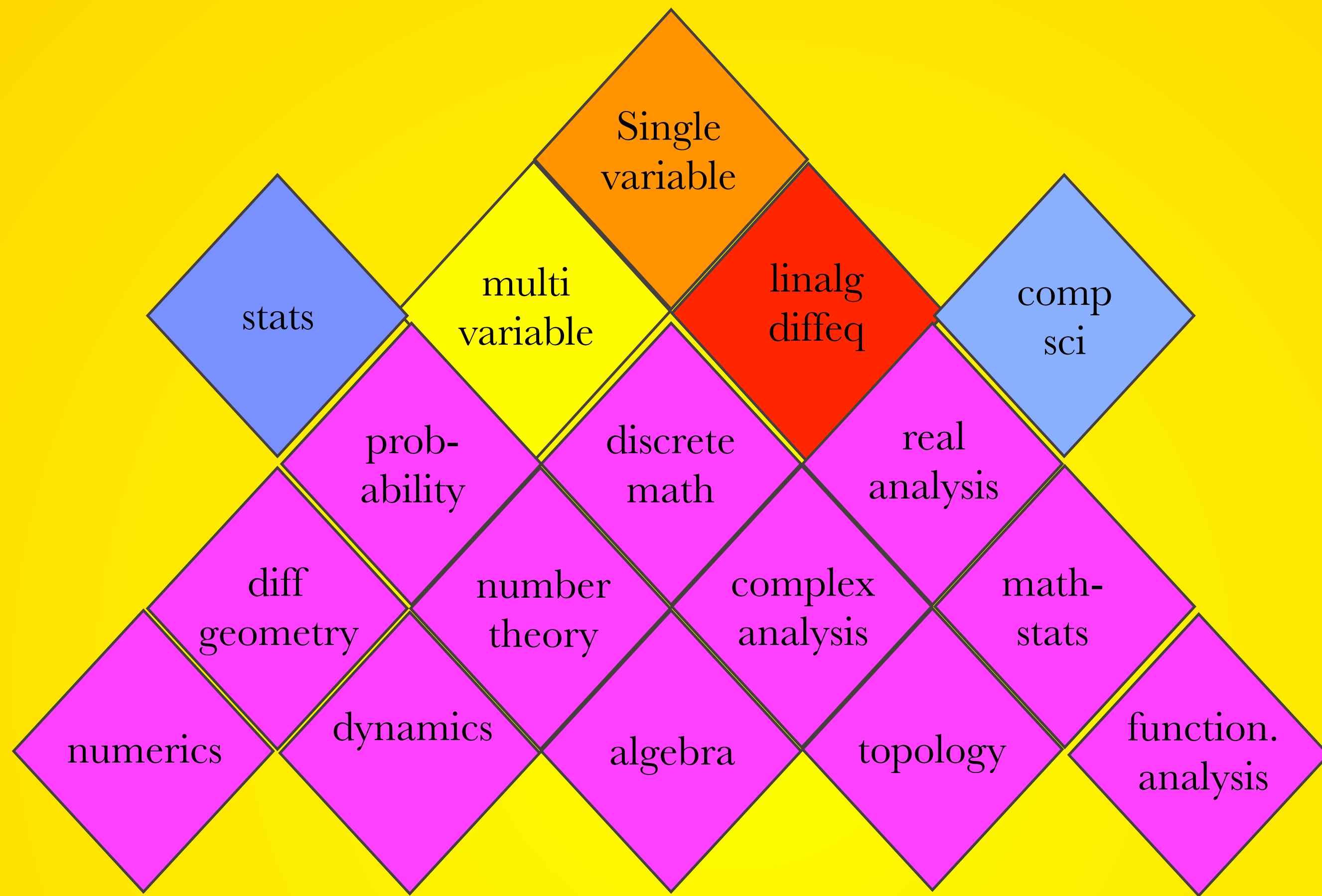
*Write down the first 20 squares,
mark the first significant digit,
then make a bin count for each digit
and draw the histogram!*

Experimental Math



E) Beyond Math 1a

The course 1A	from extremization to the fundamental theorem
functions	polynomials, exp, log, trig functions
limits	velocity, tangents, infinite limits
derivatives	product, chain rule with related rates, extremization
integrals	techniques, area, volume, fundamental theorem
The course 1B	from series and integration to differential equations
integration	integration by parts, trig substitution
series	convergence, Power, Taylor and Dirichlet series
diff equations	separation of variables, exponential and logistic
systems diff eq	equilibria, nullclines, analysis
The course 21A	geometry, extremization and integral theorems in space
geometry	analytic geometry of space, geometric objects, distances
differentiation	curves and surfaces, gradient, curl, divergence
integration	double and triple integrals, other coordinate systems
integral theorems	line and flux integrals, Green, Stokes and Gauss
The course 21B	matrix algebra, eigensystems, dynamical systems and Fourier
equations and maps	Gauss-Jordan elimination, kernel, image, linear maps
matrix algebra	determinants, eigenvalues, eigenspaces, diagonalization
dynamical systems	difference and differential equations with various techniques
fourier theory	Fourier series and dynamical systems on function spaces



Computer
Science

Physics
Astronomy

Business
Economics

BioChem
LifeScience

Psychology
Philosophy

The End