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Title: Introduction to Infectious Disease Dynamics, Part I

Attribution: Dr. Juliet Pulliam, Topics in Biomedical Sciences

Source URL: [http://lalashan.mcmaster.ca/theobio/mmed/index.php/Honours Course](http://lalashan.mcmaster.ca/theobio/mmed/index.php/Honours_Course)

For further information please contact Dr. Juliet Pulliam (juliet.mmed.clinic@gmail.com).

Introduction to infectious disease dynamics I

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Introduction to Biomedical Sciences
BSc Honours Course in Biomathematics
African Institute for the Mathematical Sciences
Muizenberg, South Africa
17 May 2010

Infectious diseases

Terminology



Exposed

Exposure -
potentially
infectious
contact between
a parasitic
organism and a
potential host

Infectious diseases

Terminology



A Venn diagram consisting of two concentric circles. The outer circle is white and labeled 'Exposed'. The inner circle is light blue and labeled 'Infected'. The inner circle is entirely contained within the outer circle, illustrating that all infected individuals are also exposed.

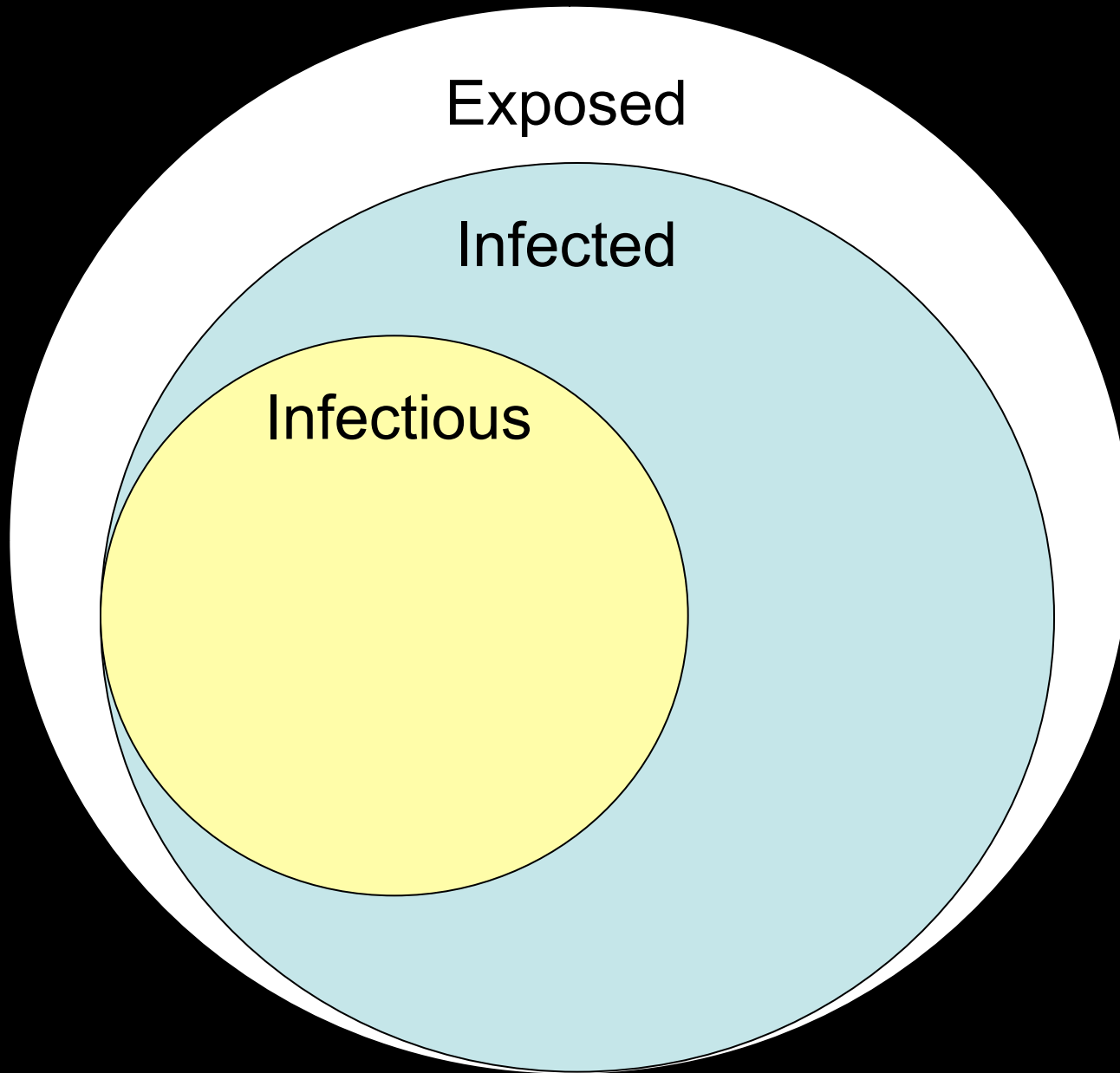
Exposed

Infected

Infection - a
parasitic
organism enters
a host

Infectious diseases

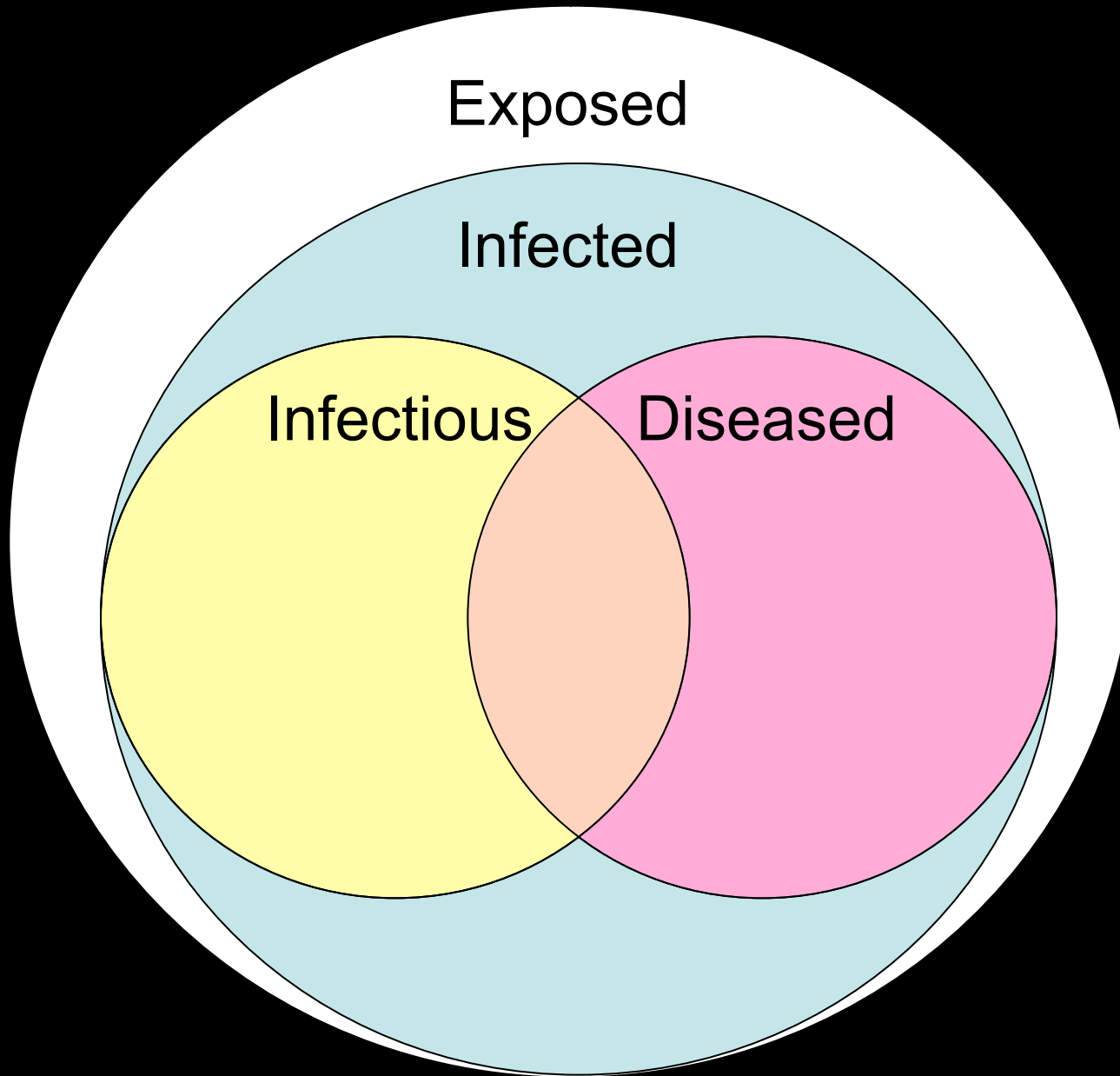
Terminology



Transmission - a parasitic organism replicates within an infected host, and the infected host sheds infectious individuals (the host is said to be “infectious” or “transmitting”)

Infectious diseases

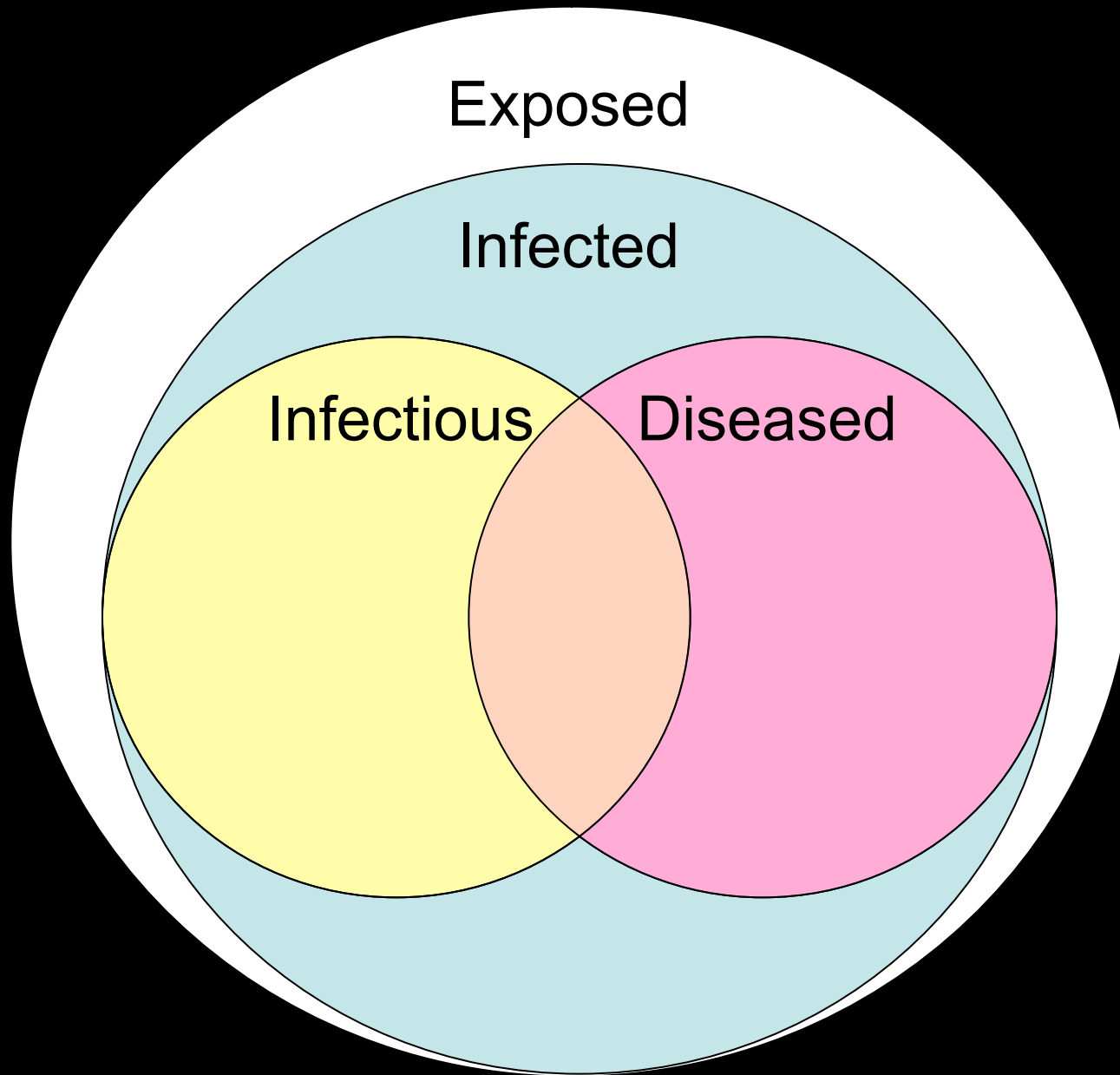
Terminology



Pathogenesis -
a parasitic
organism
causes changes
in the physiology
of an infected
host, affecting
survival and/or
reproduction
(the host is said
to be
“diseased”)

Infectious diseases

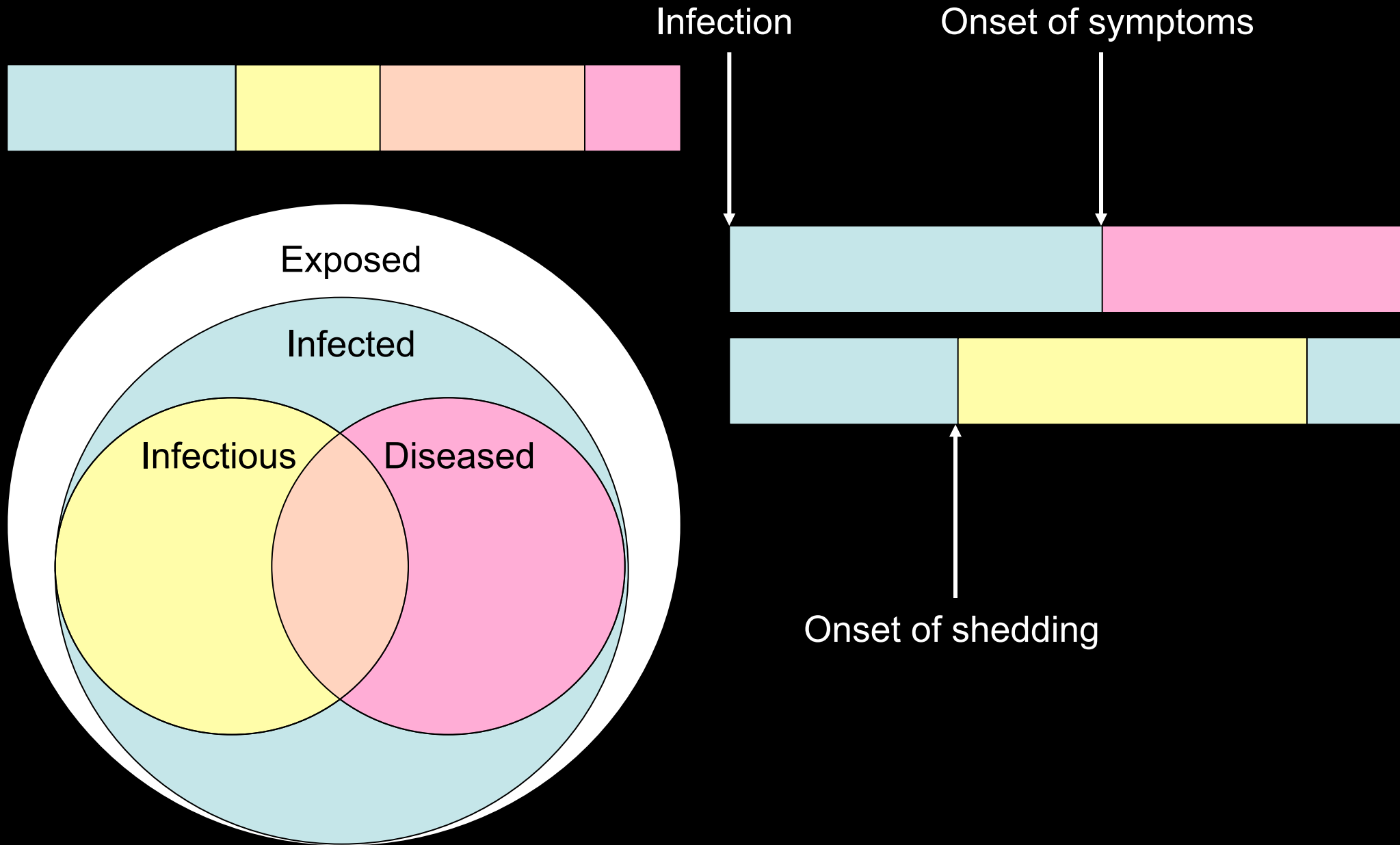
Terminology



Infectious disease dynamics are determined -- to a large extent -- by the duration of these states, as well as the degree and timing of overlap

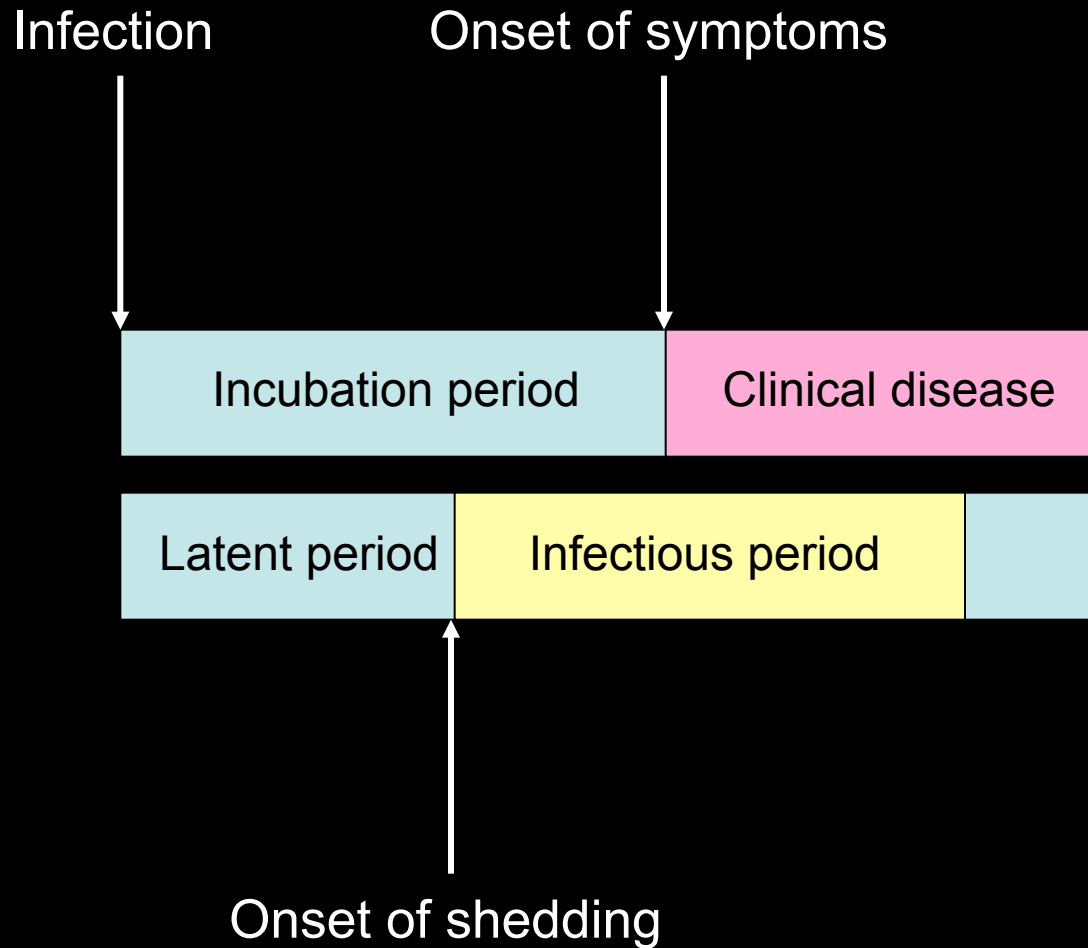
Infectious diseases

Terminology



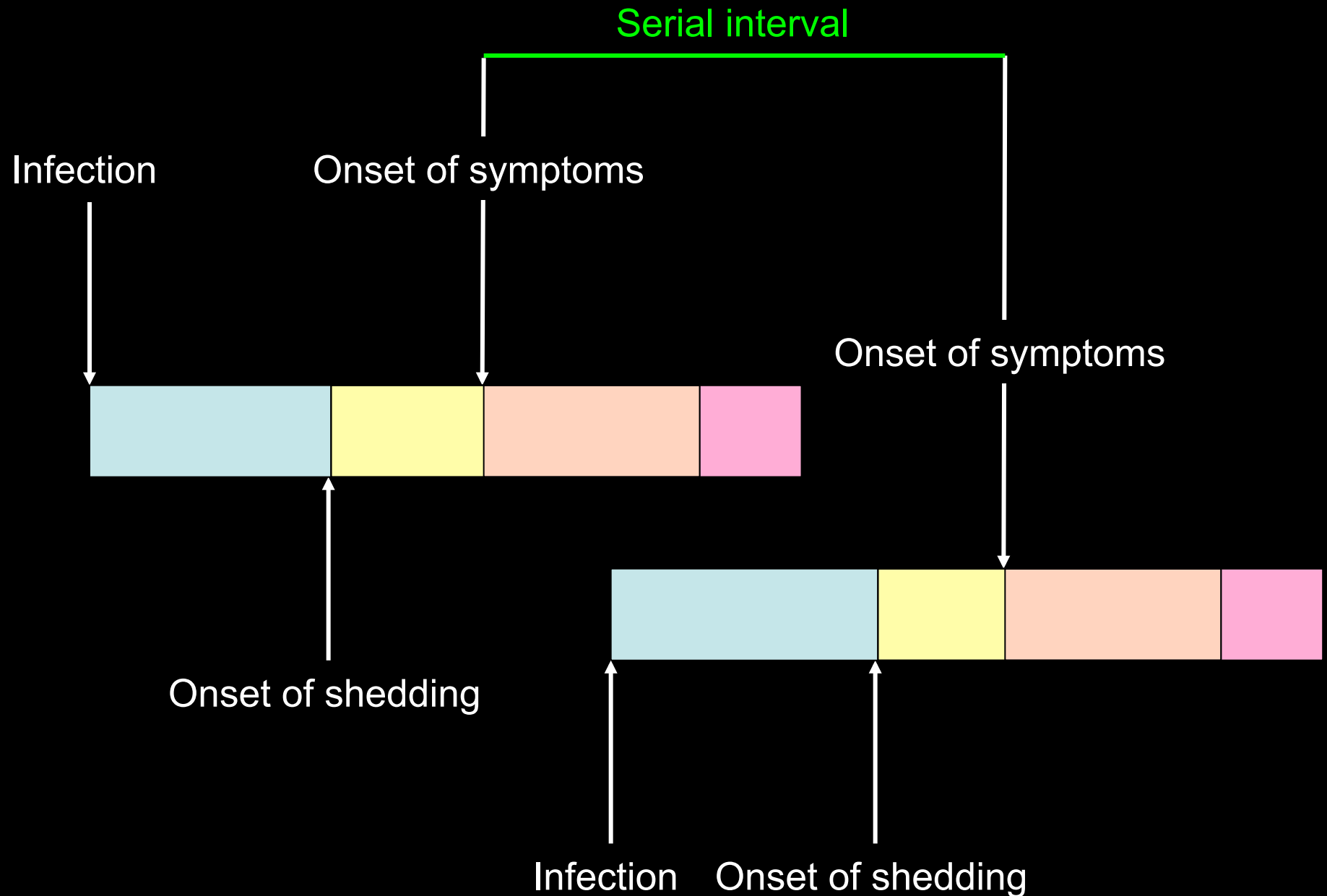
Infectious diseases

Terminology



Infectious diseases

Terminology



Infectious diseases

Transmission

Mode of transmission

Direct transmission

Direct contact

Droplet spread

Indirect transmission

Airborne

Vehicle-borne (fomites)

Vector-borne (mechanical or biological)

Portal of entry

Portal of exit

Infectious diseases

Immunity

Active immunity

Requires stimulation of antibody production

Response to many infections

Induced by most vaccines

Long-lasting

Passive immunity

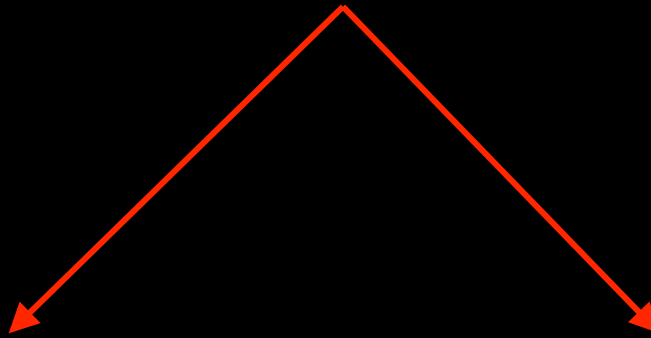
Presence of antibodies without stimulating
production

Maternal antibodies

Immunoglobulin injections

Transient

Infectious disease dynamics



Traditional epidemiology

Outbreak investigation

Disease surveillance

On-the-ground management

Mathematical epidemiology

General principles

Explanation of patterns

Prediction of spread and control

Assessment of necessary data

Shoe-leather epidemiology

Terminology

Endemic level of disease
("hyperendemic")

Epidemic

Disease outbreak

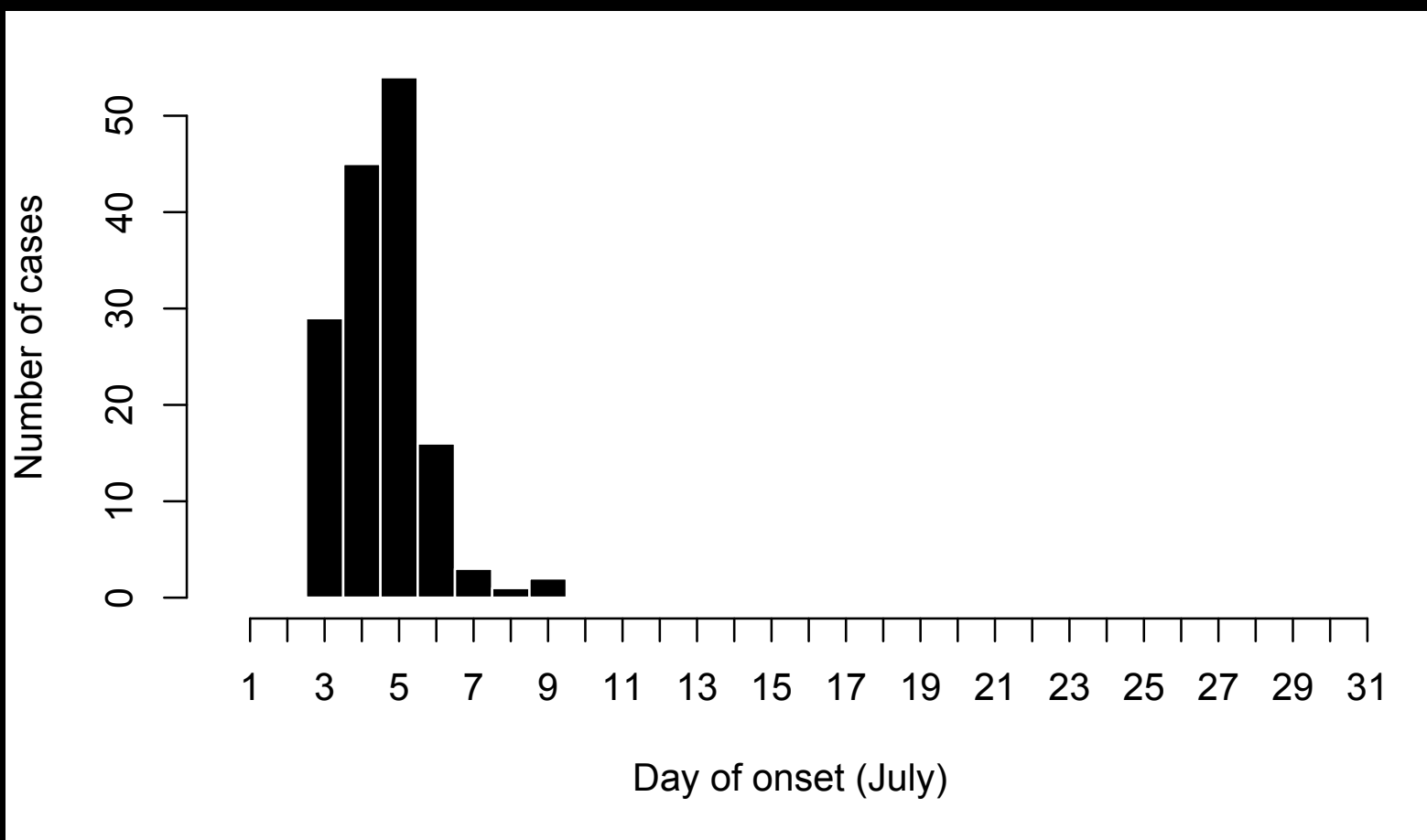
Pandemic

Sporadic cases and clusters

Shoe-leather epidemiology

Epidemic curves

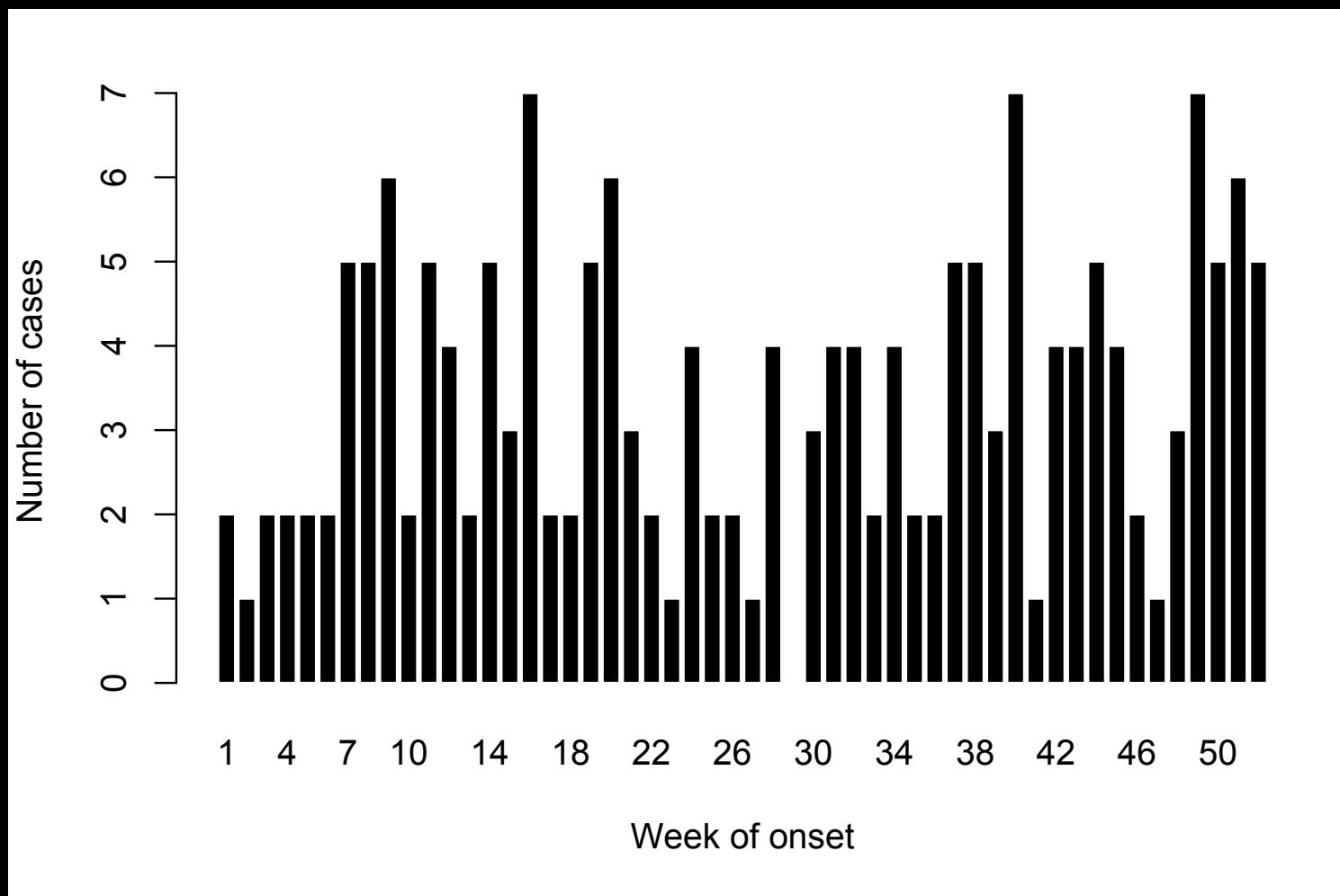
Common source epidemics
point source exposure



Shoe-leather epidemiology

Epidemic curves

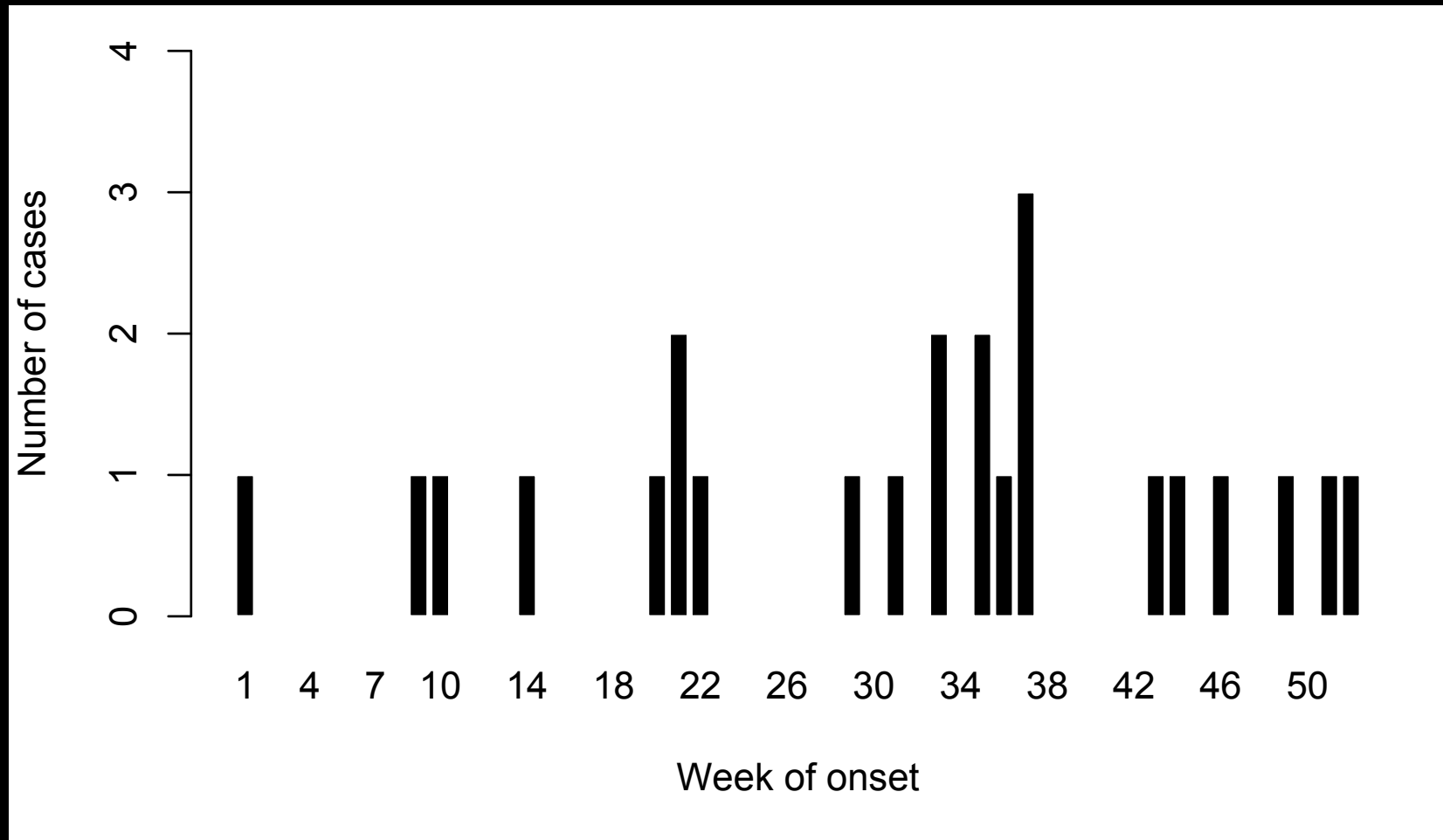
Common source epidemics
continuous exposure



Shoe-leather epidemiology

Epidemic curves

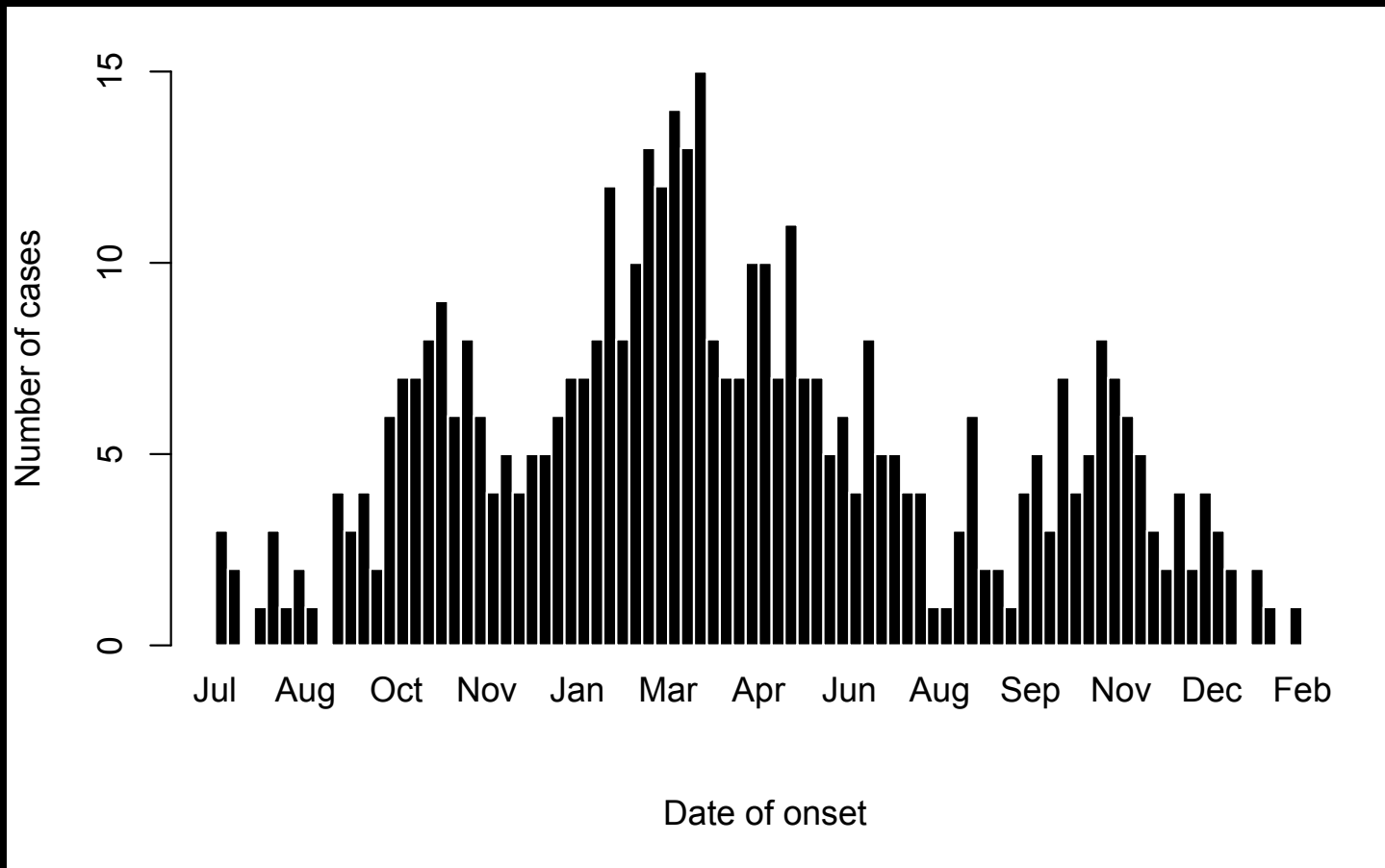
Common source epidemics
intermittent exposure



Shoe-leather epidemiology

Epidemic curves

Propagated epidemics



Simulated epidemic with $R_0=1.2$ in a population of 1500 individuals



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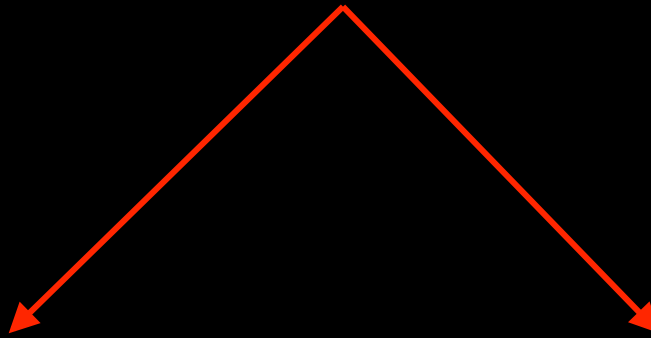
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Introduction to infectious disease dynamics II

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Infectious disease dynamics



Traditional epidemiology

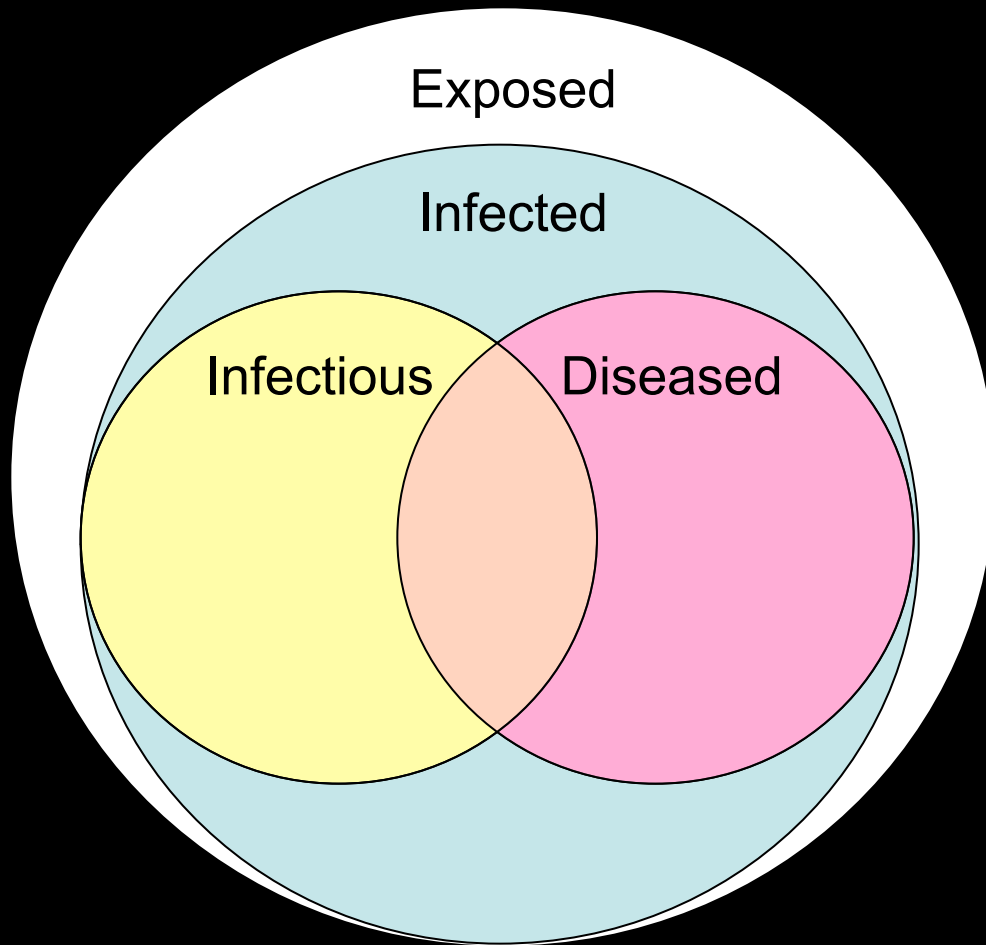
- Outbreak investigation
- Disease surveillance
- On-the-ground management

Mathematical epidemiology

- General principles
- Explanation of patterns
- Prediction of spread and control
- Assessment of necessary data

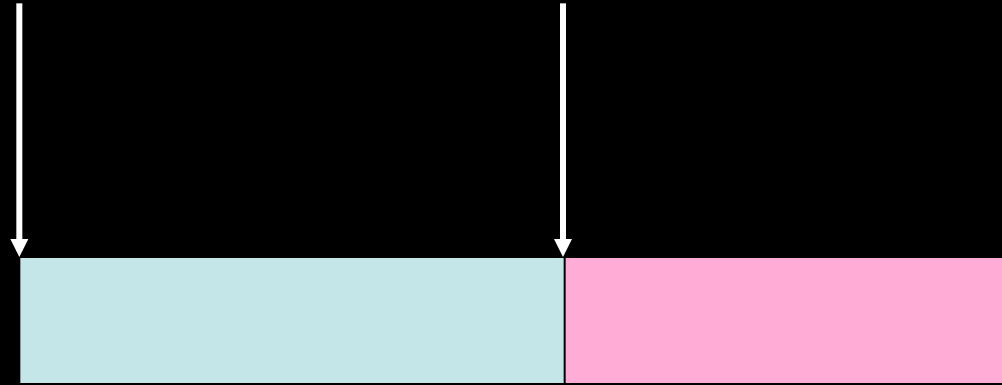
Infectious diseases

Terminology



Infection

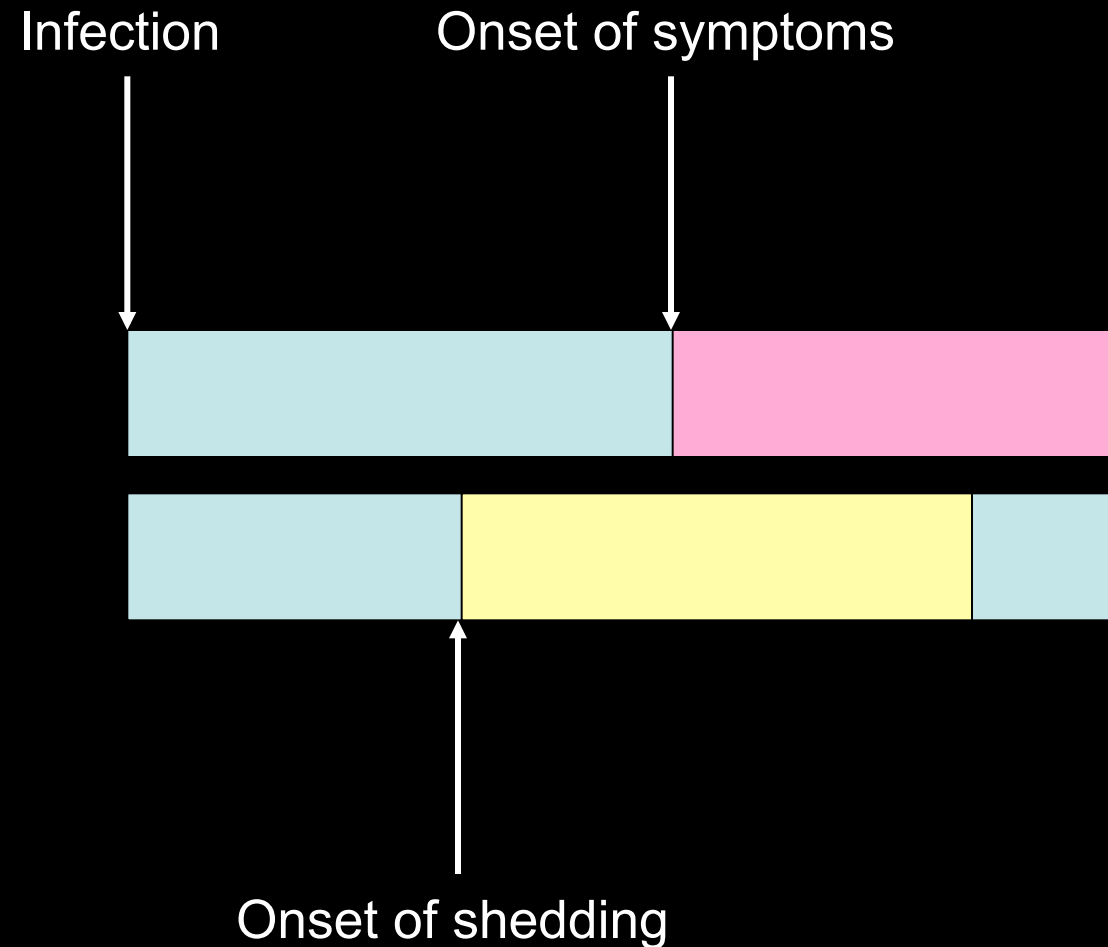
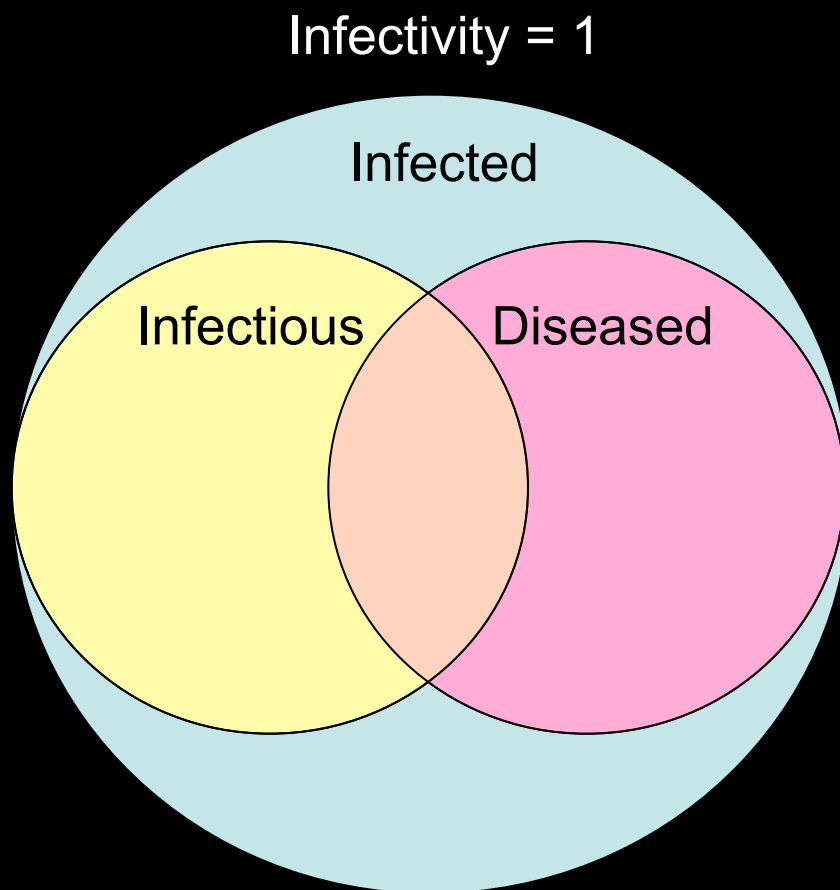
Onset of symptoms



Onset of shedding

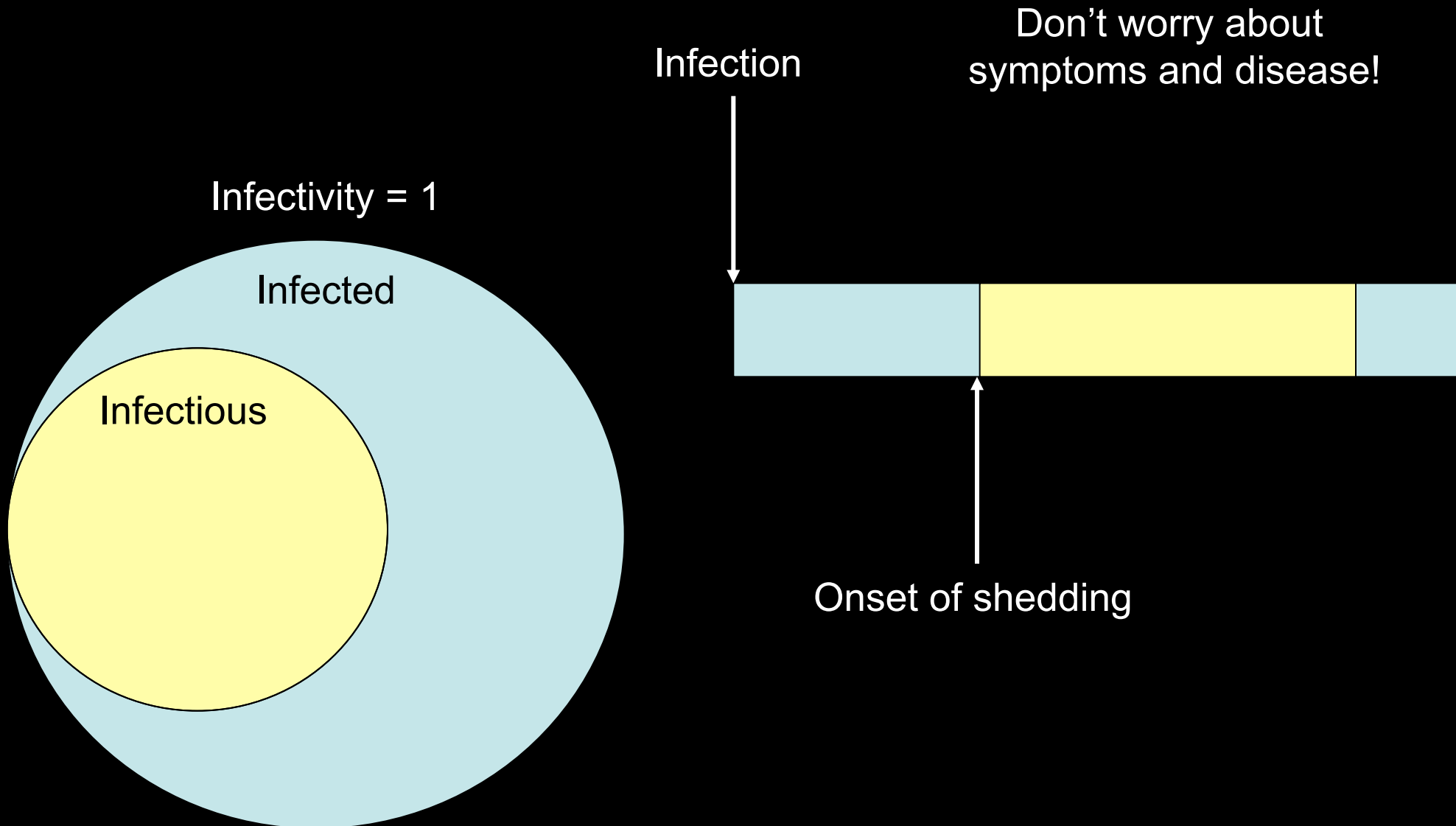
Infectious diseases

A simpler view of the world



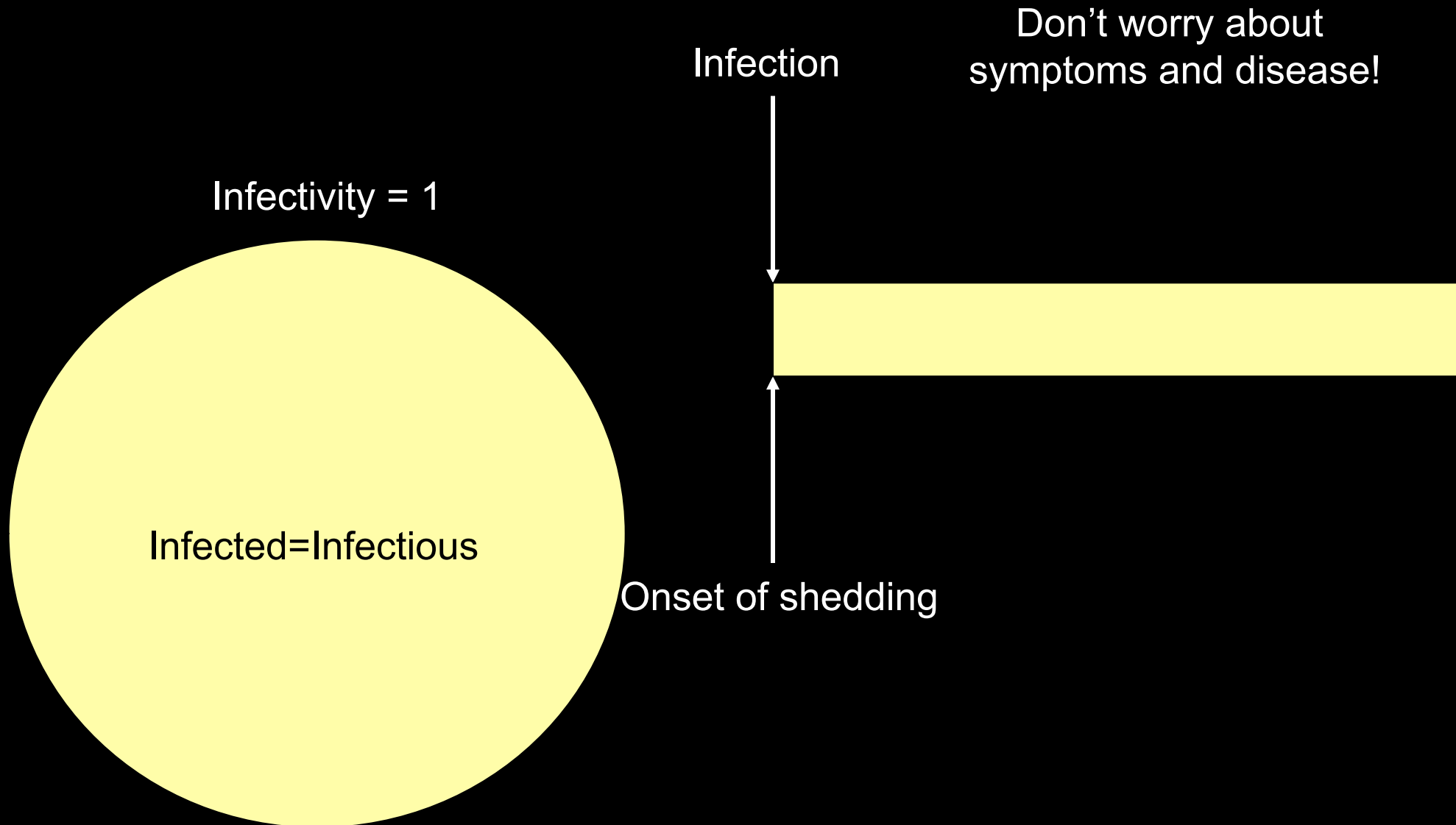
Infectious diseases

A simpler view of the world



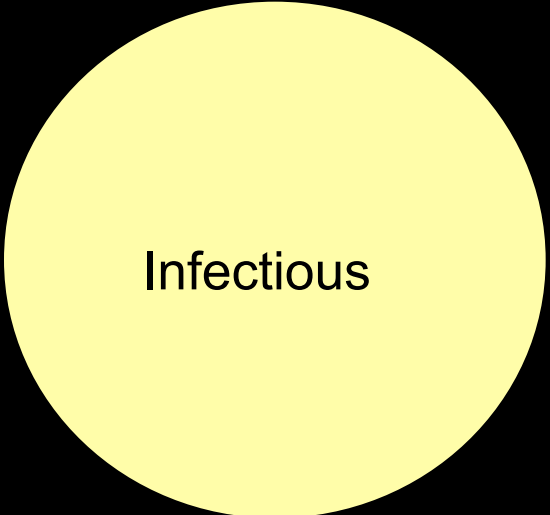
much! Infectious diseases

A simpler view of the world



Infectious diseases

much!
A simpler view of the world



Infectious

Infectious diseases

A simple view of the world



The diagram consists of three large, horizontally aligned circles on a black background. The leftmost circle is light blue and contains the word 'Susceptible'. The middle circle is yellow and contains the word 'Infectious'. The rightmost circle is light purple and contains the word 'Recovered'. All text is in a white, sans-serif font.

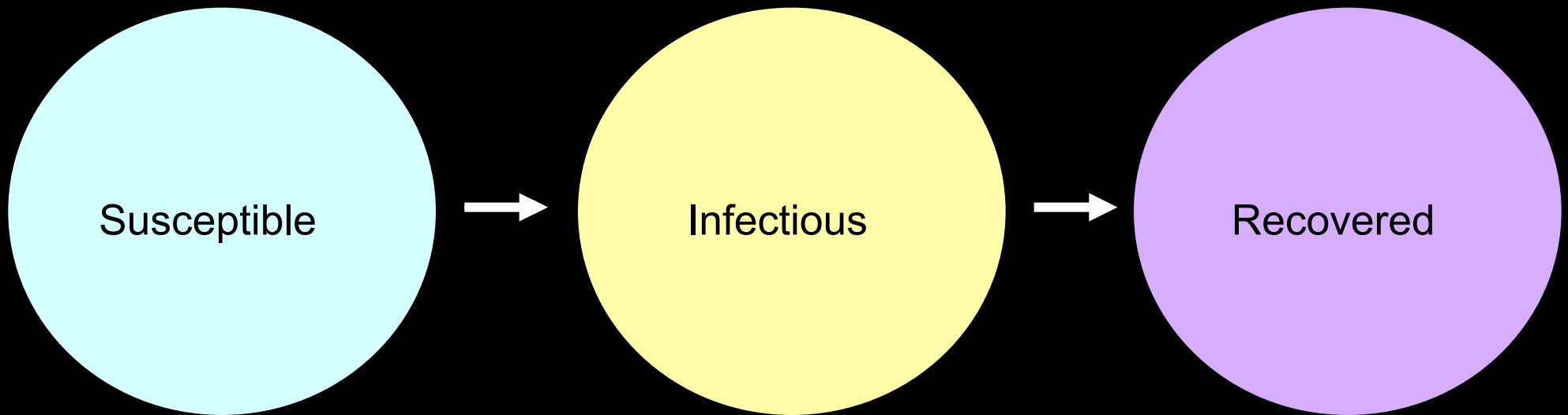
Susceptible

Infectious

Recovered

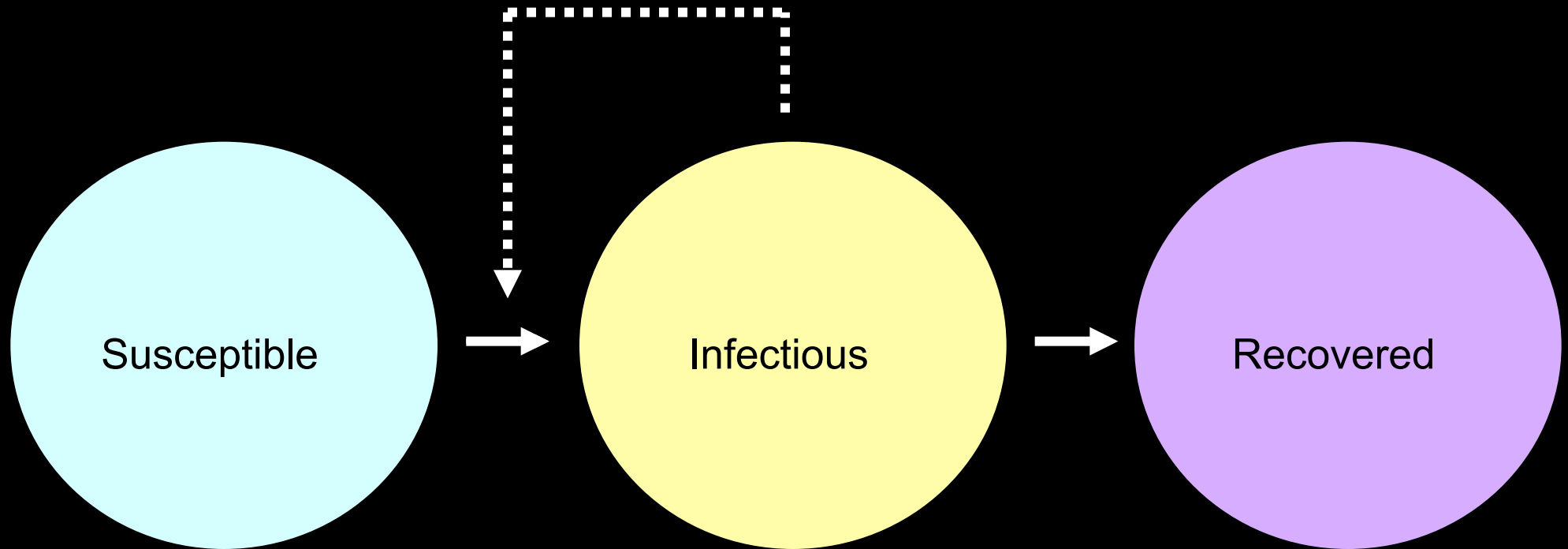
Infectious diseases

A simple view of the world



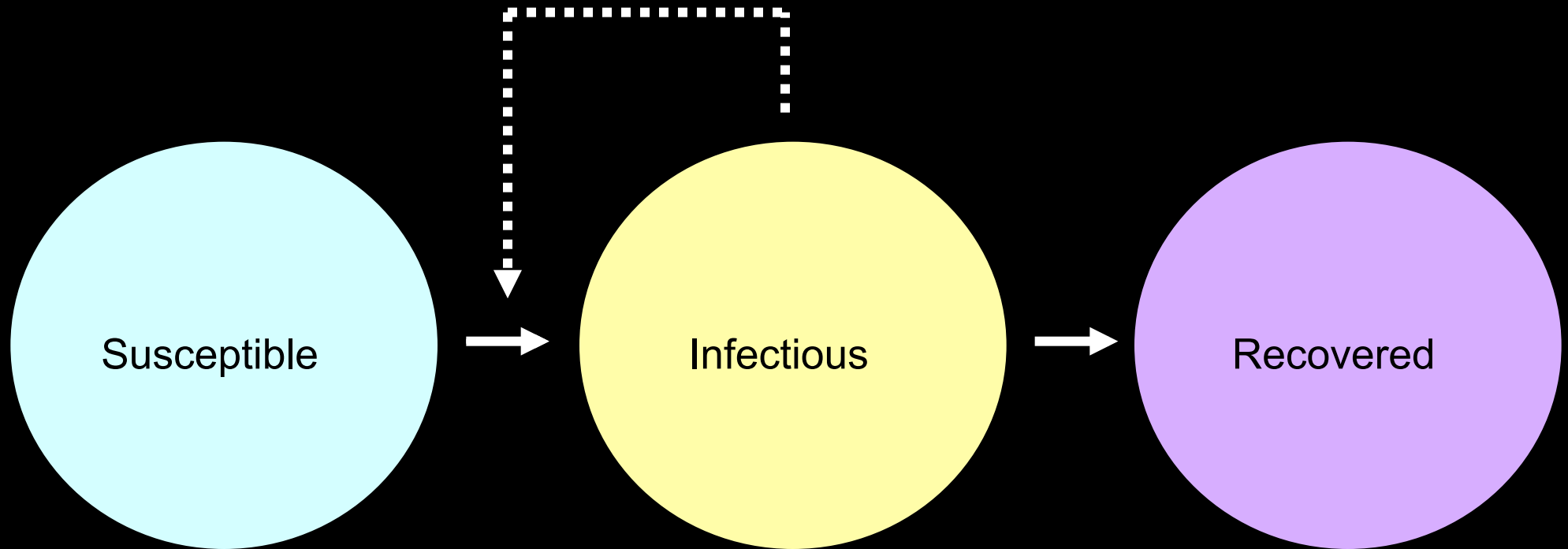
Infectious diseases

A simple view of the world



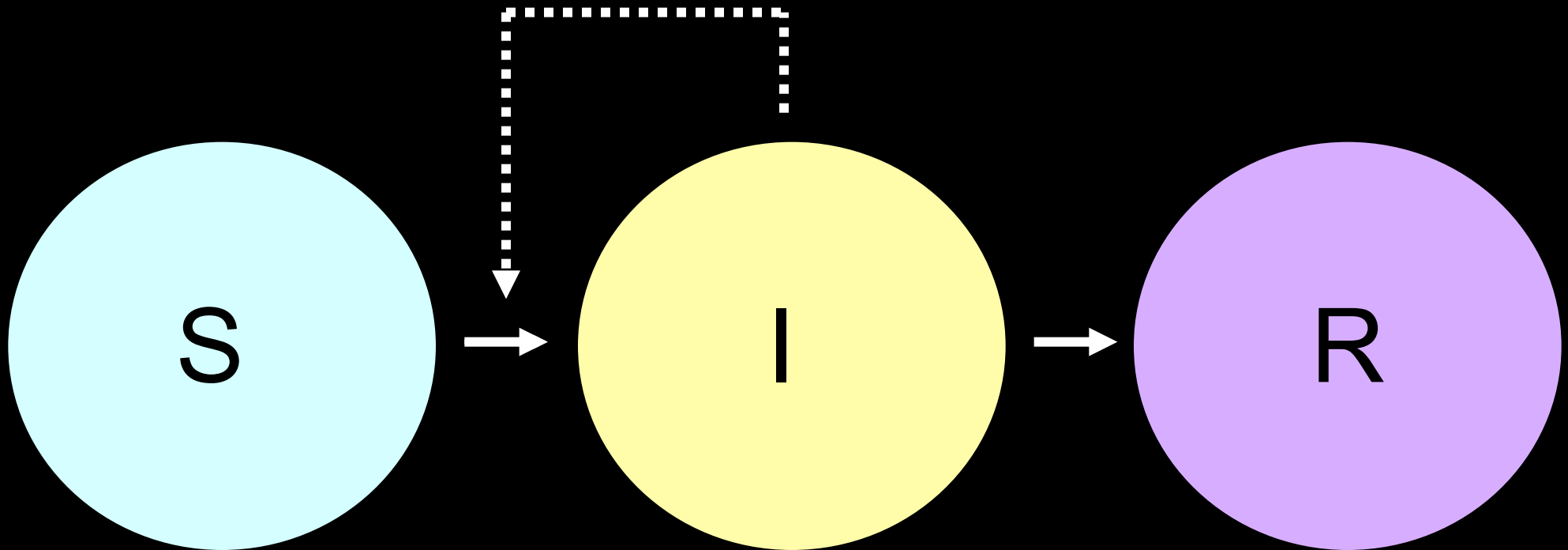
Infectious diseases

Health-related states



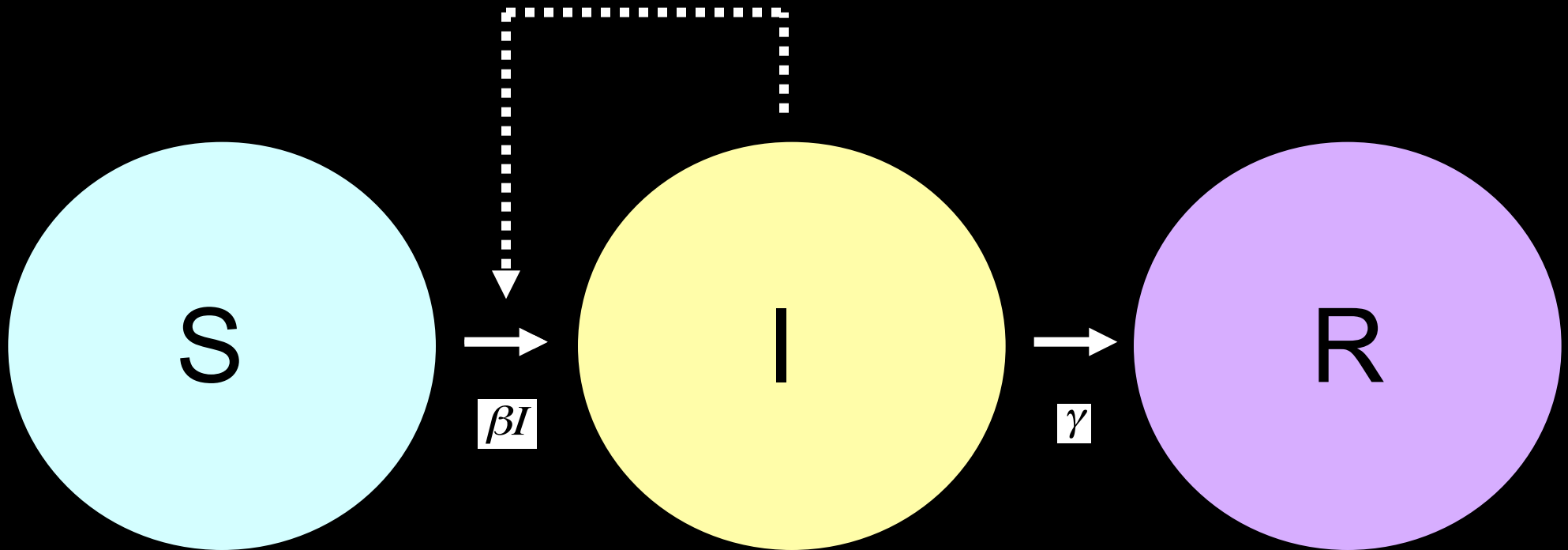
Infectious diseases

State variables



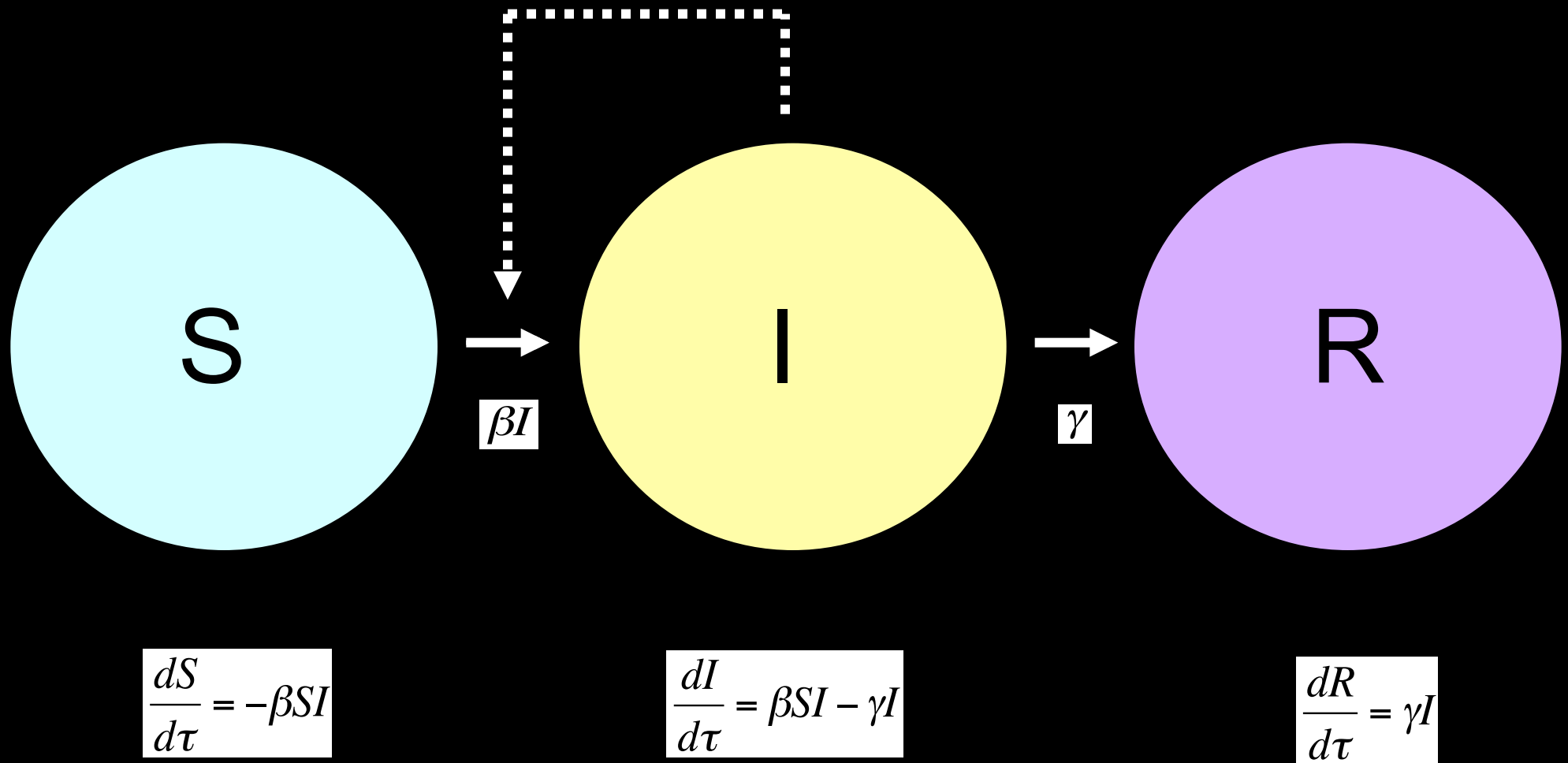
Infectious diseases

Transition rates



Infectious diseases

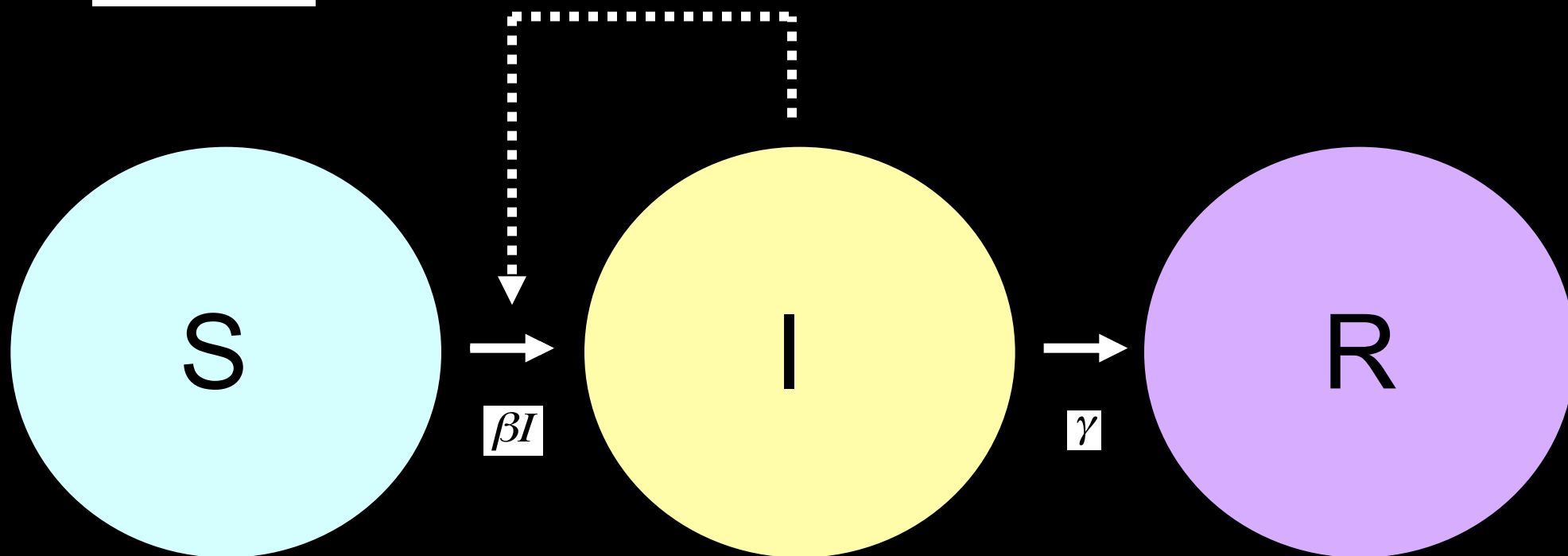
A simple disease model



Infectious diseases

A simple disease model

$$N = S + I + R$$



$$\frac{dS}{d\tau} = -\beta SI$$

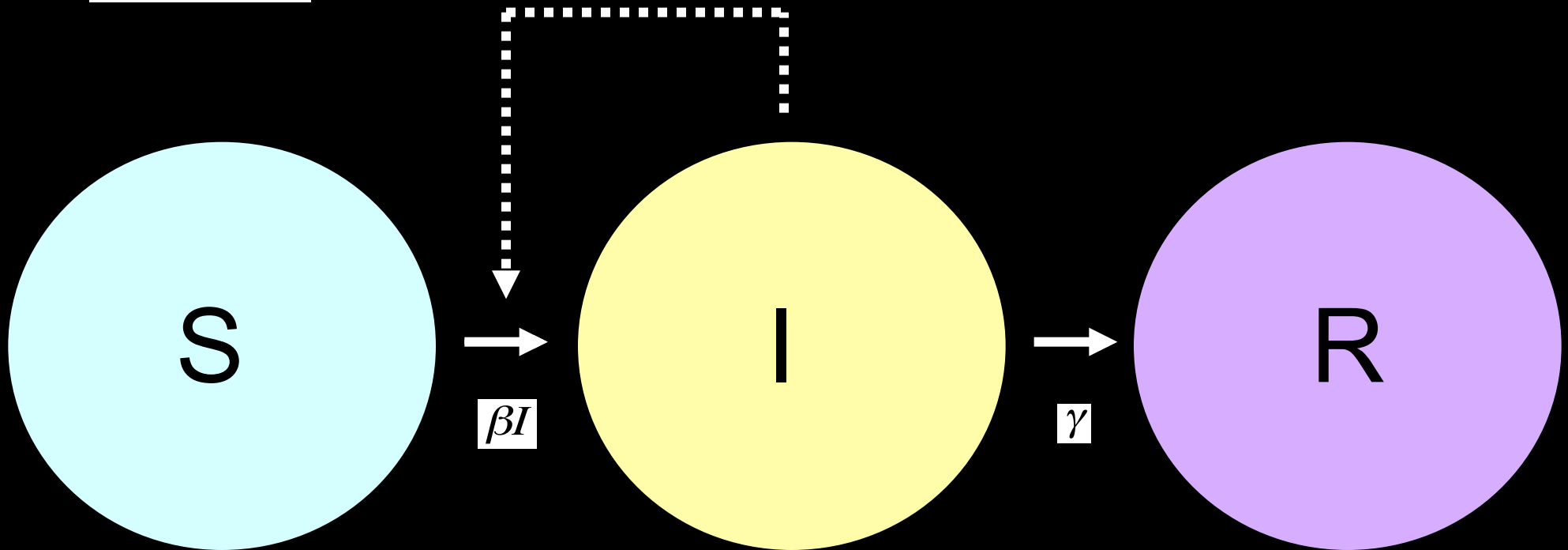
$$\frac{dI}{d\tau} = \beta SI - \gamma I$$

$$\frac{dR}{d\tau} = \gamma I$$

Infectious diseases

A simple disease model

$$N = S + I + R$$



$$\frac{dS}{dt} = -\frac{\beta SI}{\gamma}$$

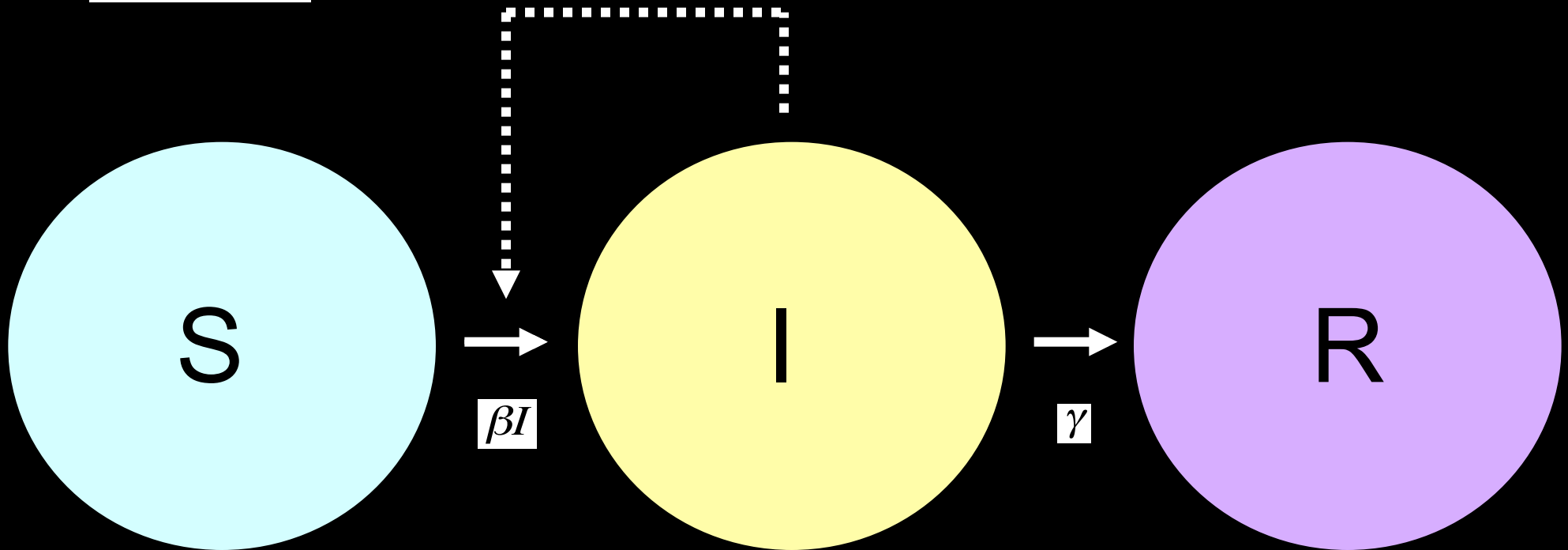
$$\frac{dI}{dt} = \frac{\beta SI}{\gamma} - I$$

$$\frac{dR}{dt} = I$$

Infectious diseases

A simple disease model

$$N = S + I + R$$



$$\frac{dS}{dt} = -\frac{\beta SI}{\gamma}$$

$$\frac{dI}{dt} = \frac{\beta SI}{\gamma} - I$$

