EMORY
ROLLINS SCHOOL OF PUBLIC HEALTH

Epidemiologic Concepts for ID Modeling

Session 1b

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Measures of natural history

Incubation period

- Time from exposure to the onset of clinical symptoms

Latent period

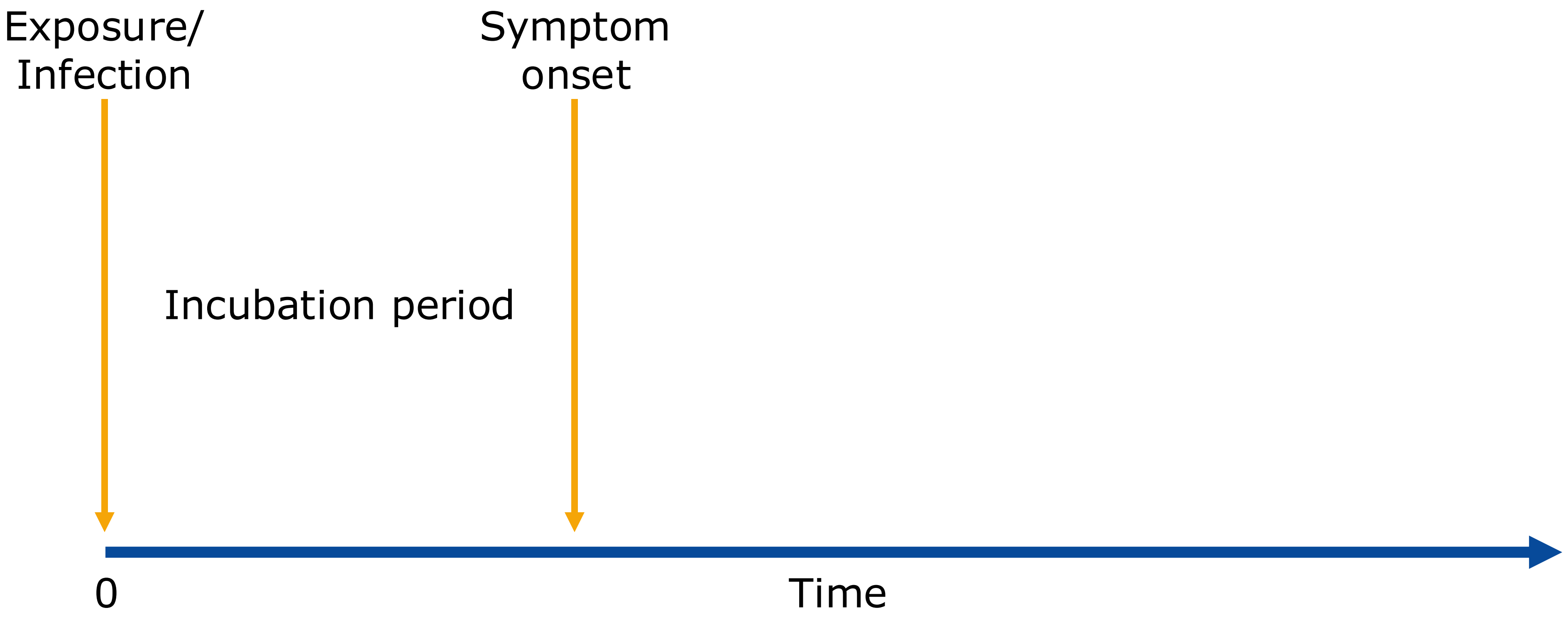
- Time from exposure to start of infectiousness

Infectious period

- Time during which an infected person can transmit to a susceptible host

The reproduction number, R, and herd immunity threshold

Incubation period



Incubation period: Why is it important?

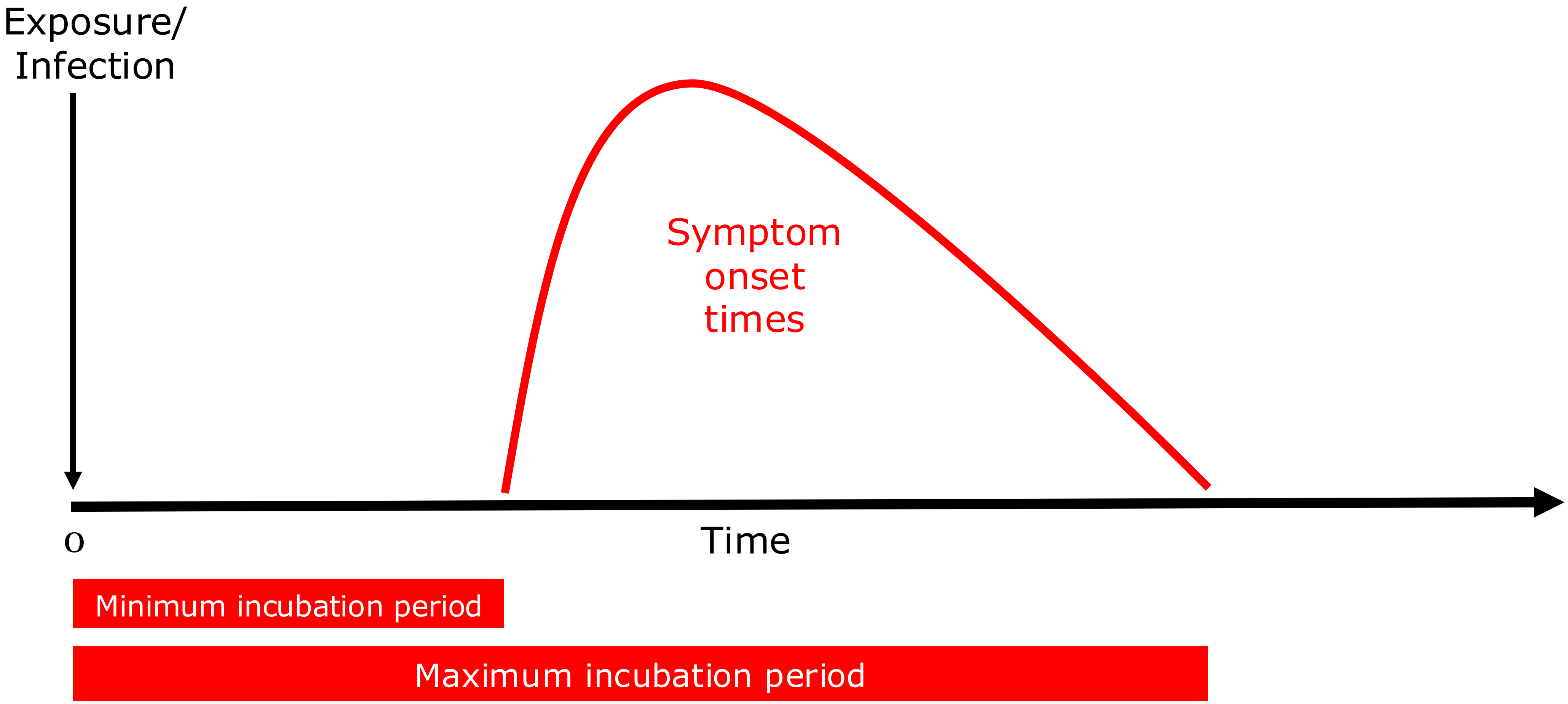
Need to measure

- Time of exposure/infection (hard)
- Time of onset of clinical symptoms (easier)

Can be affected by

- Infectious dose
- Route of infection
- Pathogen replication
- Host immune function

Incubation period



Latent period

Time from exposure/infection to start of infectiousness

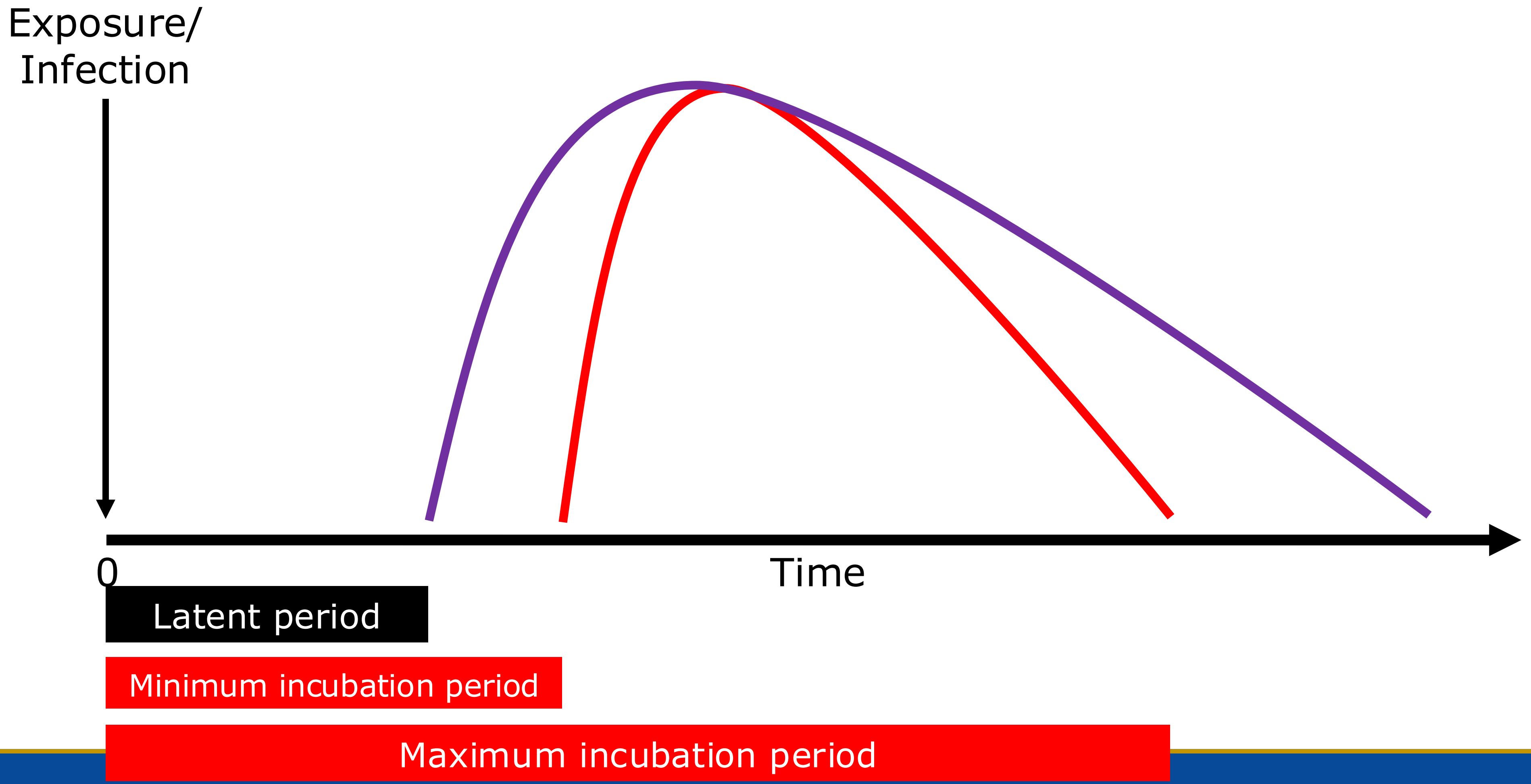
Need to measure

- Exposure
- Time of pathogen detection (?)

End of latent period can…

- precede symptoms
- be strongly associated with symptoms

Latent period



Infectious period

Time during which an infected person can transmit to a susceptible host

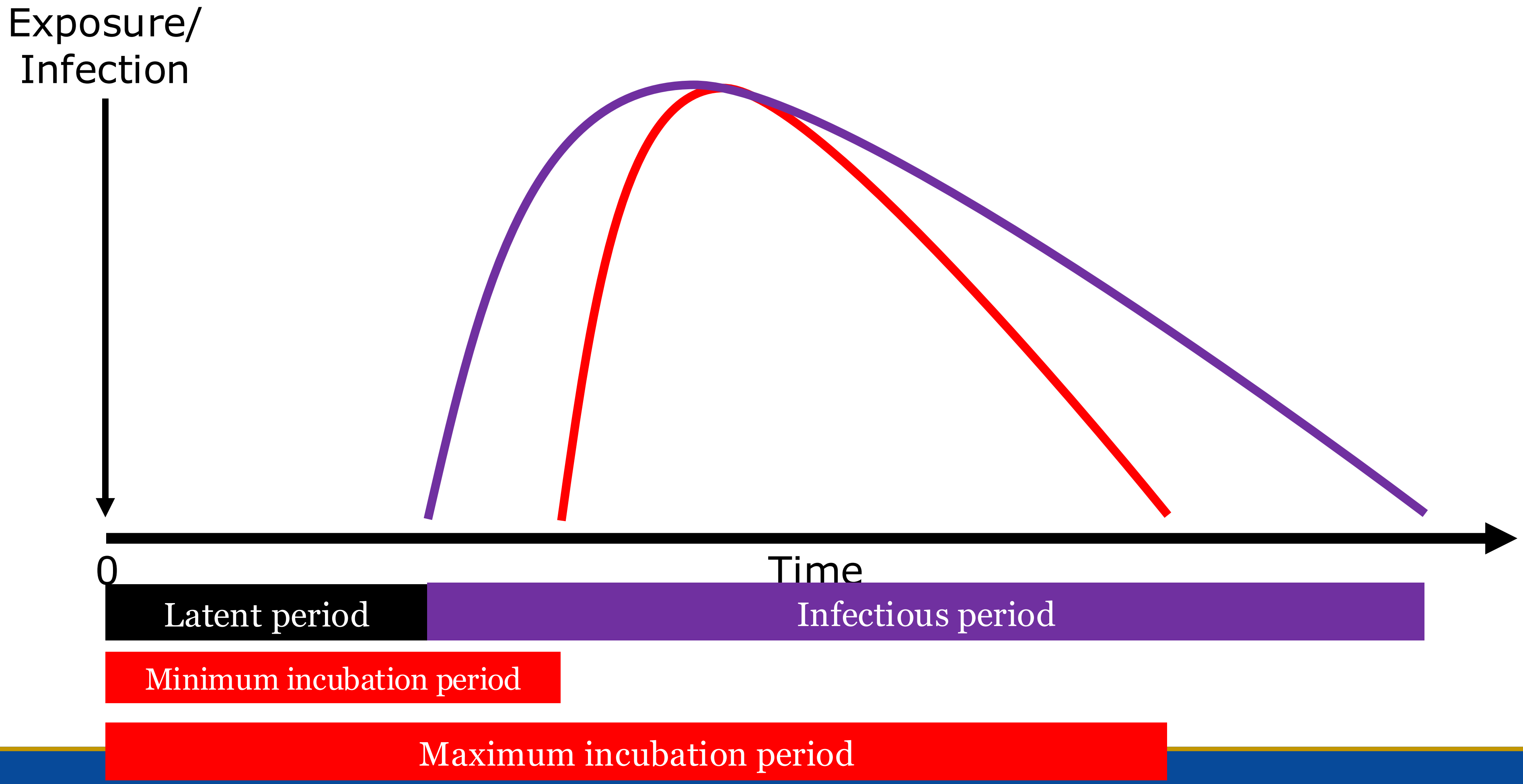
Need to measure

- Time of pathogen detection
- Secondary transmission events (contacts leading to secondary infections)

Can…

- precede symptoms
- be strongly associated with symptoms
- continue after symptoms end

Infectious period



Incubation and latent periods: Why are they important?

Public health

- Setting quarantine / isolation periods
- Prospective / active case finding

Treatment

- Application of antiviral medications

Outbreak studies

- Identifying sources of infection, epidemiology of a new pathogen

Modeling studies

- A critical parameter to predicting spread: **are people infectious prior to symptom onset?**

Over to you....

We often assume that infectiousness is uniform across the infectious period.

What are some reasons that might not be true?

Give an example when people are **more/less** infectious because of symptoms?

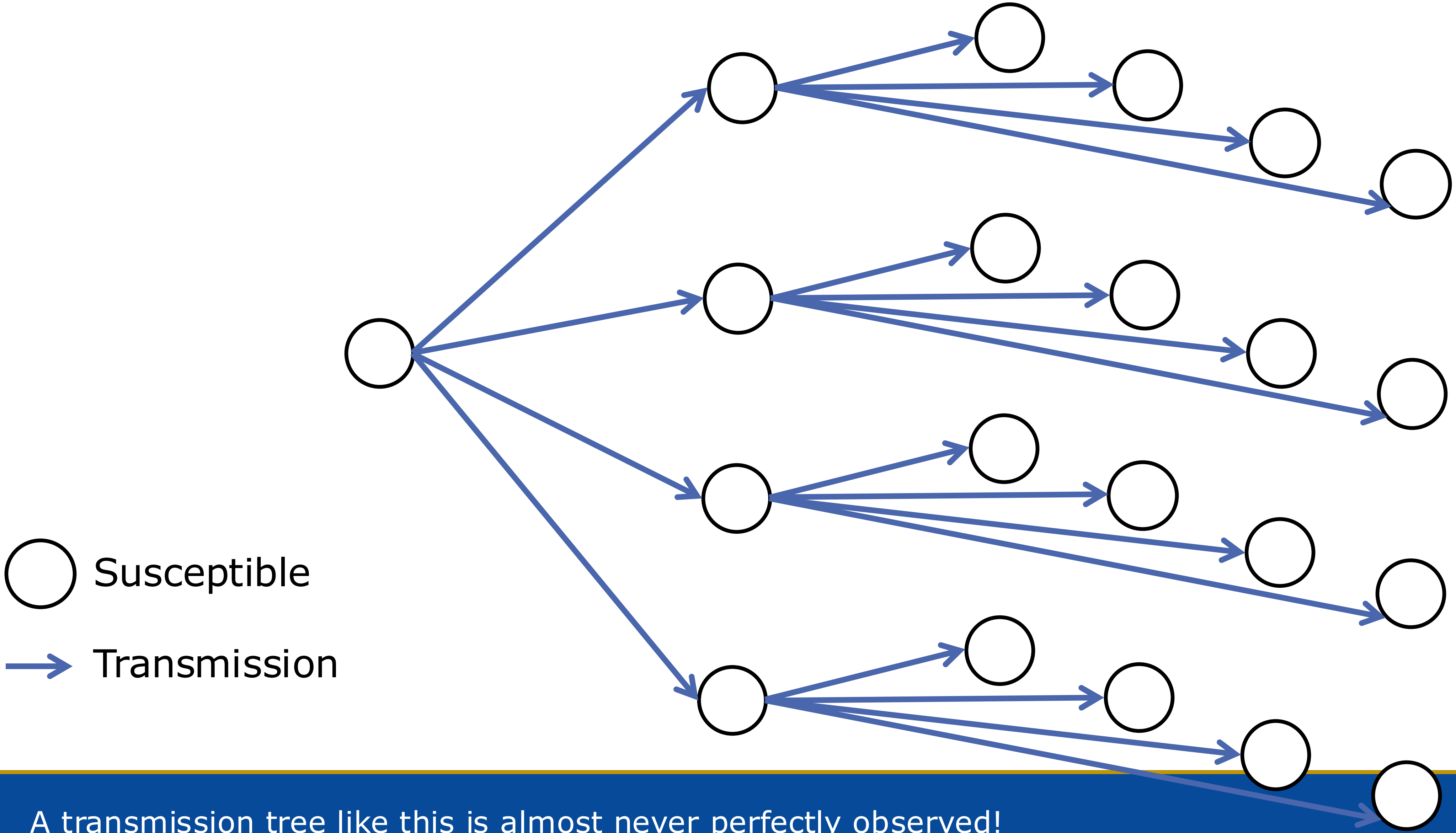
Assumptions about changing behavior sometimes incorporated in models, but not always.

Basic reproduction number, R_0

The average number of secondary infectious cases infected by a single infectious person when entering a **<u>totally susceptible population</u>**

When $R_0 > 1$ an epidemic (on average) will occur

Transmission of an infection with $R_0 = 4$



A transmission tree like this is almost never perfectly observed!

Why do we want to know R_0?

- Determines **how quickly infection will spread**
- To calculate the **expected final size** of an epidemic
  - (i.e., how many cases will there be?)
- To model/predict
  - when the epidemic will peak and
  - expected impact of control measures

R_0 of selected diseases

Disease	Transmission	R_0
Measles	Airborne	12–18
Diphtheria	Saliva	6–7
Smallpox	Airborne droplet	5–7
Polio	Fecal-oral route	5–7
Rubella	Airborne droplet	5–7
Mumps	Airborne droplet	4–7
HIV/AIDS	Sexual contact	2–5
Pertussis	Airborne droplet	5.5
COVID-19 (Delta variant)	Airborne droplet	5
SARS	Airborne droplet	2–5
Influenza (1918 pandemic strain)	Airborne droplet	2–3
COVID-19	Airborne droplet	2.5
Ebola (2014 Ebola outbreak)	Bodily fluids	1.5-2.5

https://en.wikipedia.org/wiki/Basic_reproduction_number

Calculating R_0

Basic reproduction number, R_0, from component parts

The rate of contact (a), e.g. 5 contacts/day

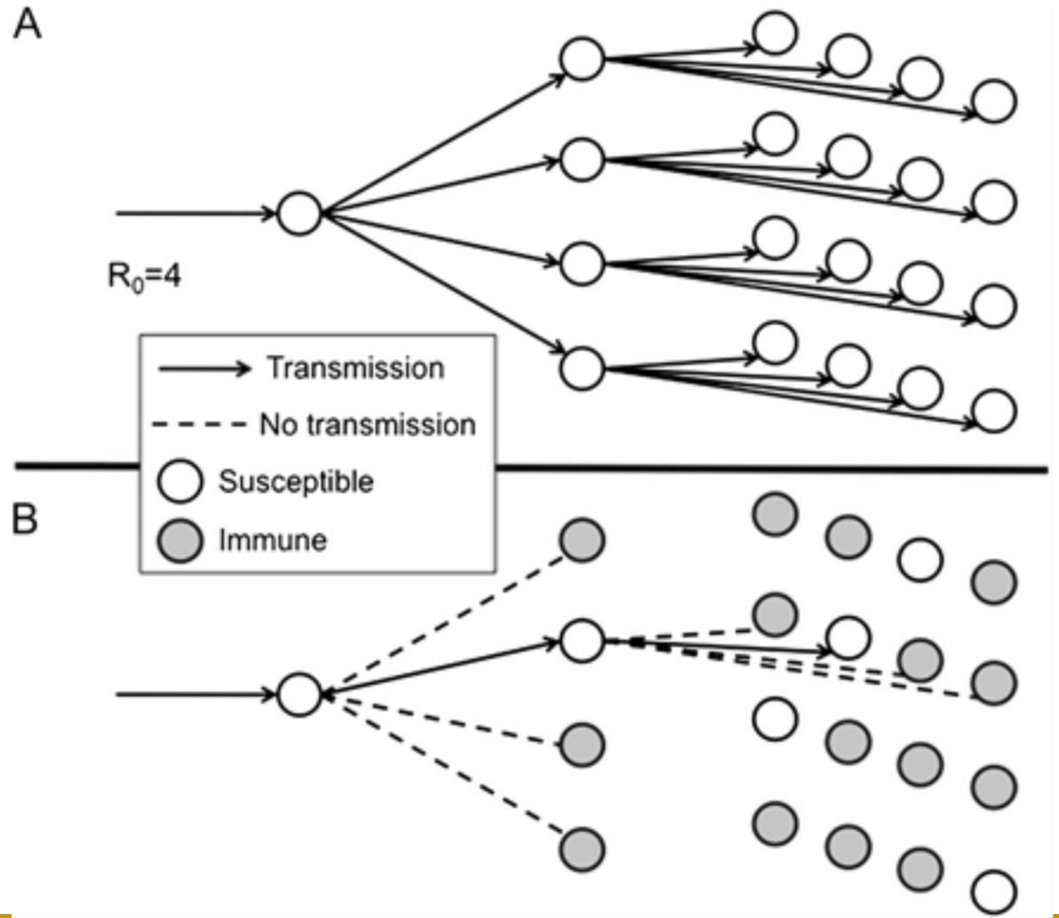
The duration of infection (d), e.g., 2 days

The probability that when an infectious and susceptible person come into contact, transmission occurs (β), e.g., 0.5 (50% probability of infection *given* contact)

So, in this case: $R_0 = \beta * a * d = 0.5*5*2 = 5$

Effective reproduction number, R_E

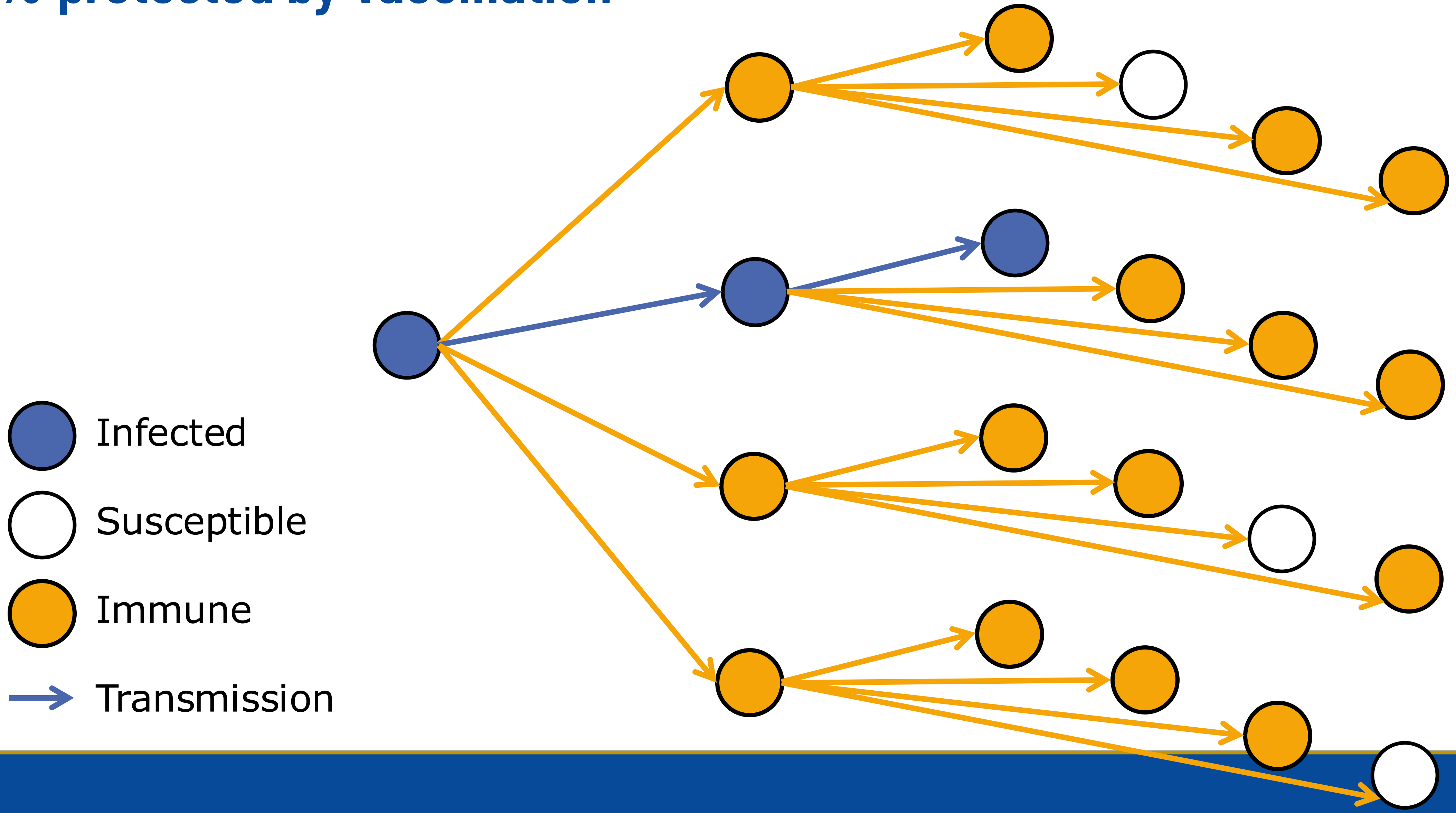
Effective reproduction number, R_E, is the **actual** number of successful transmissions per infectious person



$R_E = R_0 * s$

s = fraction susceptible

Transmission of an infection with Ro = 4, 75% protected by vaccination



Herd immunity threshold (HIT)

The proportion of the population that must be immune for an epidemic to start slowing down

- vaccination or previous infection (if infection confers immunity)

HIT = $1 - 1/R_0$

- The larger R_0, the higher the herd immunity threshold
- e.g., If $R_0 = 10$, HIT = .90

Questions?