Epidemiology & Disease Spread Concepts

for

NAADSM

Day #1, Session #2,
NAADSM Course, Fort Collins, Aug'07

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Session Outline

- Orientation of this session
- Reminder of overall objective
- Schematics of disease-spread-concepts for NAADSM
- Reproductive ratio R
- Key factors influencing R for NAADSM
- Segue to next topic of Monte-Carlo (variability and uncertainty)
- Place-holder for network session Fri.

Session Orientation & Overall Objective

Orientation Of This Session:

- Previous session re: two approaches to modeling
  - mathematical vs. simulation
- **This session:**
  - review of disease-spread-concepts at population level
- Lead to subsequent sessions re:
  - handling variability & uncertainty in NAADSM
  - inputs and outputs of NAADSM

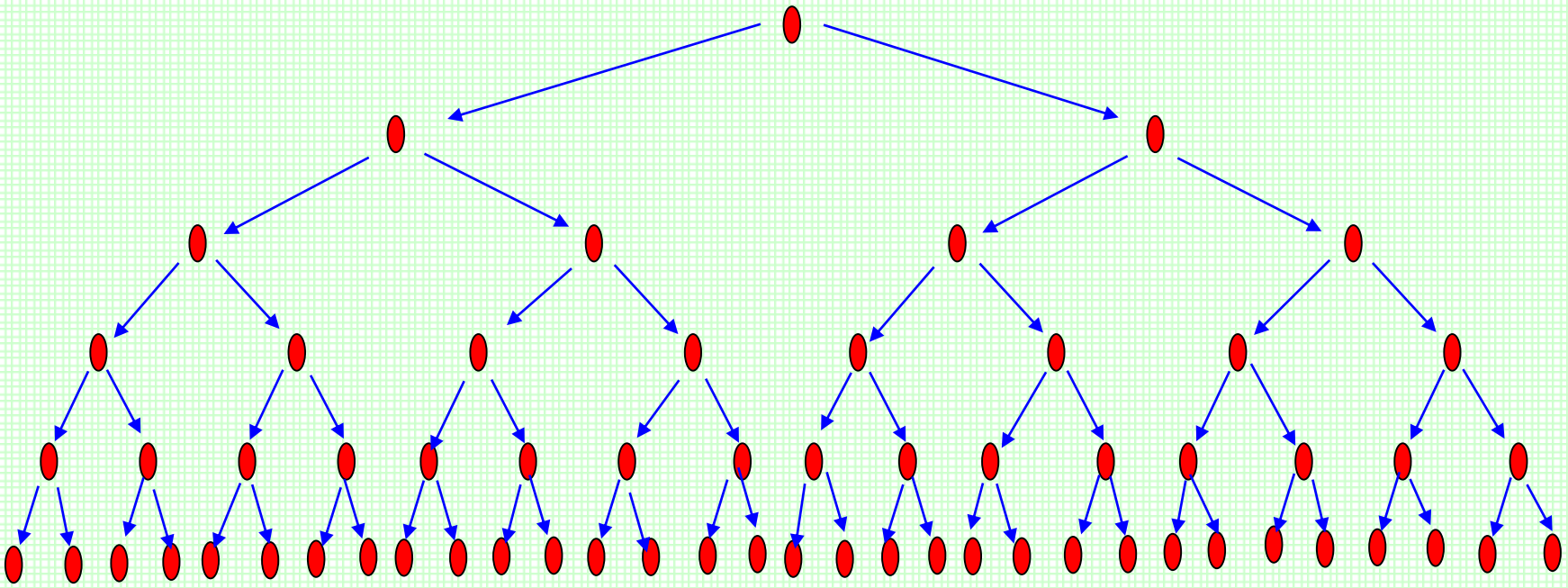
Overall Objective:

- Understanding of concepts and good modelling help make…
- **Good decisions re: disease management at population level**

Schematics of Principles of Disease Spread

McNab & Dubé, 2007 Simple models to assist in communicating key principles of animal disease control, Vet Italiana 43:317-326

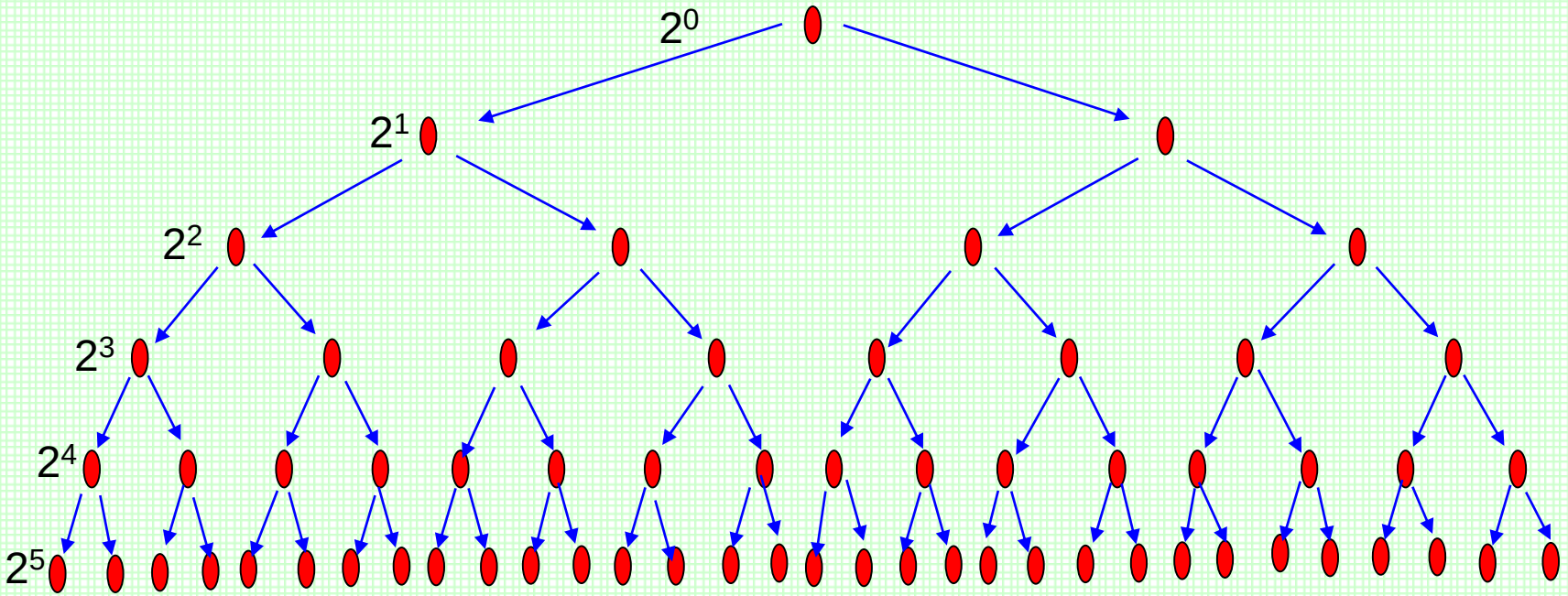
Consider spread of a cold
if each infected person
spreads it to two new people



The “reproductive ratio” (R) = number of secondary cases generated per existing case
(in this example R= 2 new cases generated per existing case)

significance of R < 1 outbreak contracts
vs. R > 1 outbreak expands

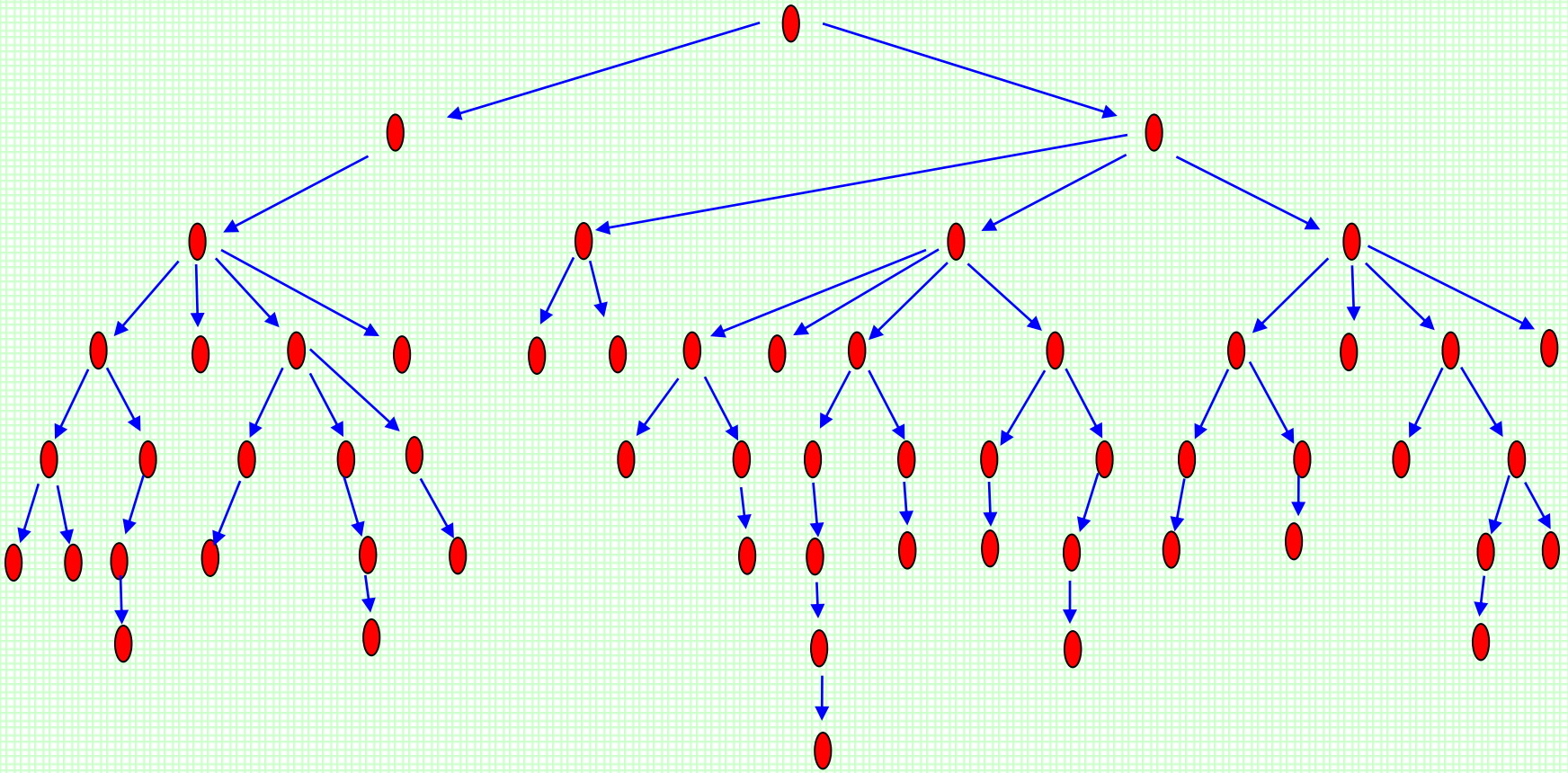
An “easy-to-see” Schematic vs. Reality



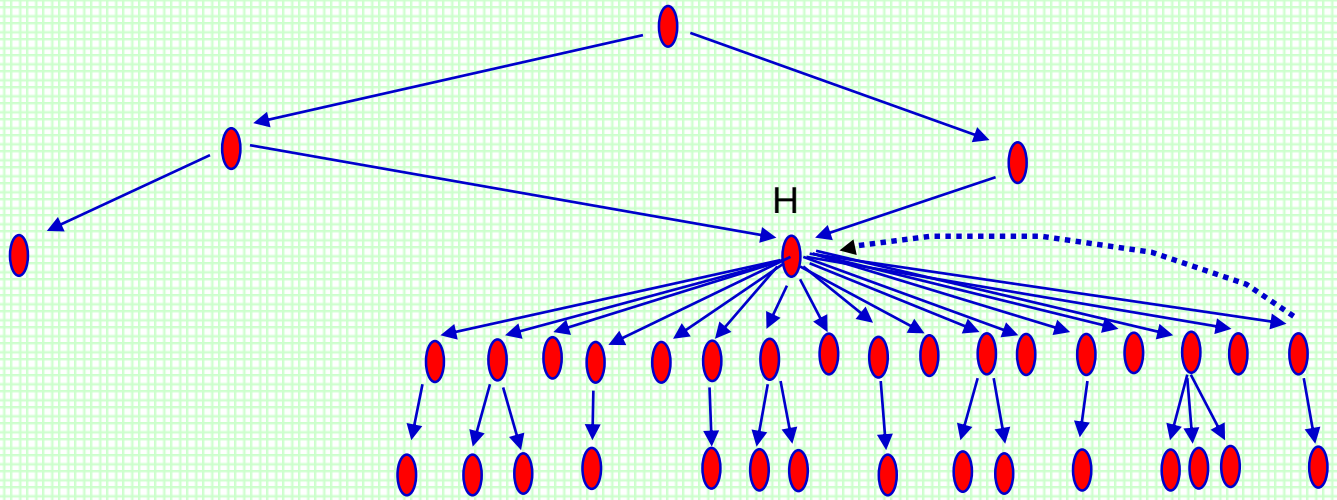
In this ordered, consistent schematic, its easy to see R = 2

But it is not always that easy…..

Usually R Changes Over Time and Is Not Consistent Between "Contemporary" Cases



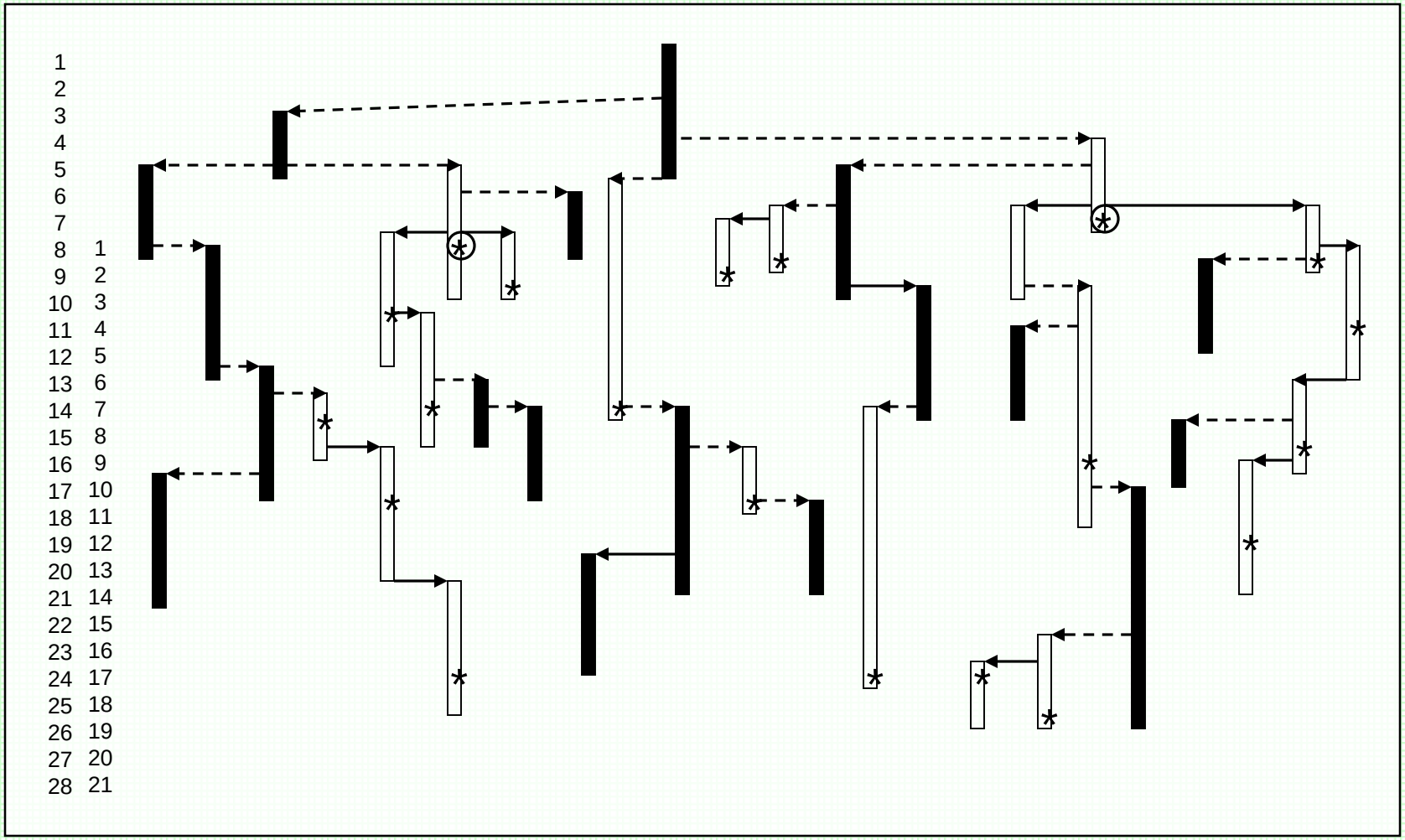
Hubs Can Have Great Influence



With H R = 1.6
Without H R = 0.9

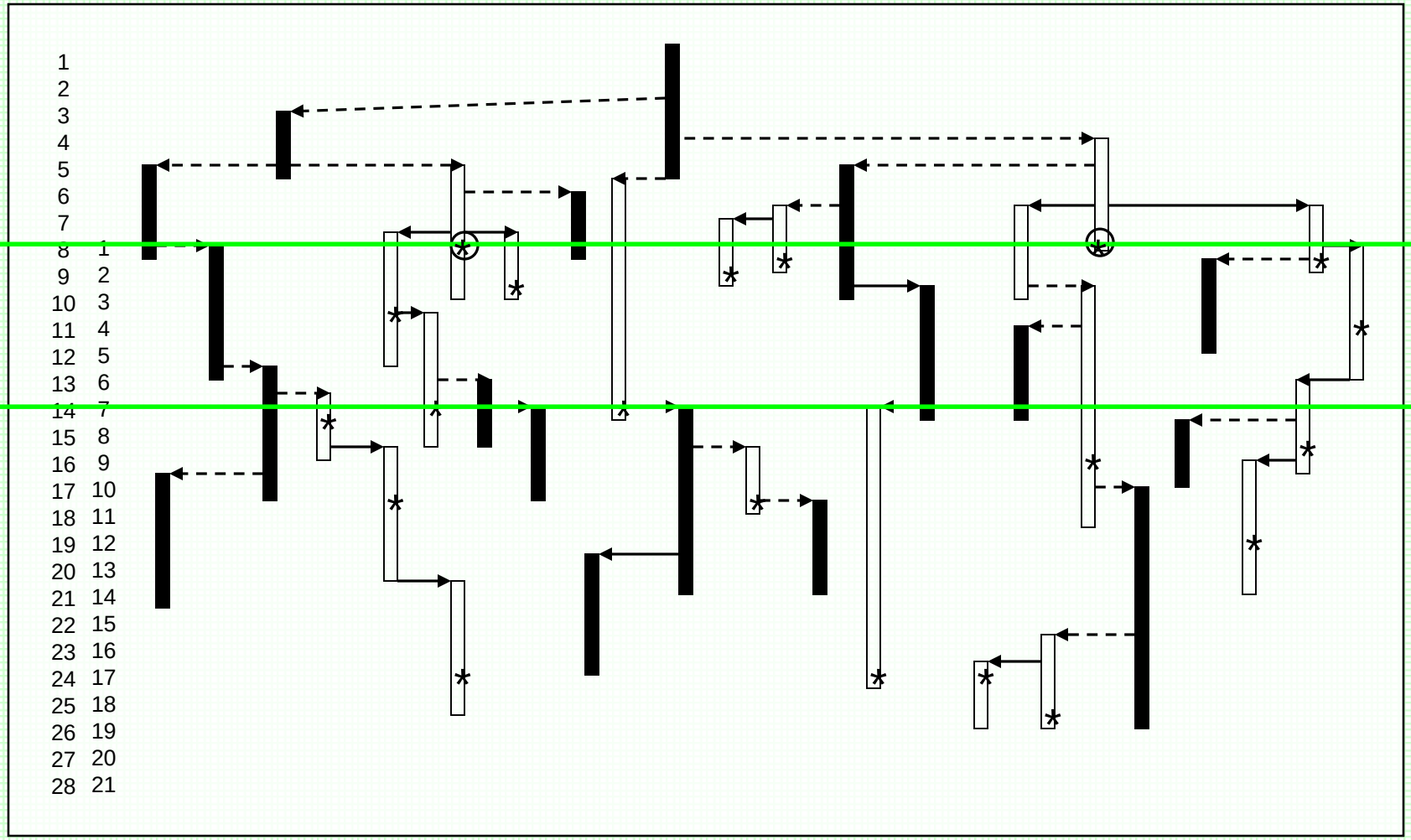
(Will return to this Fri. in “network” discussion)

Overlapping Generations – Known & Unknown

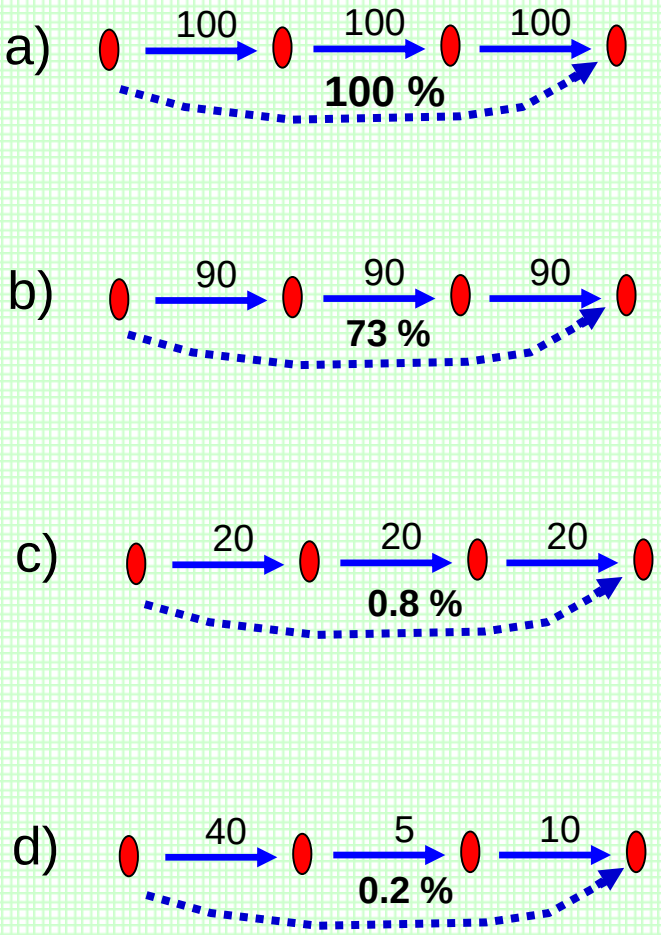


Overlapping Generations – Known & Unknown

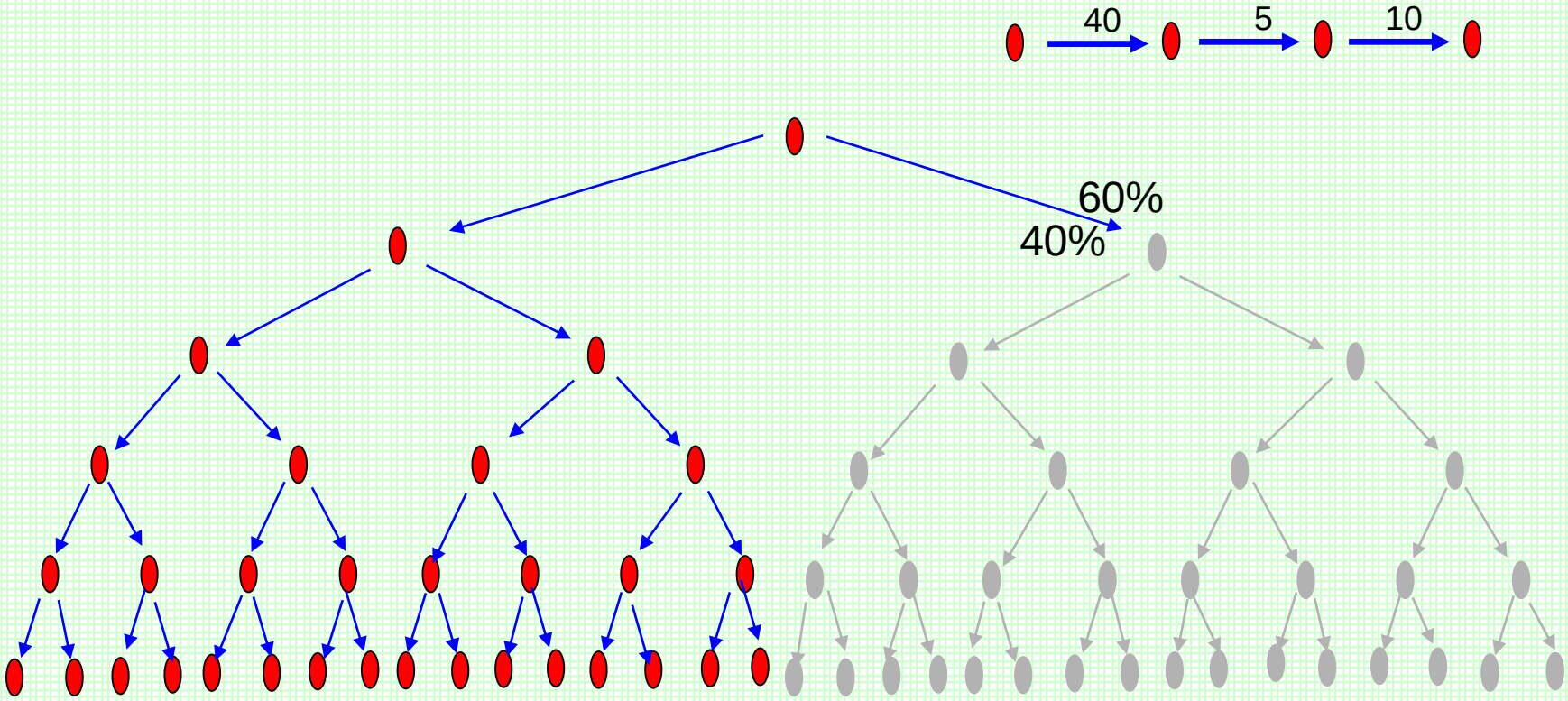
What's R new/old ?



Every Little Bit Helps



Every Little Bit Helps - Exponentially



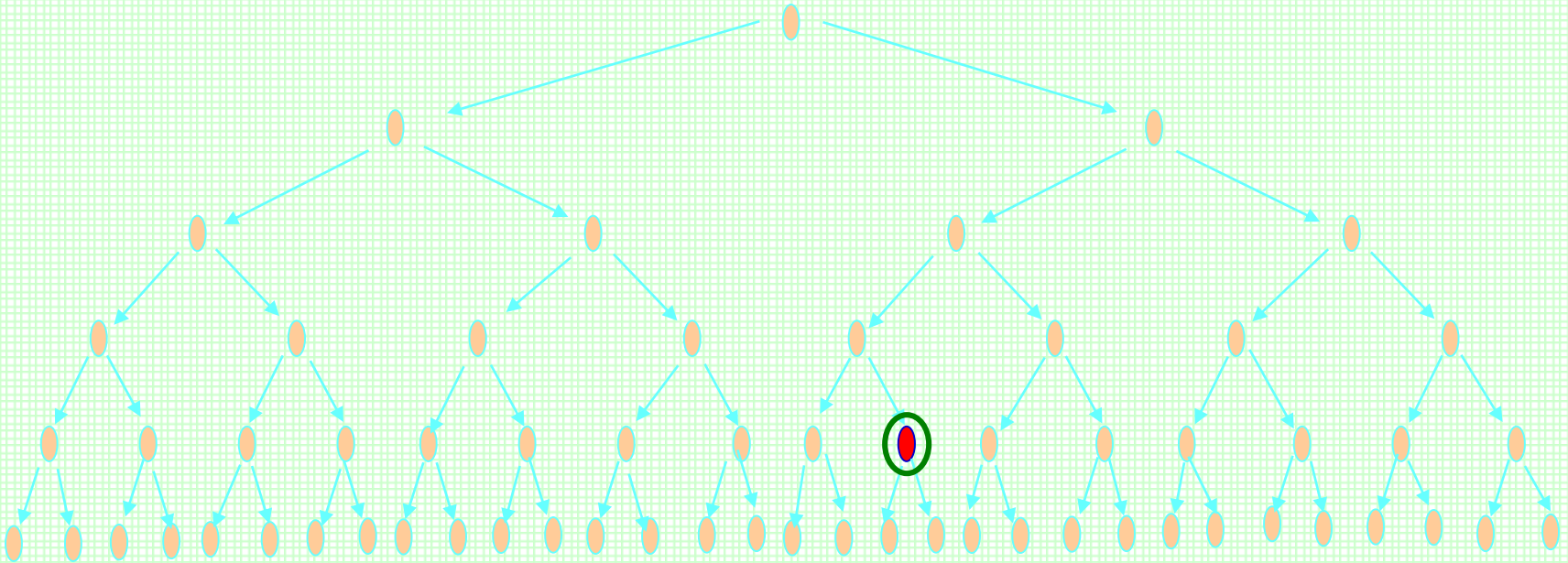
Spread AND Control are "exponential" in nature

- importance of blocking or preventing spread (biosecurity)
- often not aware of "saves"…. difficult to prove value

Disease Response

Consider:

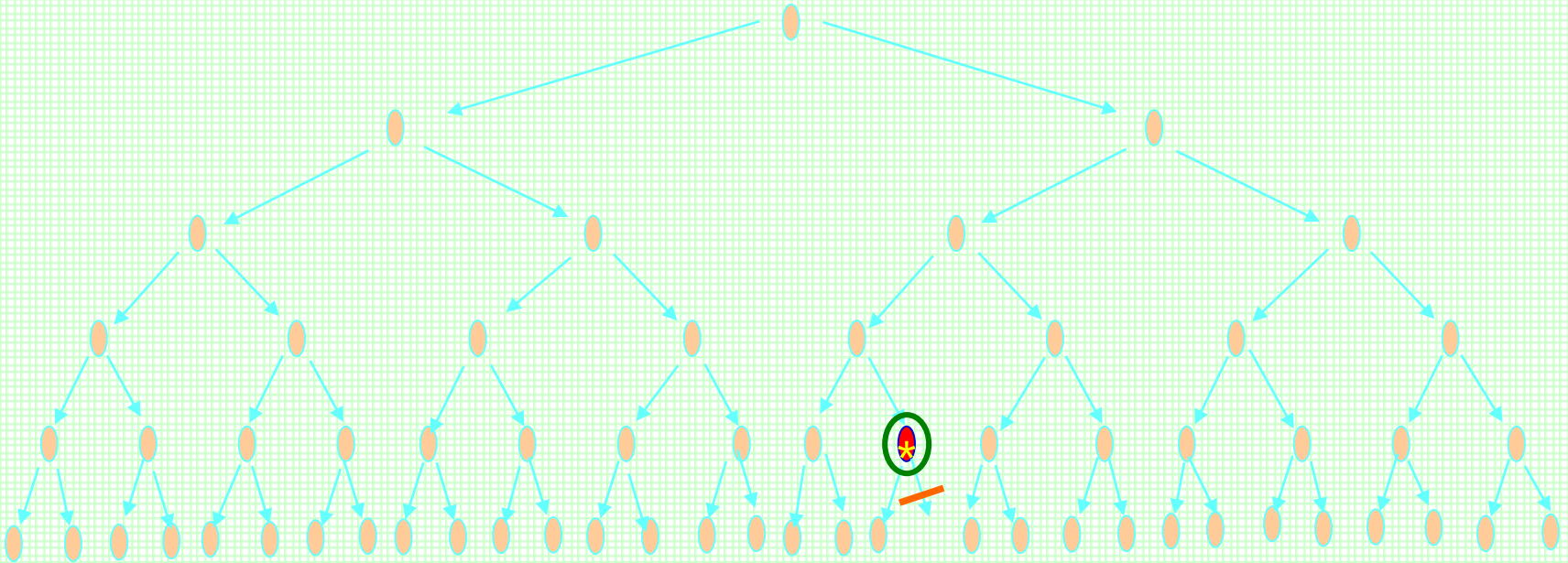
- Detection of FAD but not aware of other cases



Disease Response

Consider:

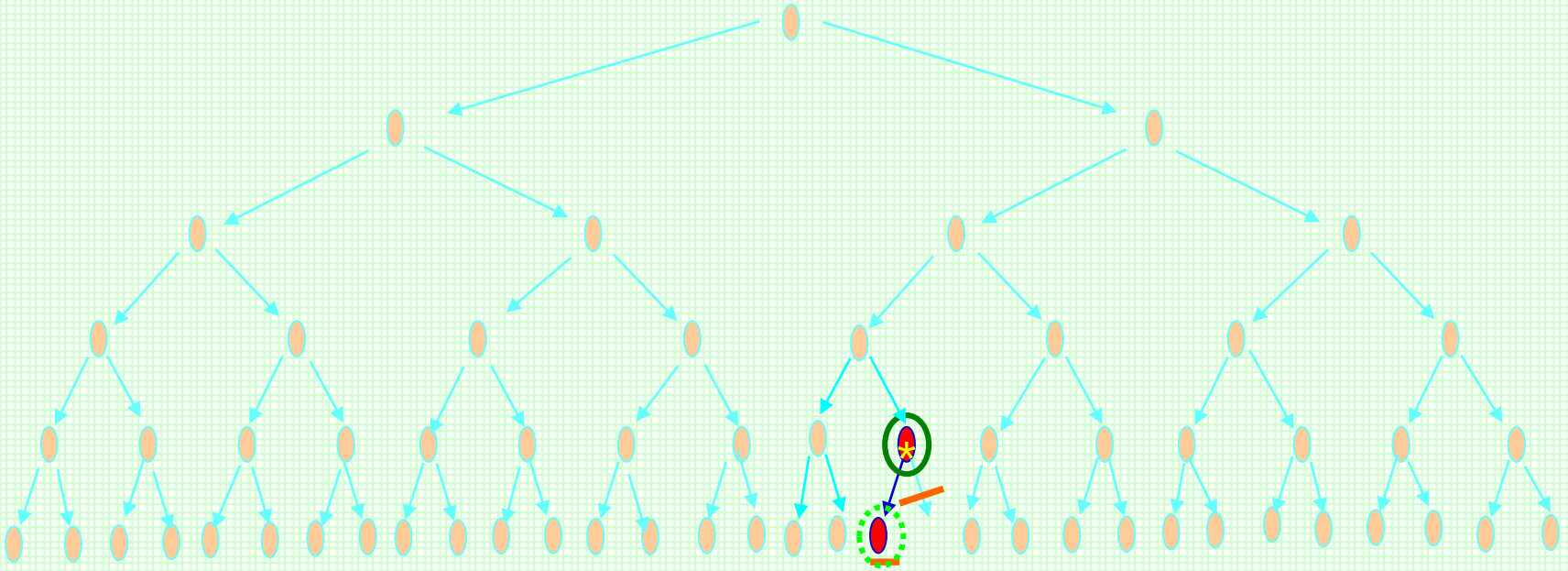
- **Detection**
- **Controlling spread from detected**



Disease Response

Consider:

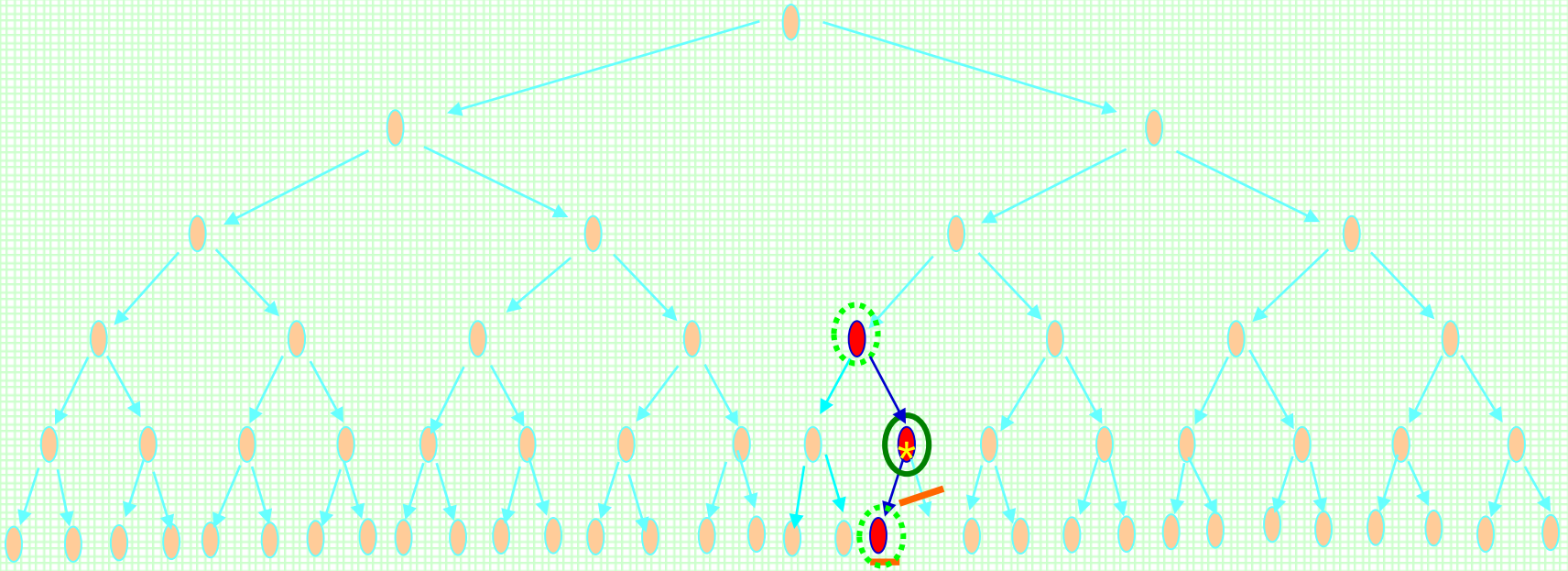
- **Detection**
- **Controlling spread from detected**
- **Trace forward**



Disease Response

Consider:

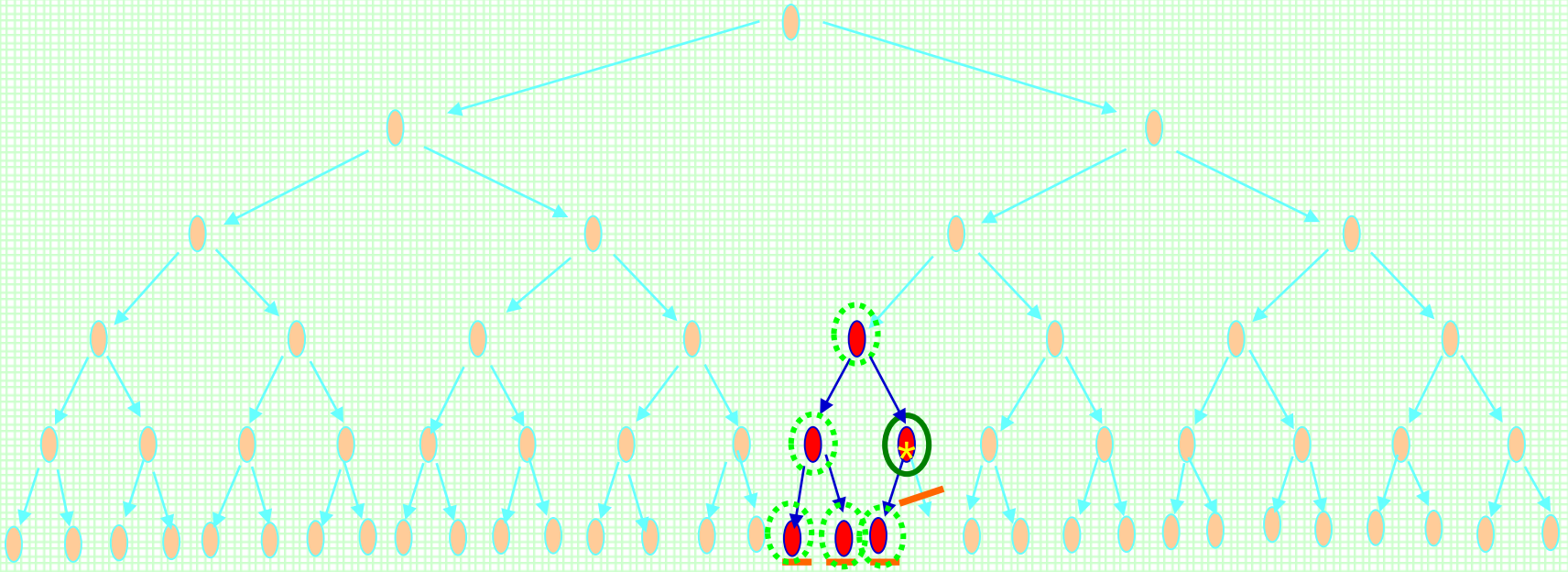
- **Detection**
- **Controlling spread from detected**
- **Trace forward, trace back**



Disease Response

Consider:

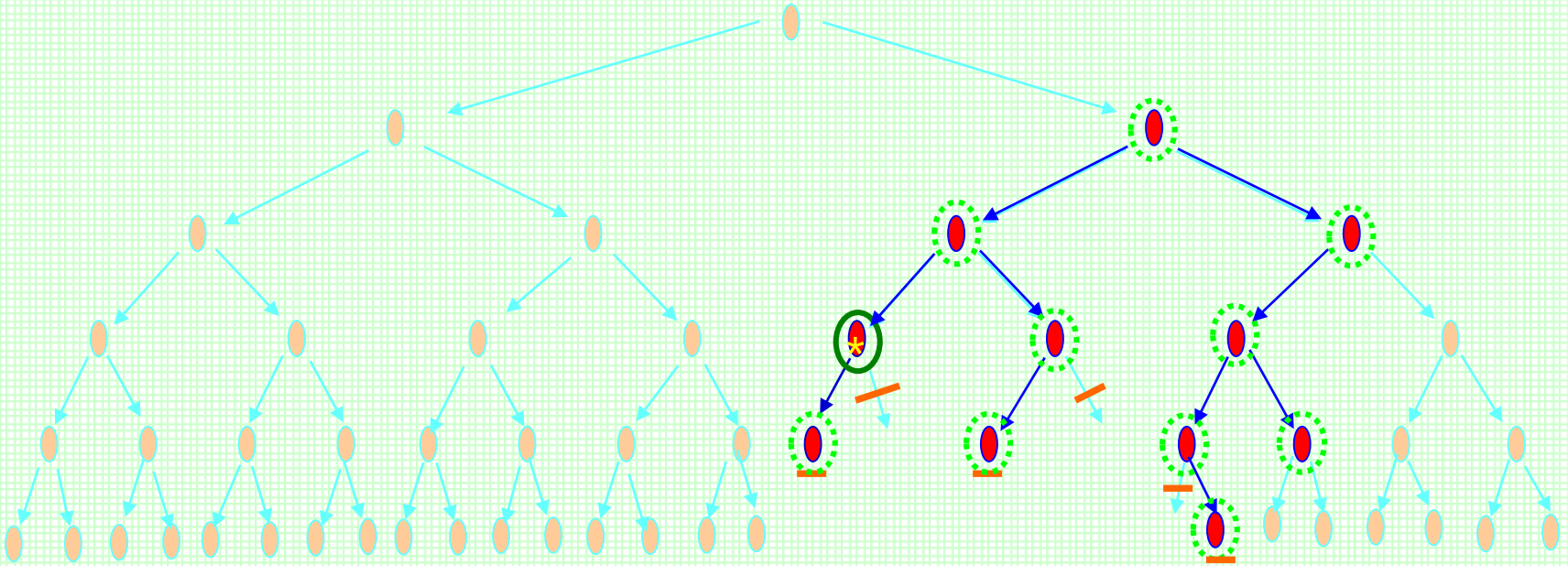
- **Detection**
- **Controlling spread from detected**
- **Trace forward, trace back and forward again**



Earlier Detection & Response

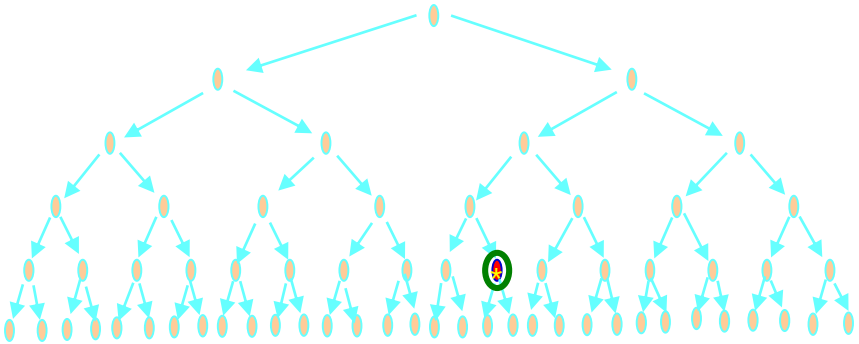
Consider:

- **More rapid detection**
- **Better tracing**
- **Controlling spread from detected (when fast enough)**



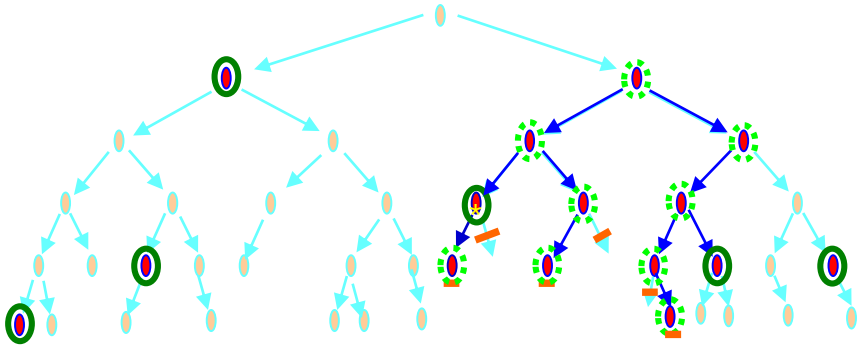
PREVENTION, Detection, response

1) @ 2 new/case, poor detctn & rspns



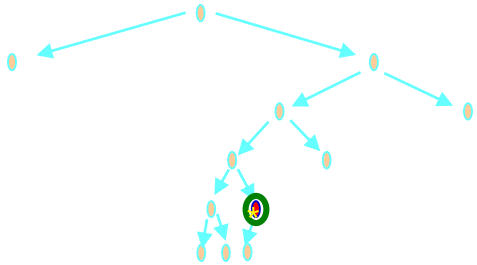
aware of 1, but 62 more (and spreading)

2) @ 2 new/case, reasonable detctn & rspns



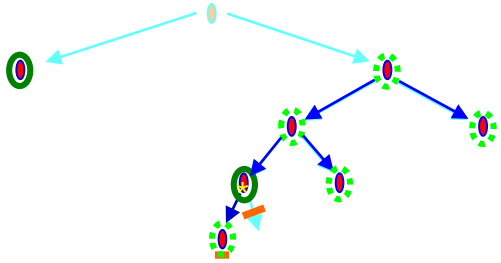
aware of 15, but 25 more (some spreading)

3) @ 1.2 new/case, poor detctn & rspns



aware of 1, but 11 more (some spreading)

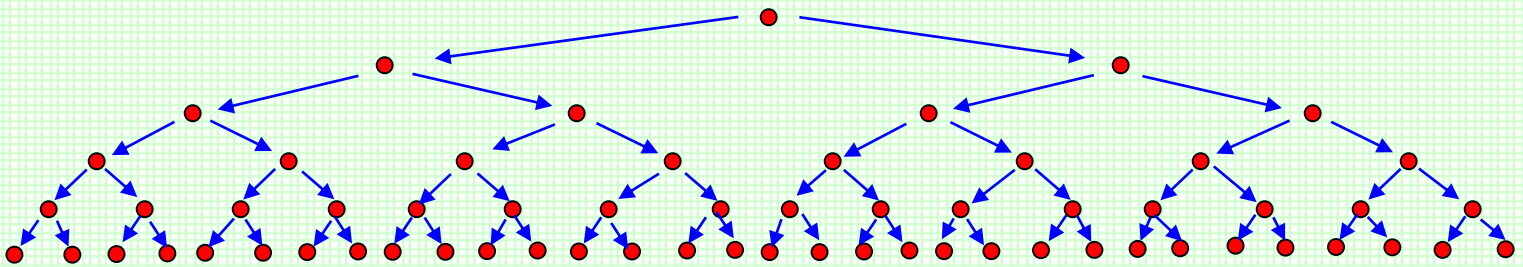
4) @ 1.2 new/case, reasonable detctn & rspns



aware of 7, but 1 more (little or no spreading)

PREVENTION, Detection, response

Disease Spread AND Control are Inherently Exponential



@ 2 new / case

New	Total
1	1
2	3
4	7
8	15
16	31*
32	63

incubation number	Total number of cases @ new cases per case 1.25	1.5	2
5	8	13	31*
10	33	113	1023

earlier detection implement controls when fewer cases

increased biosecurity barriers
increased control
decreased # new cases / case

Examples where improved biosecurity, early detection and rapid effective response resulted in fewer cases

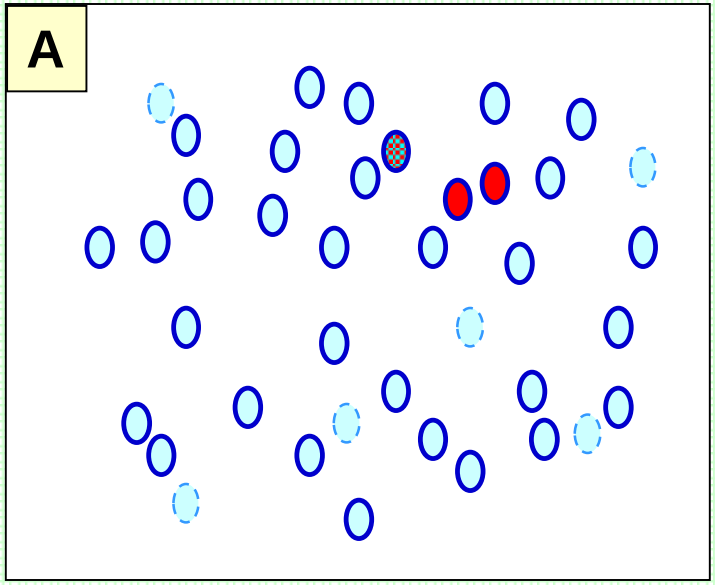
Avian Influenza in BC
2004: 53 prem. vs. 2005: 2 prem.

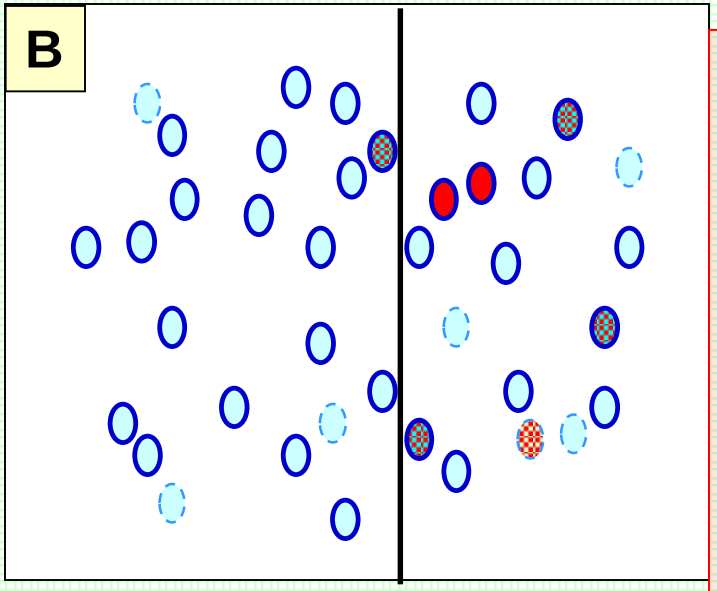
Foot and Mouth Disease 2001
UK: 2030 prem. vs. Holland: 26 prem.

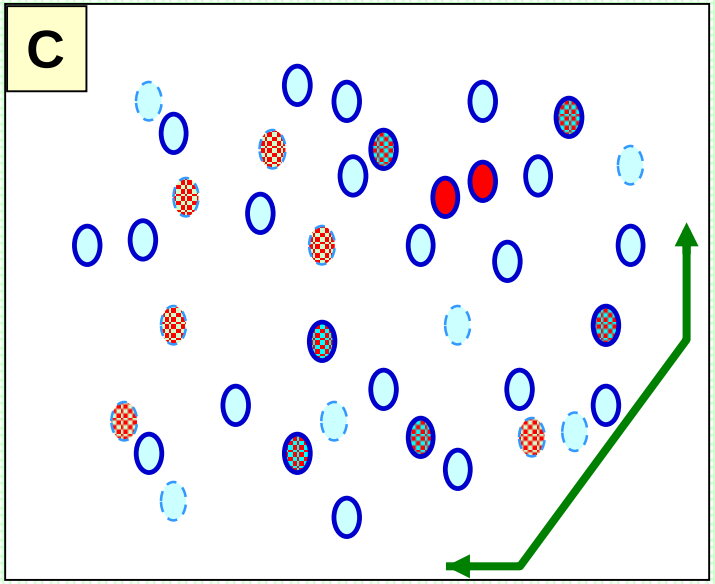
Collectively,
we must address the biology

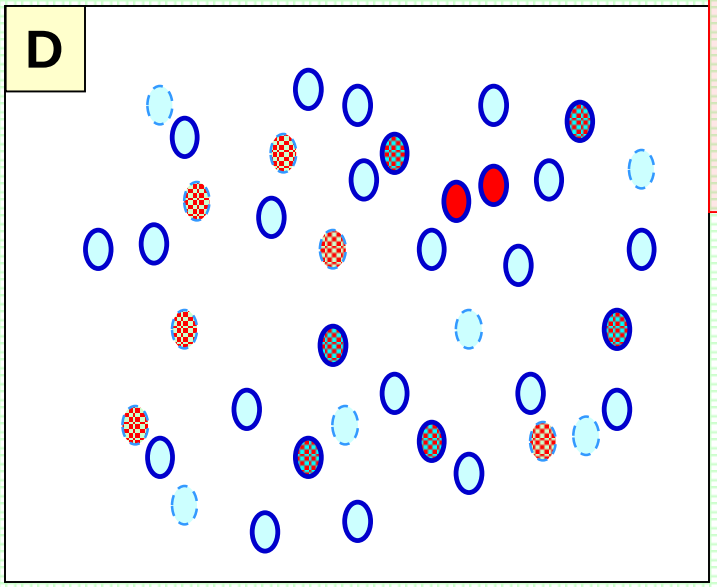
Evolving, Unknown Situations Can Look The Same

=known negative =known positive =unknown negative =unknown positive =known unit unknown positive









Which Is It ?

- Not sig.
- Economic sig.
- Pblc Hlth sig.
- Reprtabl. hot or cool
- Emerging hot or cool

Need

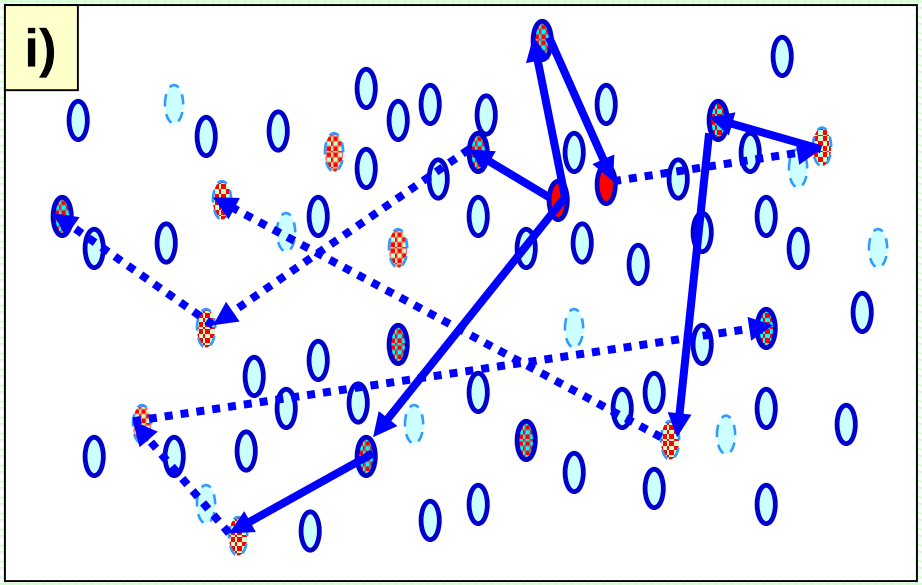
- Information
- Communication
- Appropriate Action

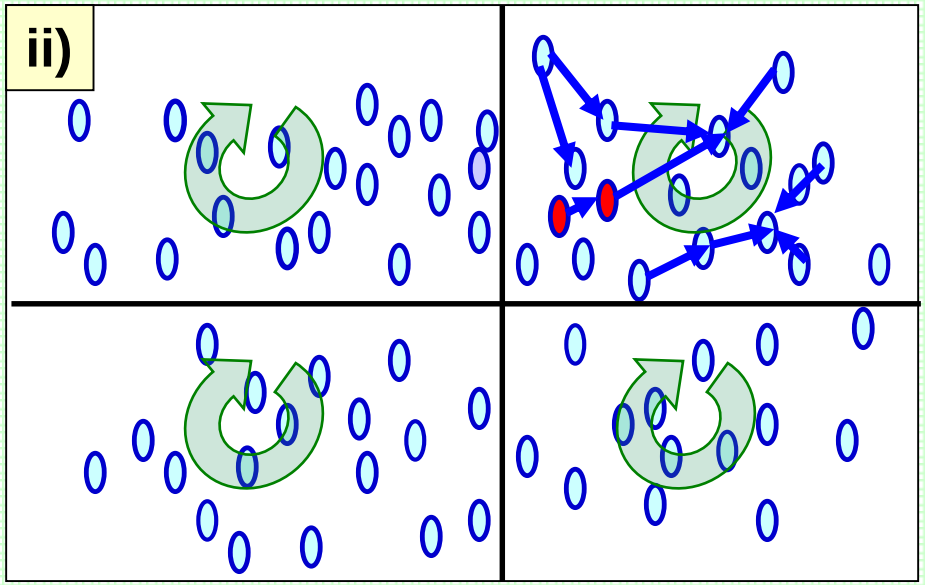
Utility of ID, Tracing, Compartmentalization ….

i) Unknown, unstructured movements, among unknown units

v.s.

ii) Known structured movements among known, compartmentalized units





If you were CEO…..

If you were CVO ?

"Formula" for (factors influencing) R

Reproductive Ratio….. R
(i.e. factors influencing to how many people I "give" my cold)

d = duration available as infectious e.g. 5 days

c = contact frequency e.g. 5 contacts per day

t = transmission probability per contact e.g. 20% of contacts

s = susceptibility probability per transmission e.g. 40% susceptible

R = d x c x t x s
R = 5 days/case x 5 cntct/day x .2 trns/cntct x .4 (susp) cases/trns
R = 2 cases/case
R = 2

If R > 1 the epidemic expands, if R < 1 it slows and burns out

Formula for R

What factors influence R ?

R = d x c x t x s

↓ d = duration available as infectious

- stay home
- early diagnosis (call veterinarian, lab diagnosis, surveillance)
- depopulation
- pre-emptive slaughter of contacts (while latent or sub-clinical)

↓ c = contact frequency

- avoid meetings
- avoid unnecessary livestock movements and contacts
- farm premises security
- livestock movement restrictions

Formula for R

What factors influence R ? (continued)

R = d x c x t x s

↓ t = transmission probability per contact stay home
- wash hands, don't shake hands / kiss at greeting
- clean coveralls / boots
- clean and disinfect
- shower-in / shower-out

↓ s = susceptibility probability per transmission
- s = [1 - (inftd % + vacc imn % + missing %)]
- s = [1 – (.2 infct + .3 vac + .1miss)]
- s = .4

(R will decrease on own as "i" increases c.p.)

Examples NAADSM Model Inputs Influencing R

$$R = d_{\text{uration infc.}} \times c_{\text{ontact freq.}} \times t_{\text{rans. P.}} \times S_{\text{usp.}}$$

- Disease parameters
  - latent, sub-clin, clinical, immune
- Contact rates
  - frequency of direct contact …of indirect contact
- Probability of transmission
  - ….direct and indirect
- Controls
  - detection, movement restrictions, destruction, vaccination

But Variability & Uncertainty → Monte-Carlo (next session)

Example Application of NAADSM – Relative Comparisons

Varying Input Variables Influencing R (Sessions later in course !!)

- **Early reporting** (decrease duration infectious d)
- **Improved biosecurity** (decrease p. of trans. t)
- **Combinations** (e.g. BiosSec, Early Rpt, Better Trace, Improve Destrct., Reduced Mvmnt)

Do NOT Interpret Numbers Literally !!!

Output	Model	Baseline	Imprvd Erly Rprt	Imprvd BioScrty	BsErTrDs Mv
		mean	mean	mean	mean
Number Of Farms	drct/indrct transmtn.	448	334 -25%	18 -96%	4 -99%
	plus airborne	558	407 -27%	26 -95%	5 -99%

Apparent Epidemic Curve -- includes only de

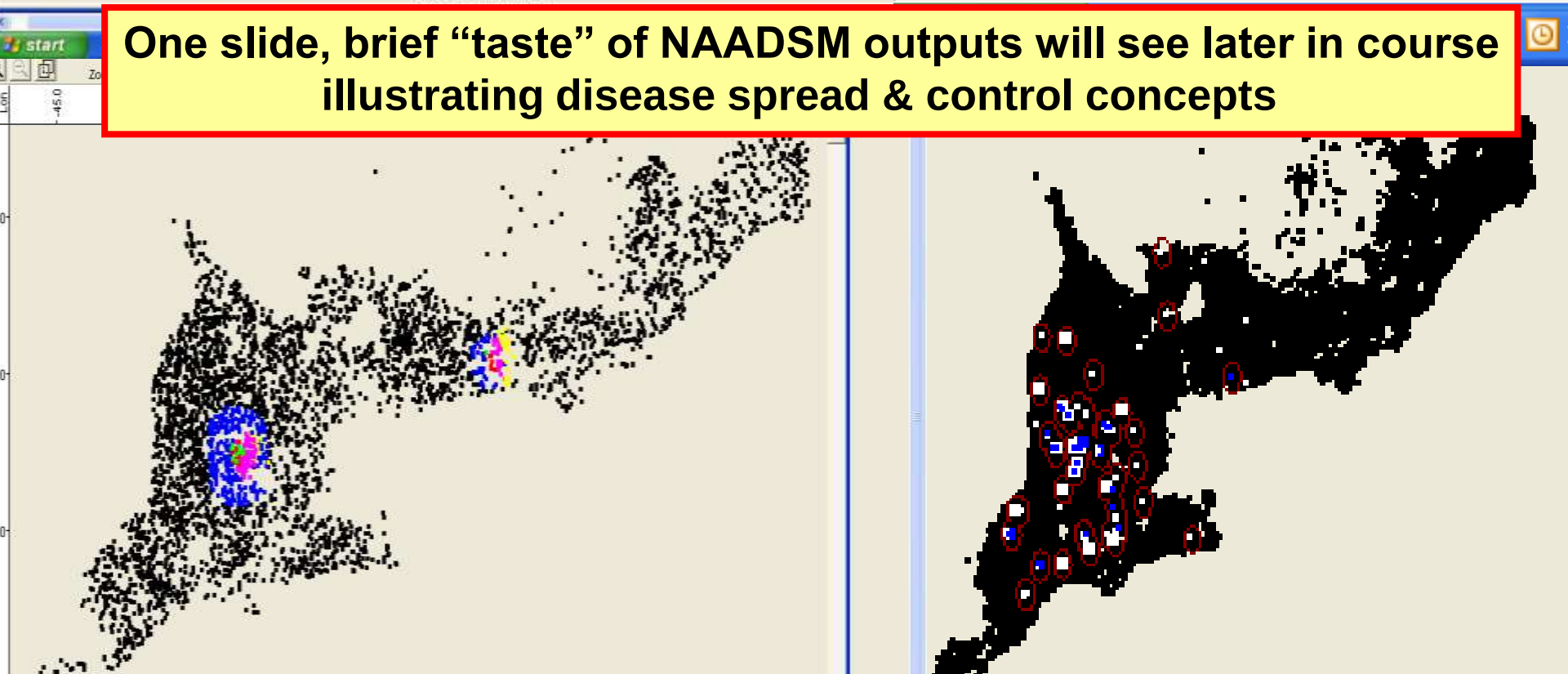
☑ Reasons for infection -- includes all infection

Initially infected	1
Airborne*	194
Direct contact*	5
Indirect contact*	46
TOTAL	246

☐ Actual Epidemic Curve -- includes all infecti

* In the course of a simulation run, these activities may o

One slide, brief "taste" of NAADSM outputs will see later in course illustrating disease spread & control concepts



Take Home Message To Industry

1. **Bugs / toxins do not read or act with intent; spread is mostly passive; mostly, they move where you buy, carry or let them ride in.**

2. **Spread and control are "exponential", so every little bit helps and little things matter.**

3. **Decision makers need to know what and how much is at risk, where and when vs. "who" is contaminated with what, where and when, AND how things flow, so can trace and anticipate.**

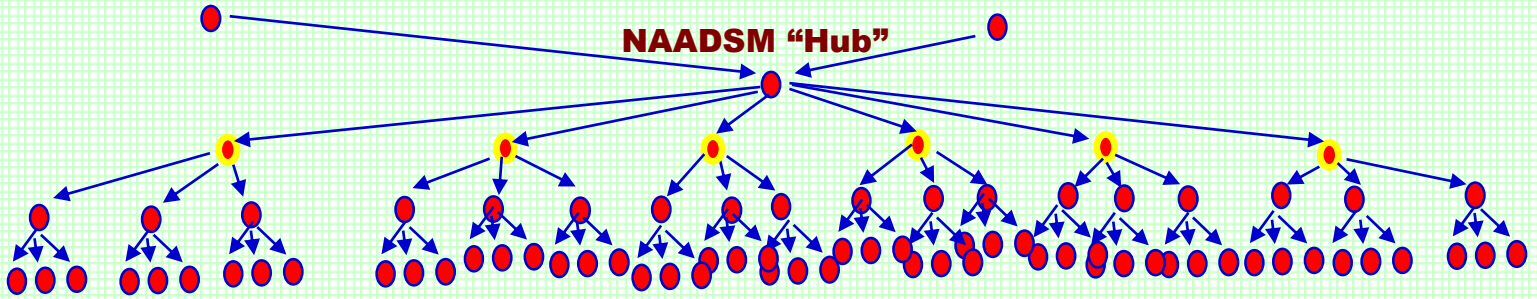
4. **Peacetime holistic bio-security and system-design that facilitate prevention of spread, early detection, rapid aggressive investigation / tracing / response; pays exponential biological dividends (often unknown).**

5. **Industry workers, physically addressing the biology is what matters; your/their routine daily actions influence your animal disease future far more than you may have thought.**

This is empowering.

Let's Encourage an Epidemic of Improvement

People are more likely to take action if they believe their actions will benefit those they sincerely care about.



Networks and Networking → Fri.

Back to Session Outline

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QUESTIONS ?