Why Make Models

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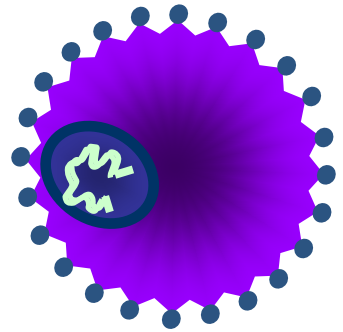


Fibonacci Numbers

- 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, …


- Lilies and irises = 3 petals

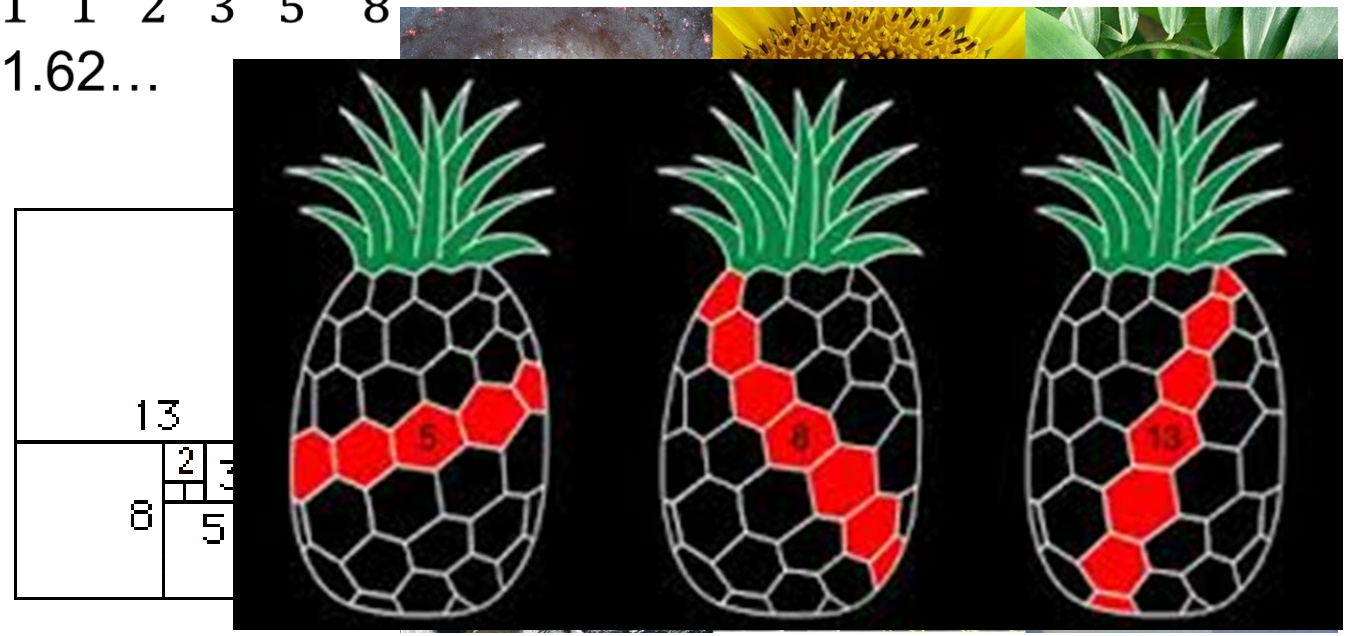

Buttercups and wild roses = 5 petals

Corn marigolds = 13 petals

Black-eyed Susan's = 21 petals

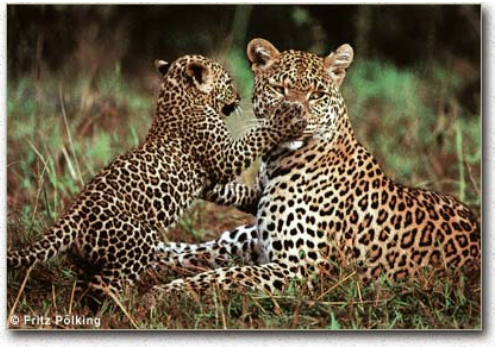
Fibonacci Numbers and Golden Ratio

- 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, …
- $\frac{1}{1}, \frac{2}{1}, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \ldots$
- 1.62…



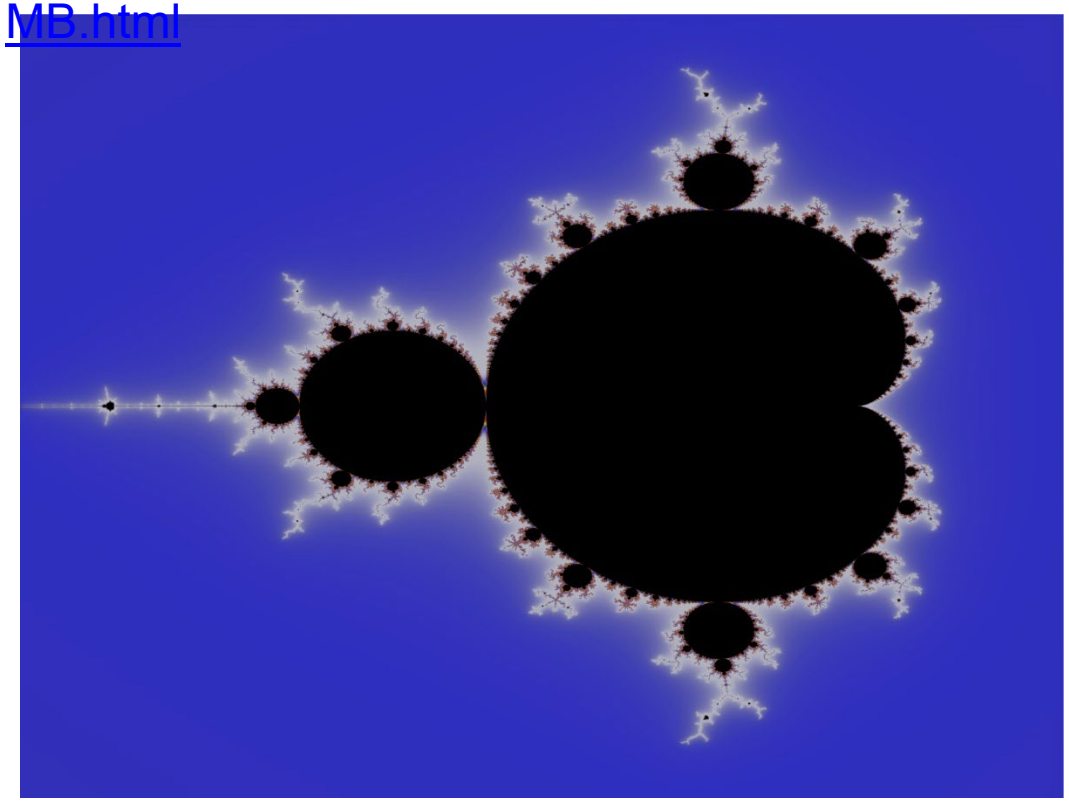
Which one is your cat?

Why do animals' coats have patterns like spots, or stripes?

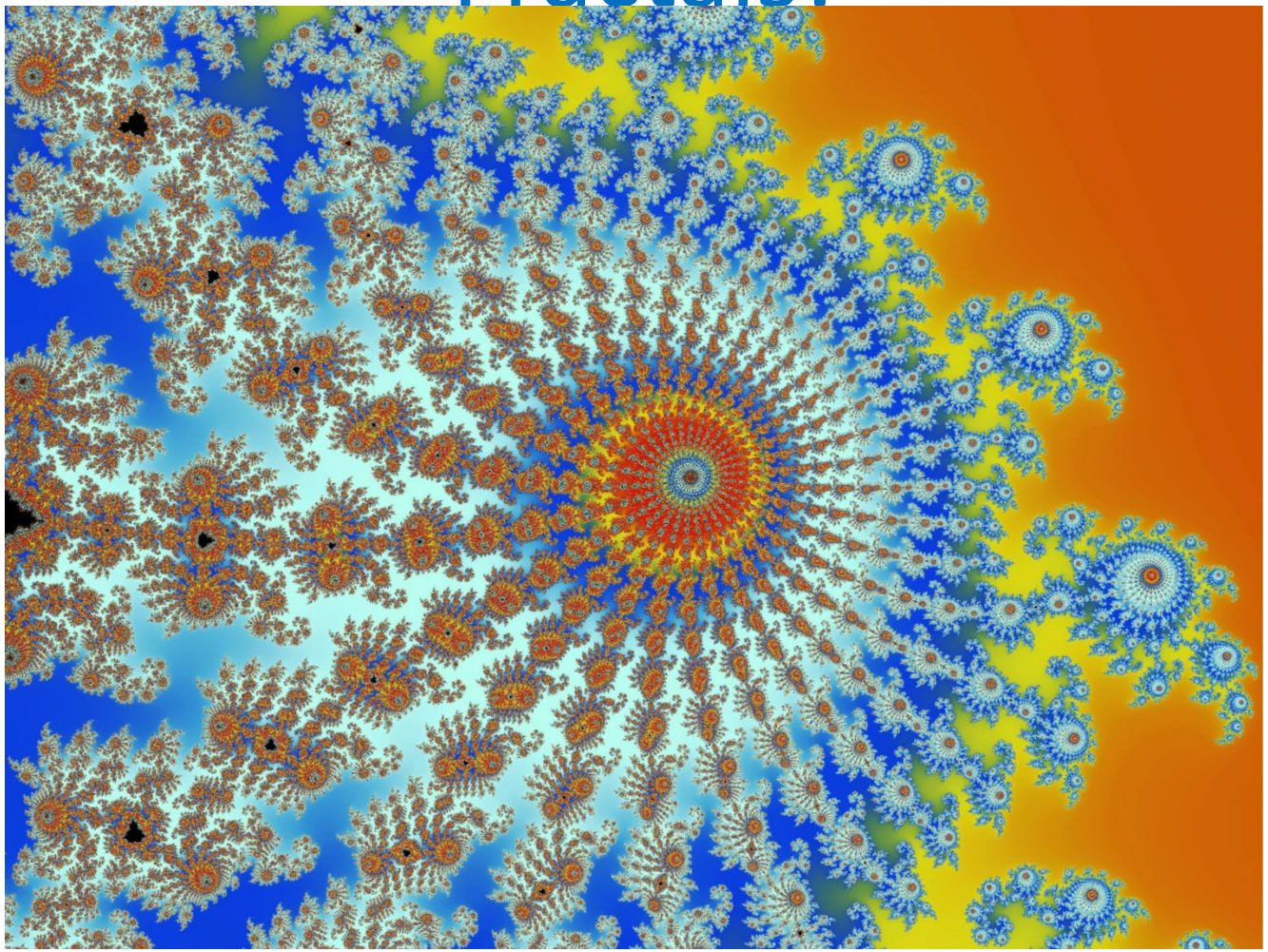


Fractals!

http://math.hws.edu/eck/js/mandelbrot/MB.html

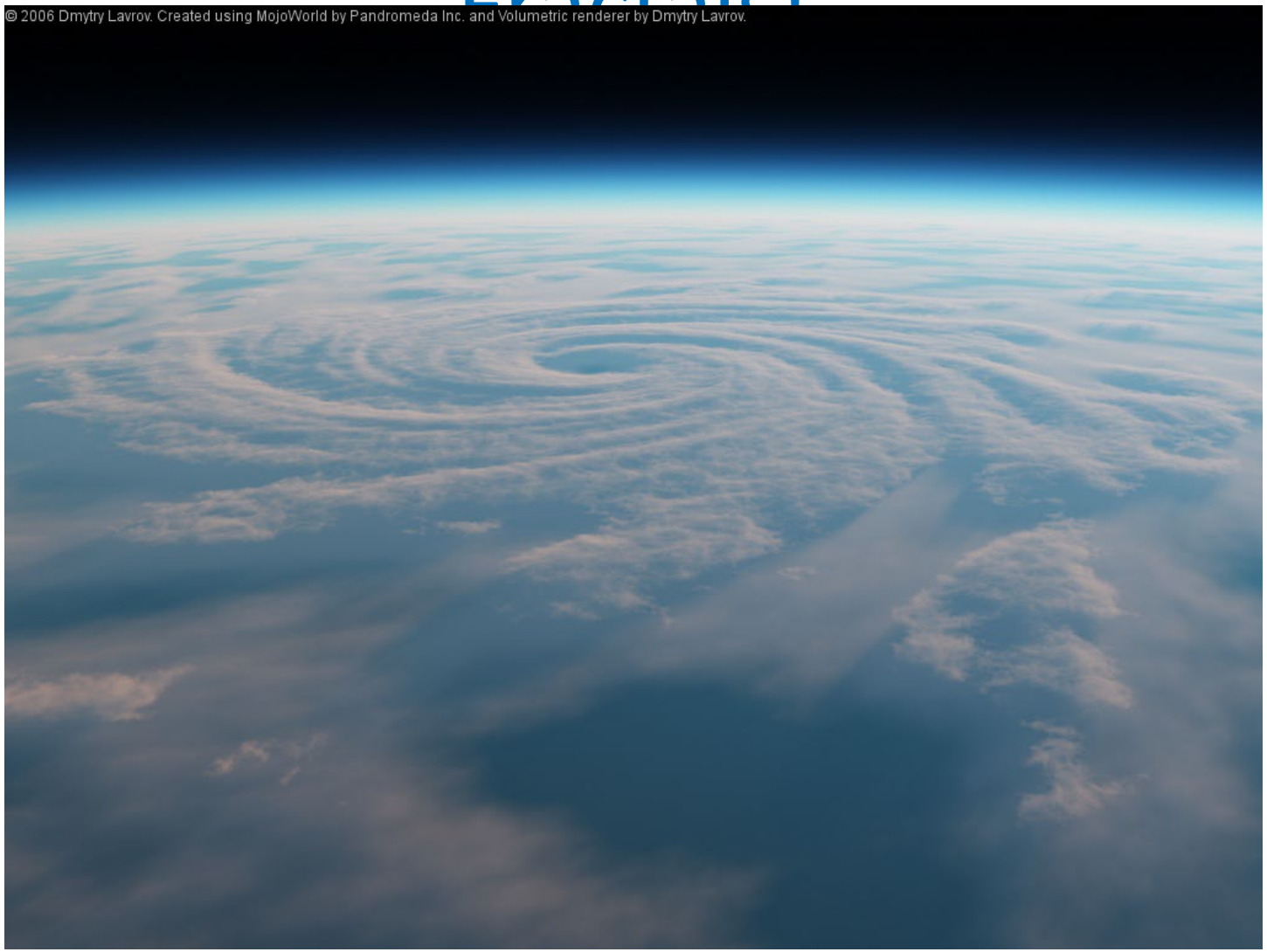


Fractals!



Fractals!

Fractals!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Fractals!


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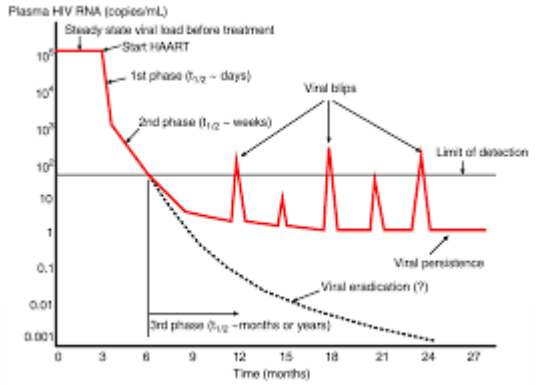
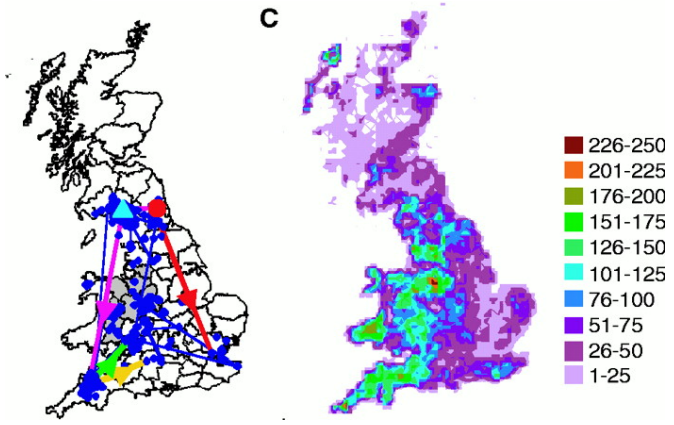
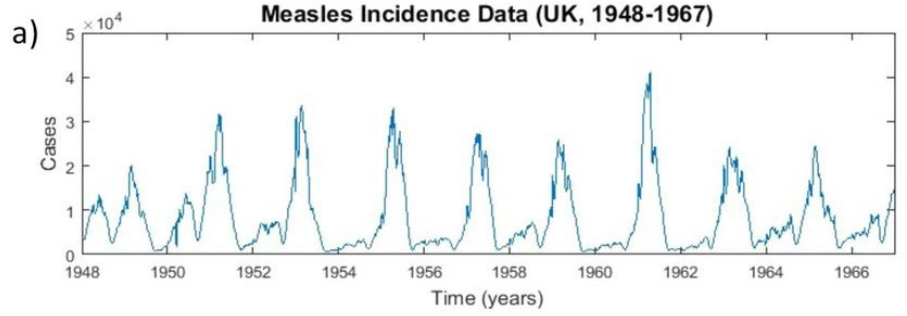
Making Models

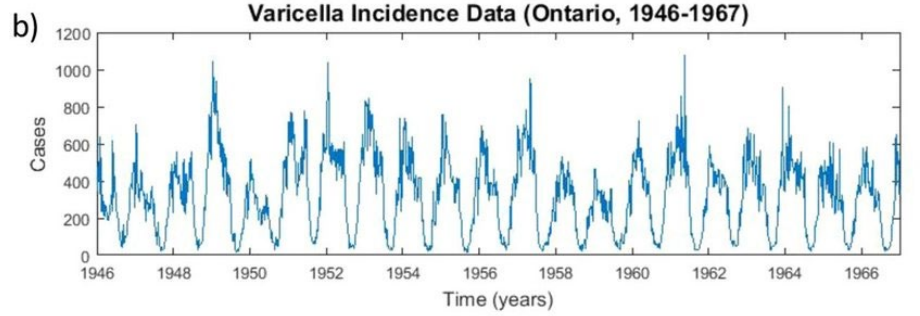
- To understand
  - Biology
  - Chemistry
  - Physics
  - Social science
  - Psychology
  - Health
  - etc

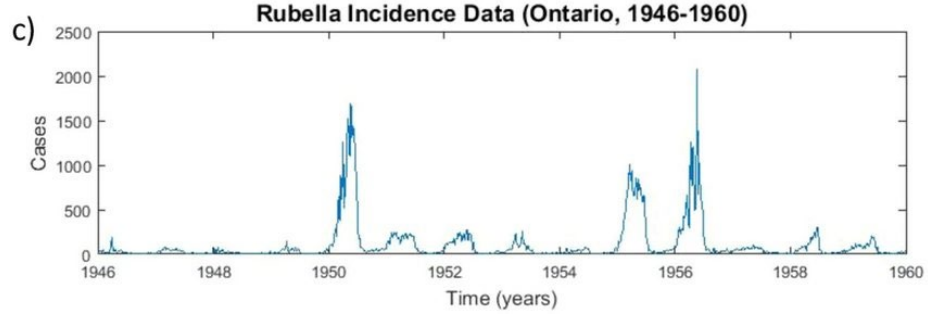
- To understand patterns in the work around us!!
  - Quantitative
  - Qualitative











CDM CMM
Centre for Disease Modelling
Centre de la modélisation des maladies

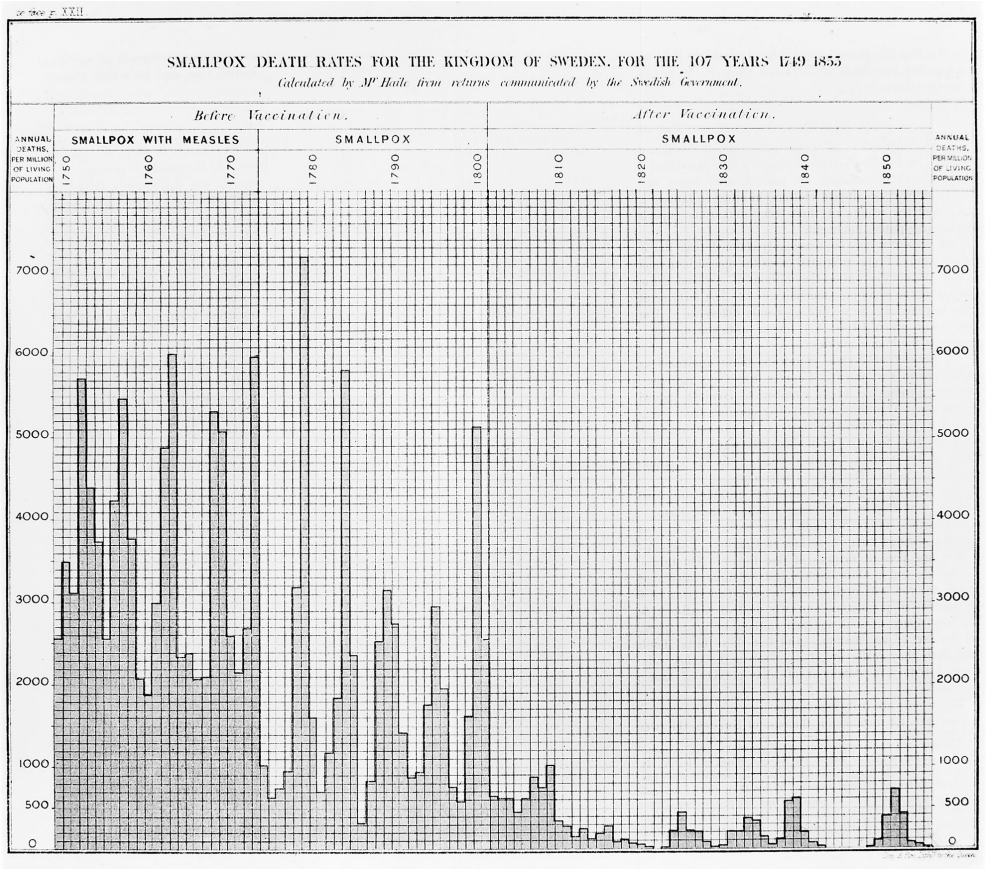
science | YORK UNIVERSITÉ UNIVERSITY

Mathematical Epidemiology

Some history of epidemiology

Daniel Bernoulli (1700 – 1782), mathematician and physicist, one of the greatest scientists of the 18th century

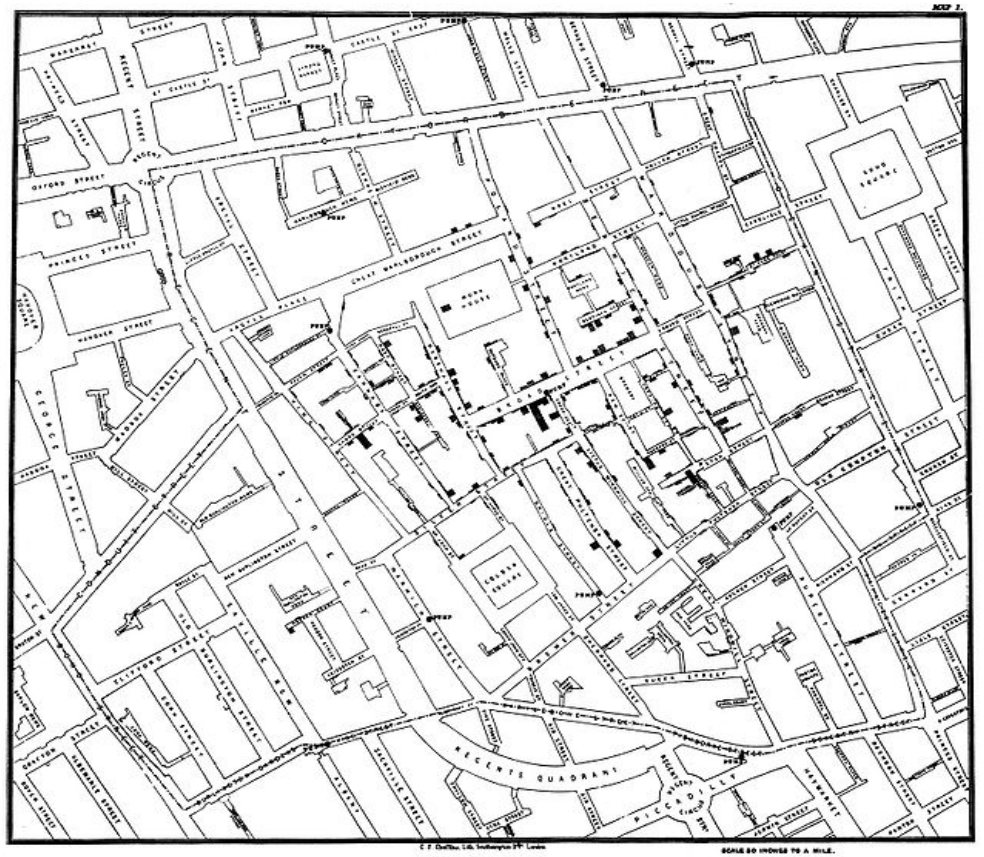
Wrote a mathematical analysis for smallpox vaccination to encourage people to get vaccinated (1760)



Some history of epidemiology

John Snow (15 March 1813 – 16 June 1858) was a British physician and a leader in the adoption of anesthesia and medical hygiene.

He is considered to be one of the fathers of epidemiology, because of his work in tracing the source of a cholera outbreak in Soho, England, in 1854.



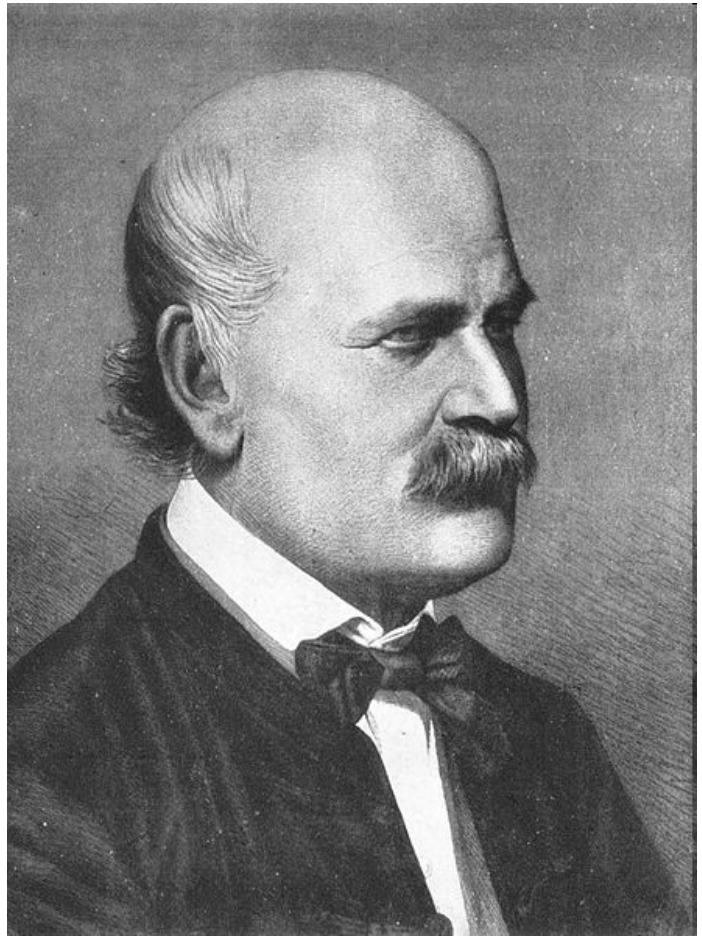
Original map by Dr. John Snow showing the clusters of cholera cases London epidemic of 1854 .

Centred around Broad St pump.

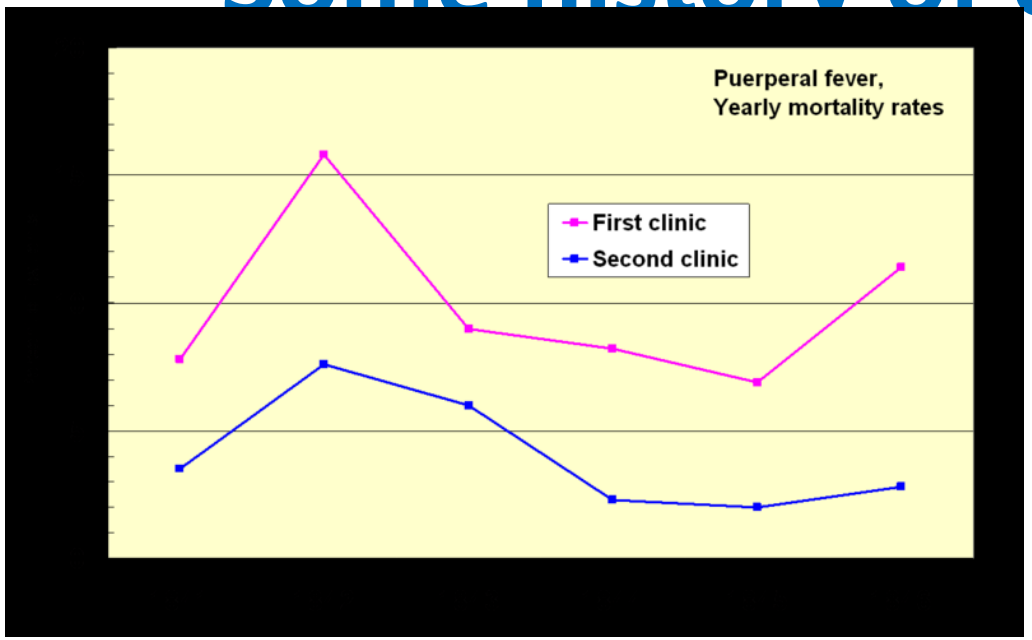
Used statistics to show connection between the quality of the source of water and cholera cases.

Some history of epidemiology

- Ignaz Philipp Semmelweis (July 1, 1818 – August 13, 1865), was a Hungarian physician called the *"saviour of mothers"*



Some history of epidemiology



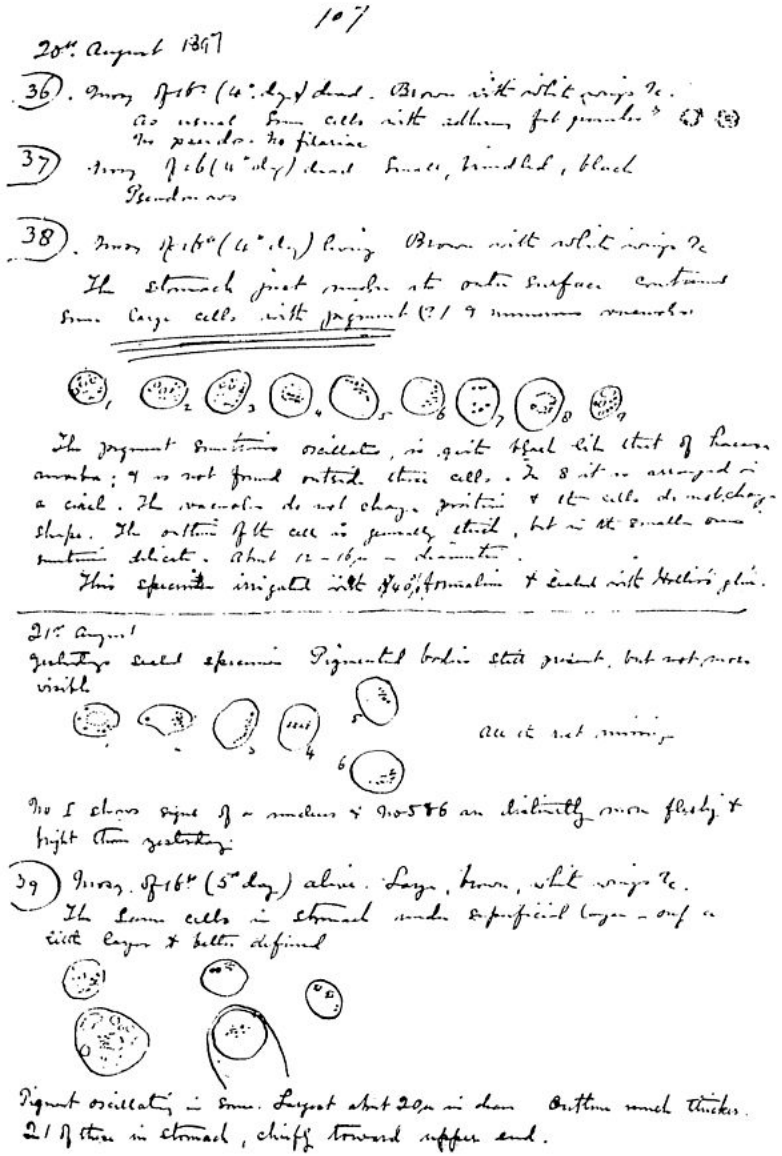
- Semmelweis' discovery took place at the Vienna General Hospital
- The *Second Clinic's* rate was considerably lower, averaging less than 4%.
- This fact was known outside the hospital.

The two clinics admitted on alternate days but women begged to be admitted to the Second Clinic due to the bad reputation of the First Clinic

Some women even preferred to give birth in the streets, pretending to have given sudden birth *en route* to the hospital (a practice known as *street births*), which meant they would still qualify for the child care benefits.

Semmelweis was puzzled that puerperal fever was rare amongst women giving street births.

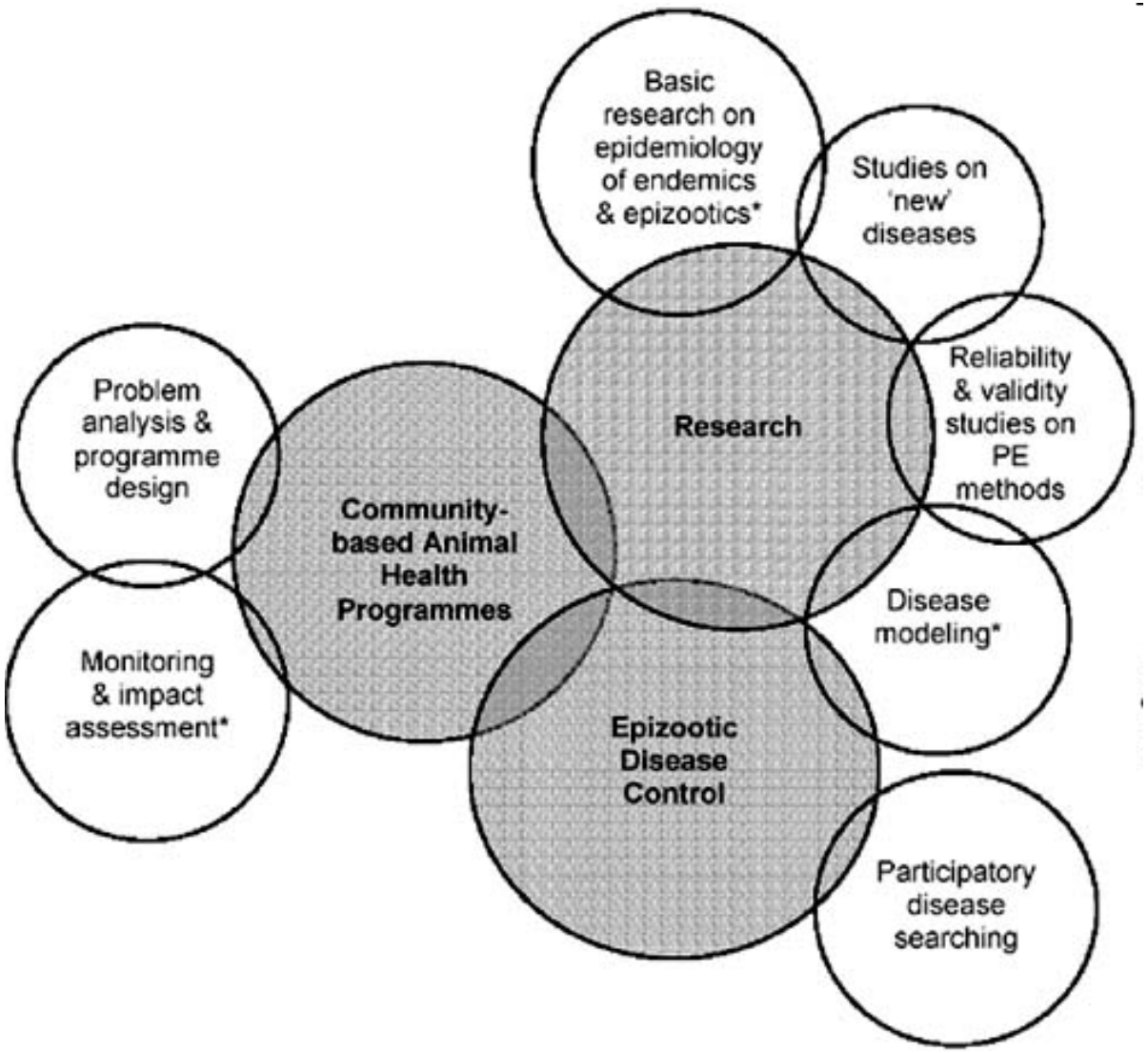
Some history of epidemiology



Sir Ronald Ross

British medical doctor who received the Nobel Prize for Physiology or Medicine in 1902 for his work on malaria,

Epidemiology



Kermack and McKendrick

Bulletin of Mathematical Biology Vol. 53, No. 1/2, pp. 89–118, 1991.
Printed in Great Britain.

0092-8240/91$3.00+0.00
Pergamon Press plc
Society for Mathematical Biology

CONTRIBUTIONS TO THE MATHEMATICAL THEORY OF EPIDEMICS—III. FURTHER STUDIES OF THE PROBLEM OF ENDEMICITY*

W. O. KERMACK and A. G. MCKENDRICK
Laboratory of the Royal College of Physicians,
Edinburgh, U.K.

1. Introduction. In a previous paper (Kermack and McKendrick, 1932) an attempt was made to treat from a general point of view the problem of a single disease in a population which consisted of three categories of people—namely, never infected, sick and recovered—and in which the infectivity of the disease was a function of the period of illness, whilst the susceptibility of a recovered person was a function of the period which had elapsed since the time of his recovery. New individuals entering the population either by birth or by immigration naturally entered the category of the never infected which for convenience we called "virgins". It was pointed out that the results obtained were subject to two important limitations: (1) that the disease under consideration was the only cause of death; (2) that the age of the individuals did not affect their infectivity, susceptibility or reproductiveness.

It is the purpose of the present paper to remove the first of these limitations

Fig. 16.1 McKendrick (1876–1943) and Kermack (1898-1970)

Mathematical hypothesis about how infectious diseases spread through a population.

Building on the research of Ross and others, McKendrick and Kermack published their theory in a set of three articles from 1927, 1932, and 1933.

COVID Modelling the in News

Schools 'may need to close to control new variant'

Variant spreads 56% faster and may need tougher measures to control, a study suggests.

24 Dec 2020 | News | Health

www.france24.com › France 24 › Europe

Covid-19: New scientific model can predict virus peaks of ...

Sep 25, 2020 — **Covid**-19: New scientific model can predict virus peaks of ... **France** may not have long to wait as the next peak is predicted for the beginning of October. ... Compared to **mathematical models** traditionally used in epidemiology, "there are far fewer parameters ...

www.ft.com › content

Neil Ferguson, a virus modeller sounds the alarm

Mar 20, 2020 — The epidemiologist and his team revealed the UK's **coronavirus** ... It was sobering **news** from the bespectacled 51-year-old, one of the first global experts to warn at the start of this year that the outbreak in the Chinese city of **Wuhan** could ... ...

www.cnrs.fr › europe-modelling-evolution-second-wav...

Europe: Modelling the Evolution of a Second Wave of Covid ...

Sep 23, 2020 — ... Federico II, have developed a new **mathematical model** inspired by high energy physics to predict the next waves of the **Covid**-19 pandemic. ... Press · CNRS **News** · Documentation · Recruitment · Directory · Intranet ... of infections will take place in **France**, the simulations underscore the importance of ...

Provincial modelling says Quebec can cope with coronavirus variants if people follow the rules | CBC News

A lot hinges on continued adherence to public health measures and how many variants were imported by travelers in December and early January. The INSPQ says Quebec is in a "very favourable" situation right now, but it could go off the rails quickly.

February 17

New coronavirus variant could dominate in Ontario by next month, model shows | CBC News

There's a race underway by public health officials across Ontario to assess how much of the highly transmissible variant first reported in the United Kingdom is now in the community, in order to keep it at bay until widespread COVID-19 vaccinations get underway.

January 9

CNN

Covid-19 deaths will rise almost 80% by February, researchers foresee

(CNN) As the number of coronavirus cases in the United States ... That model, released five days ago, projected about 395,000 deaths by ...

Oct 15, 2020

News

About 255,000 results (0.59 seconds)

Physical distancing until September could save nearly 100000 ...
CTV News - Apr. 30, 2020
SHARE. KITCHENER – A new **mathematical model** suggests that extending physical distancing ... Tracking every case of **COVID-19** in **Canada**.
University of Waterloo study says continuing social distancing ...
Waterloo Chronicle - Apr. 30, 2020
View all

COVID-19 models released by governments are 'not a crystal ...
Globalnews.ca - Apr. 10, 2020
While the data may appear grim, a **Canadian mathematics** professor cautions the public while analyzing the numbers as they are just scenarios ...

Coronavirus spread slowing in Canada; death rate rises due ...
Globalnews.ca - Apr. 28, 2020
However, while the **COVID-19** fatality rate was initially calculated as roughly 2.2 per ... The new **models** suggest the country could see total deaths hit ... has repeatedly been questioned by infectious disease and **mathematical** ...

Canada may have 100000 more COVID-19 cases than the ...
Macleans.ca - Apr. 6, 2020
Canada may have 100,000 more **COVID-19** cases than the numbers ... from the Centre For **Mathematical Modeling** of Infectious Diseases).

How to interpret COVID-19 disease models and projections
CBC.ca - Apr. 4, 2020
How to interpret **COVID-19** disease **models** and projections ... **Models** are **mathematical** representations that are often simplified to help us understand ... Deonandan said **Canadian** health officials haven't answered how long ...

Better late than never? What to expect from COVID-19 ...
CBC.ca - Apr. 22, 2020
What to expect from **COVID-19** modelling — if Manitoba ever reveals it ... government, which showed **Canadians** projections two weeks ago of ... The expert in **mathematical models** of pandemic growth and control ...

Questions:

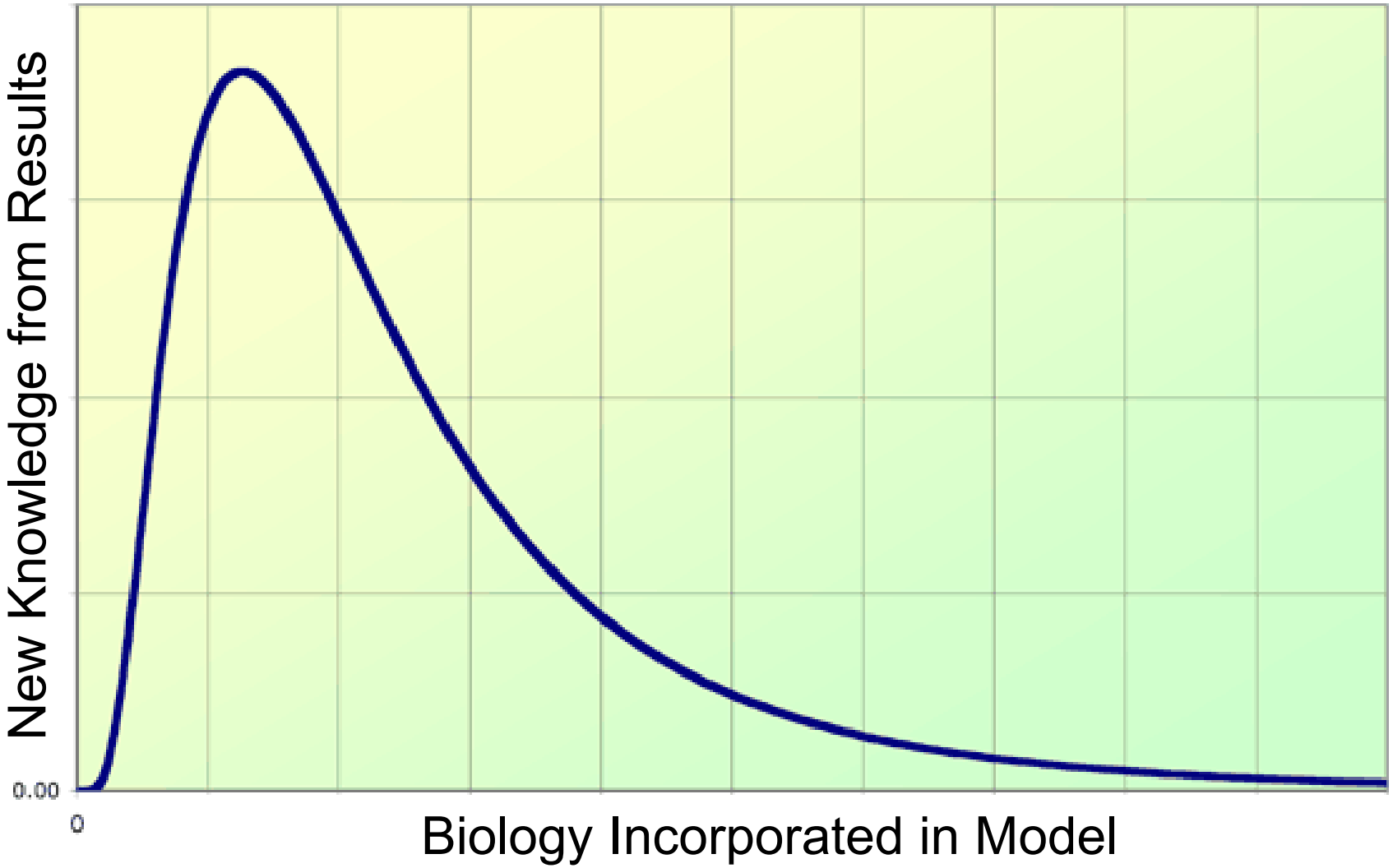
What's in a model?
What do you do?
What do you look for?
What data do you use?

What mathematical tools do you use?
Are models right?
If a model is wrong, what does that mean?

Learning Goals

- Understand the basic model structure underlying all models of infectious diseases
- Gain understanding
  - ‘reproduction number’
  - ‘herd immunity’
  - ‘social distancing’
  - ‘heterogeneity’
  - etc
- Increased proficiency in
  - Reading and discussing modelling papers with an understanding and critical eye
  - Interpreting news stories involving infectious disease models

More vs. More


New Knowledge from Results
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Biology Incorporated in Model