Vaccination and virulence evolution

Joint Graduate Student Seminar

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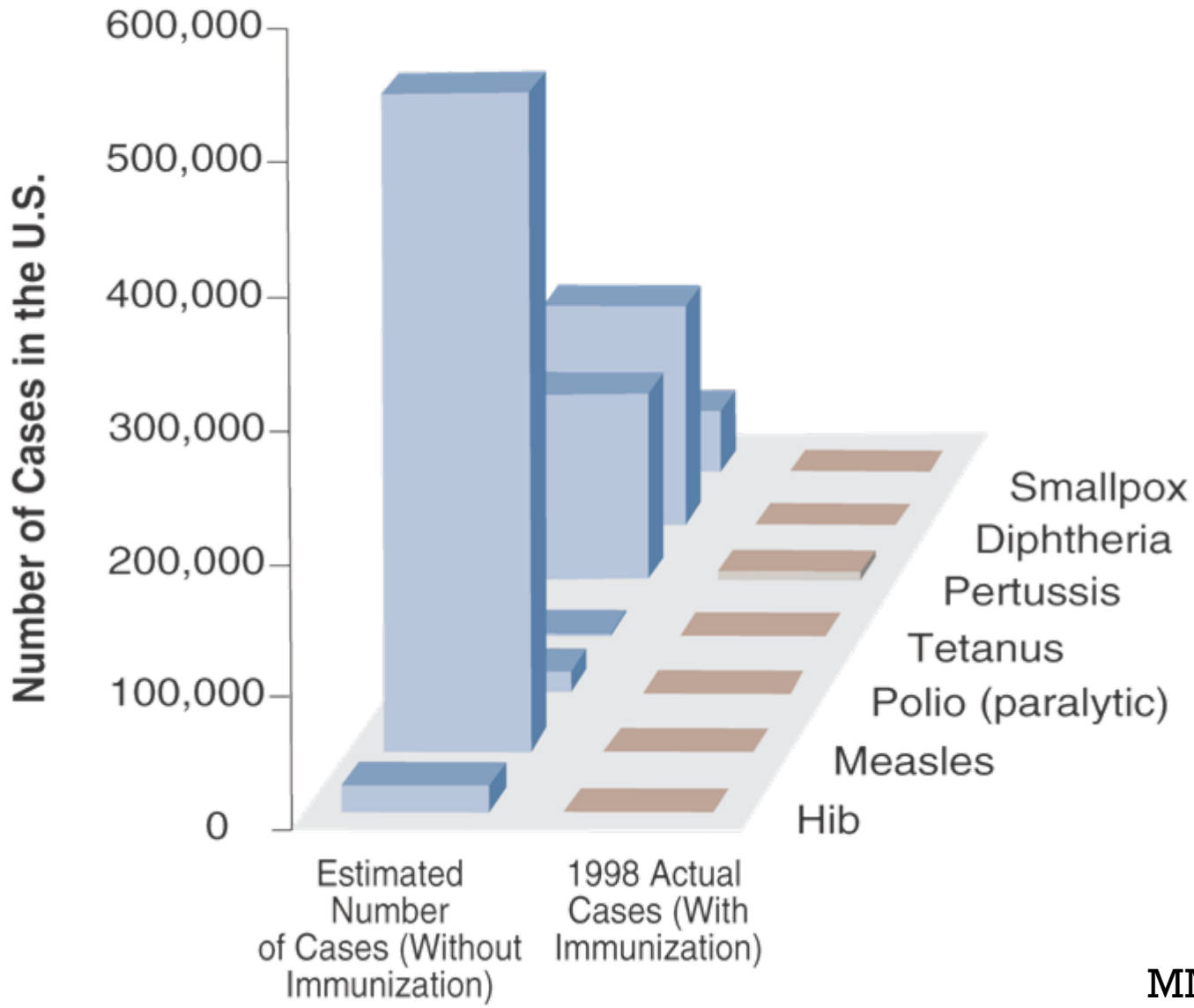
Outline

1. Vaccination
2. Trade-off evolution model
3. Evolution examples
   - myxomatosis
   - malaria
4. Conclusion

Vaccination

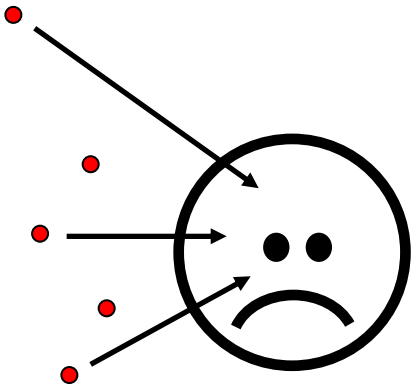
- In 1796, Charles Jenner: Cowpox
- 1800's compulsory childhood vaccination
- 20th and 21st century: the most productive for vaccine development

Vaccination reduces the cases of infectious diseases



MMWR 1999

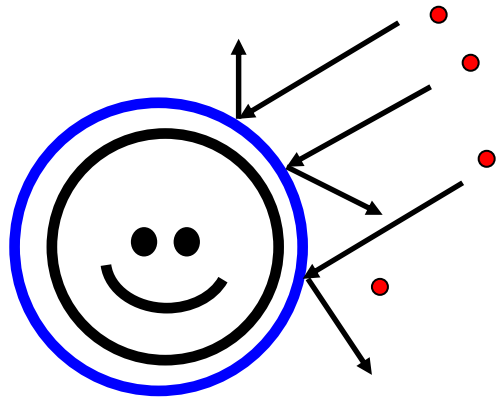
Perfect and imperfect vaccines



Naïve host

Perfect vaccine

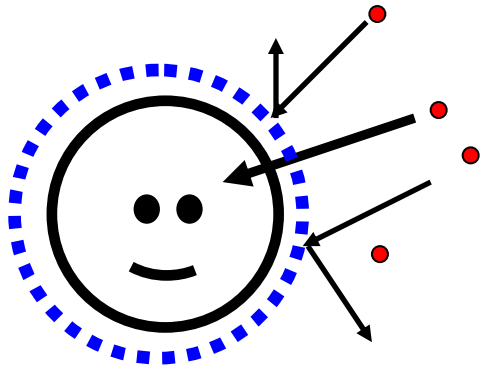
Rare



Immune host

Imperfect vaccine

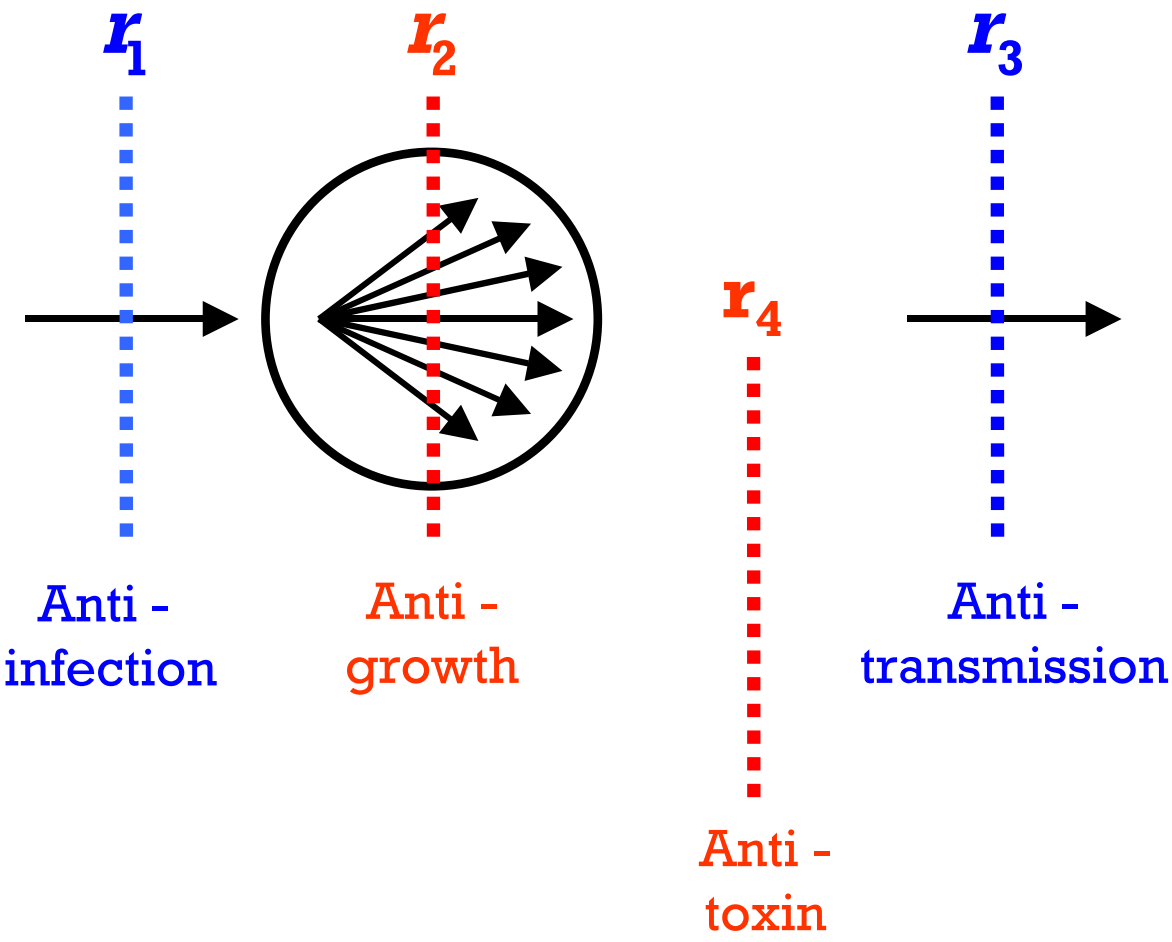
Common



Semi-immune host

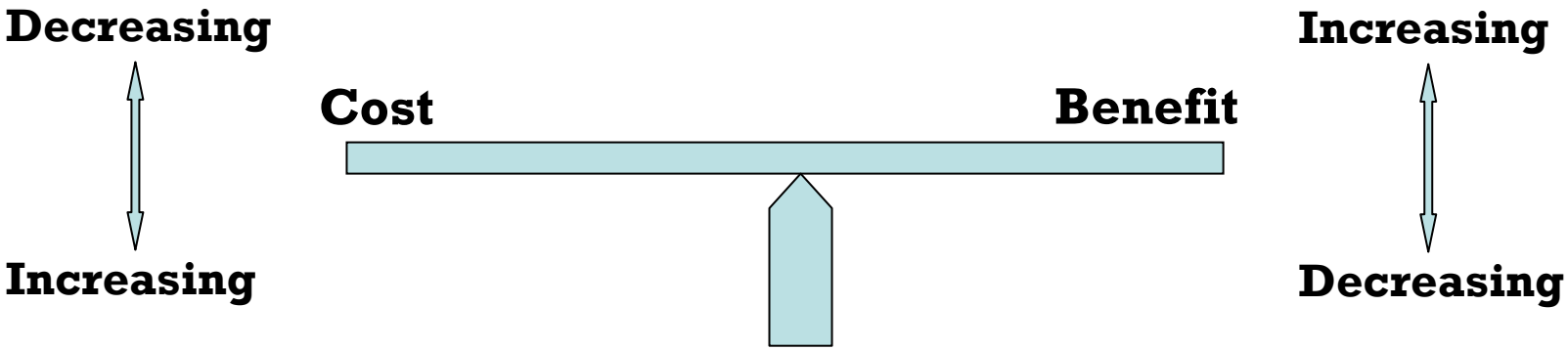
Jenner 1796

Semi-immunity influences different steps of parasite life cycle



Gandon *et al.* 2001; Mackinnon *et al.* 2009

Trade-off model



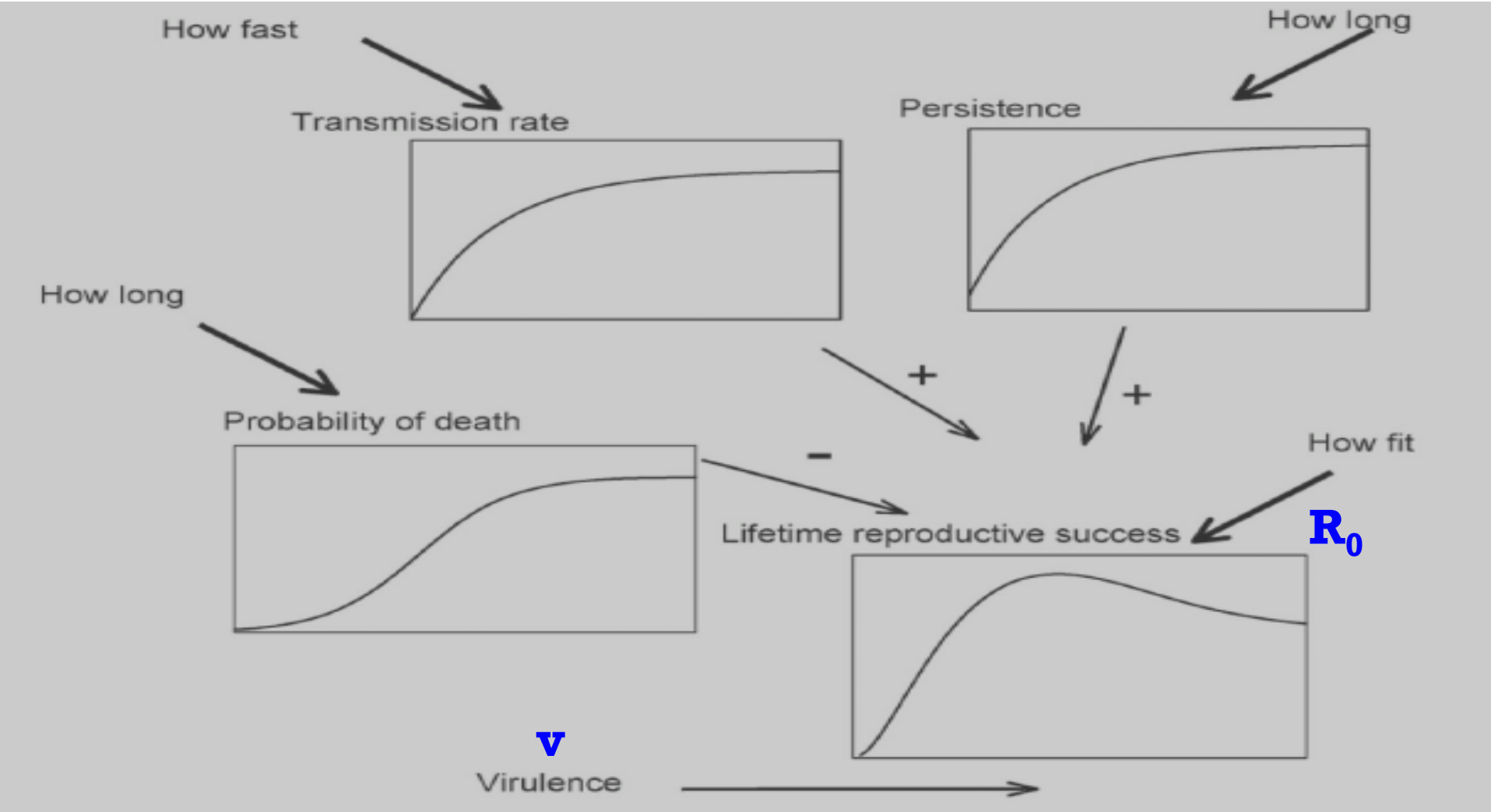
Trade-off evolution model

$$R_0 = \frac{bN}{v + d + r}$$

R_0, basic reproduction no.
b, transmission rate
N, susceptible host no.
v, mortality caused by parasite
d, mortality caused by other factors
r, cleared rate

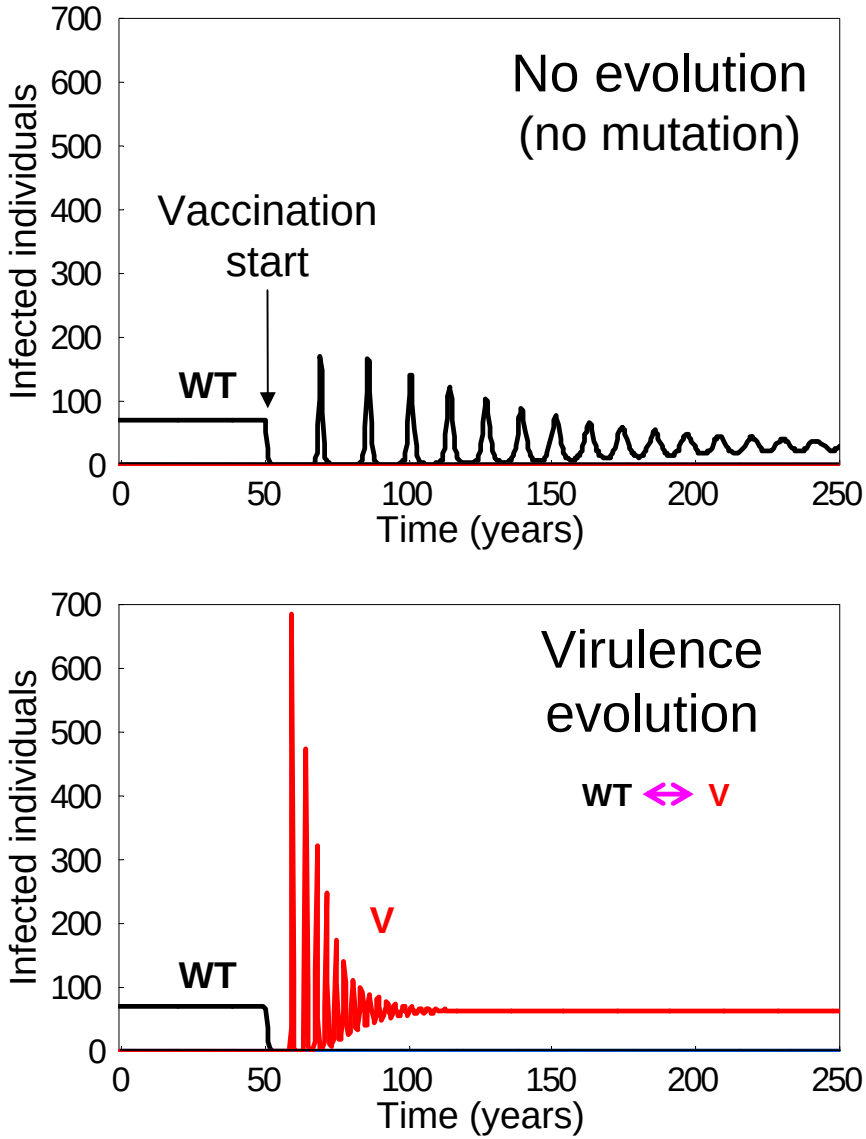
May & Anderson 1983

Factors influence virulence evolution



Mackinnon *et al.* 2009

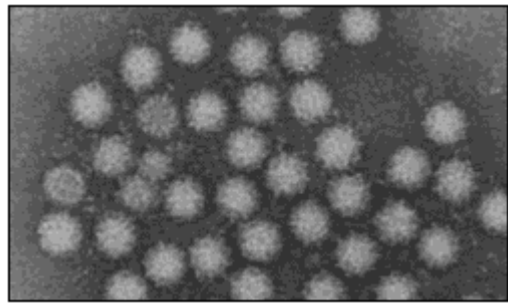
Predicted direction of virulence evolution



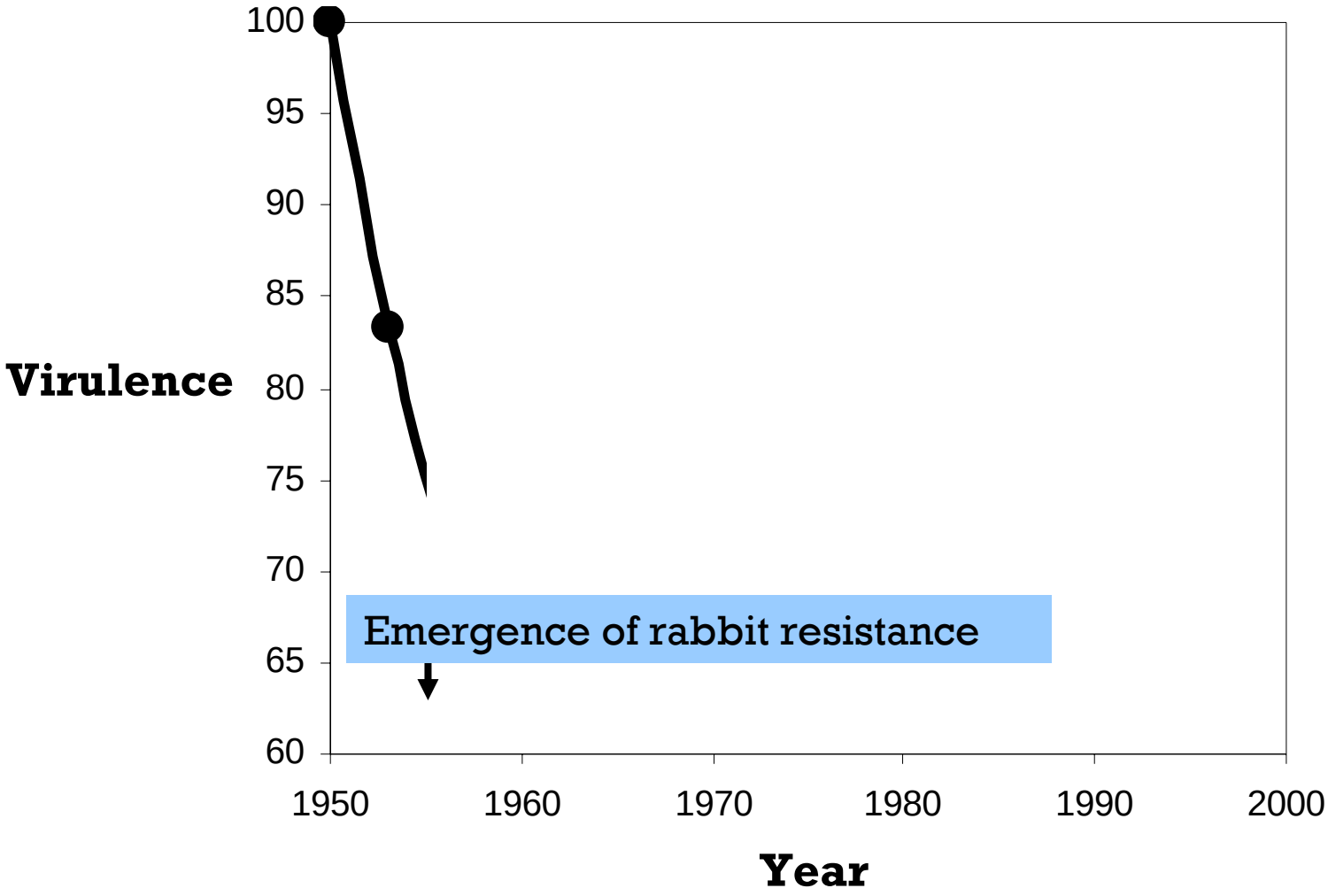
André *et al.* 2003

Myxomatosis as classical experimental evolution

- **1759**: European wild rabbit introduced into Australia
- **1919**: first suggestion to use Myxoma virus to control rabbits in Australia
- **1950**: rabbits denuded the landscape
- **1950**: myxomatosis successfully released among Australian rabbits



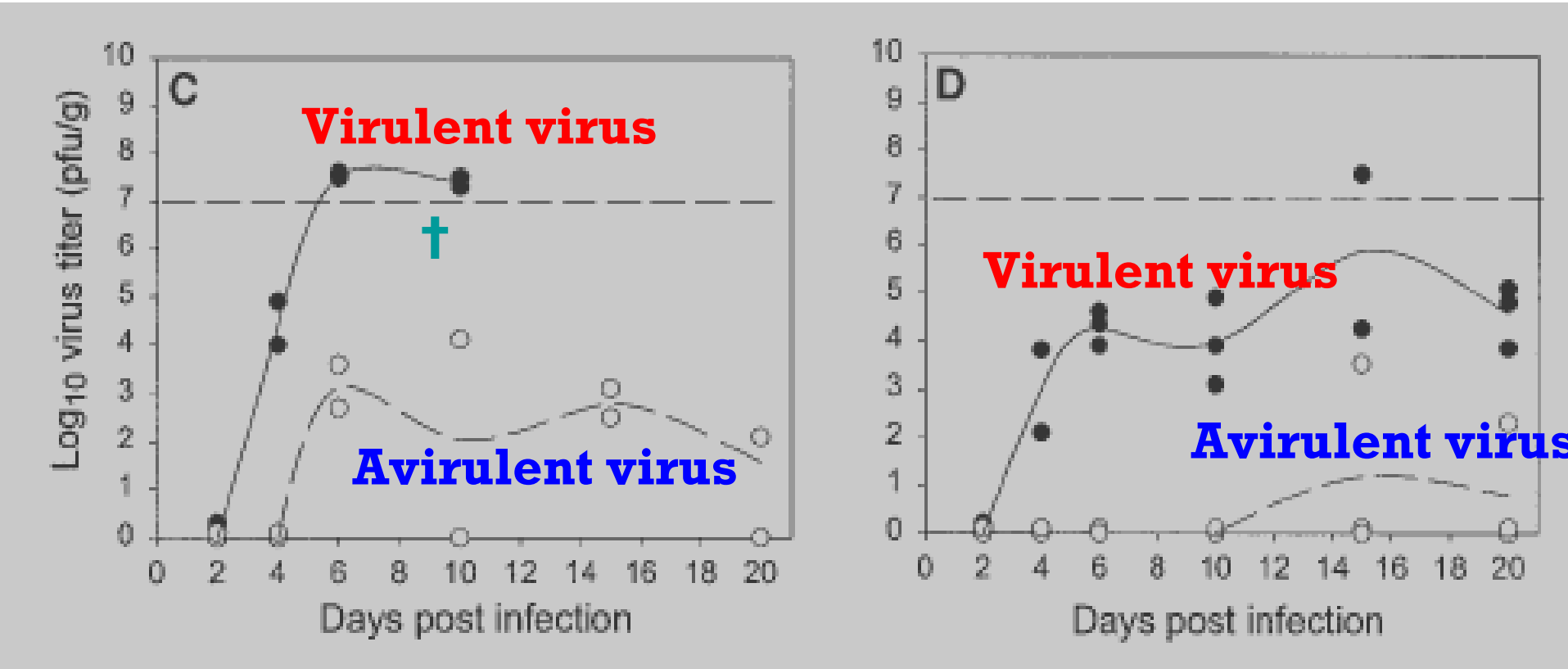
Virulence evolution for 50 years



Fenner & Fantini 1999

Possible reason for myxomatosis evolution

Naïve rabbit **Resistant rabbit**



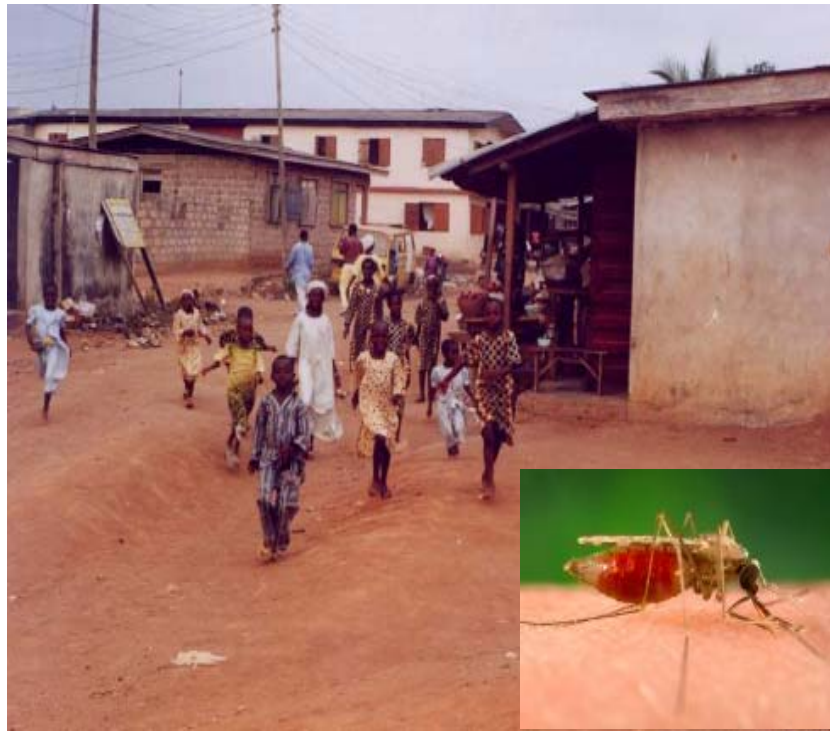
Best & Kerr 2000

Malaria

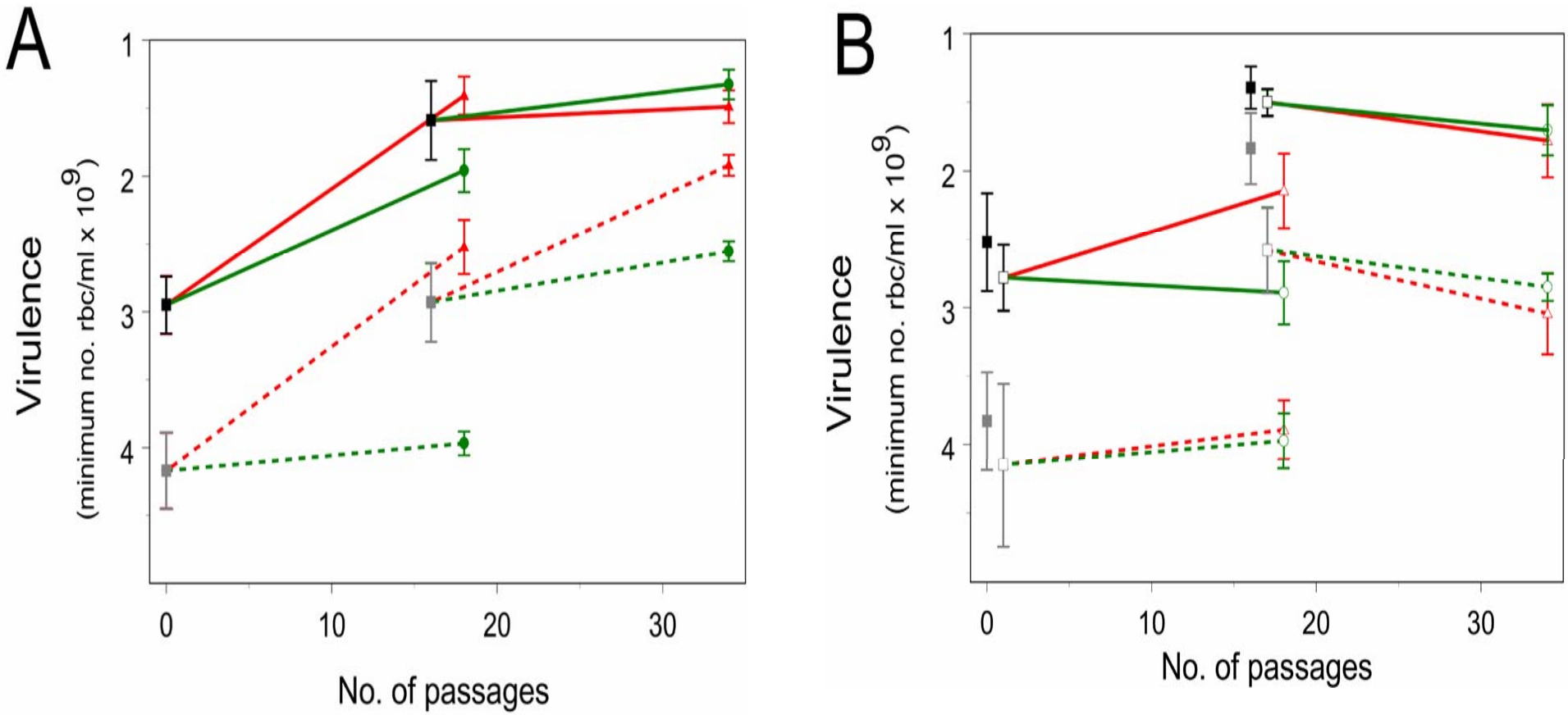
One major public health problem in warm climates

Transmitted through mosquito

Different types of vaccine for malaria



Vaccination selects for higher virulence



Virulence to resistant mouse of parasite from immunized host

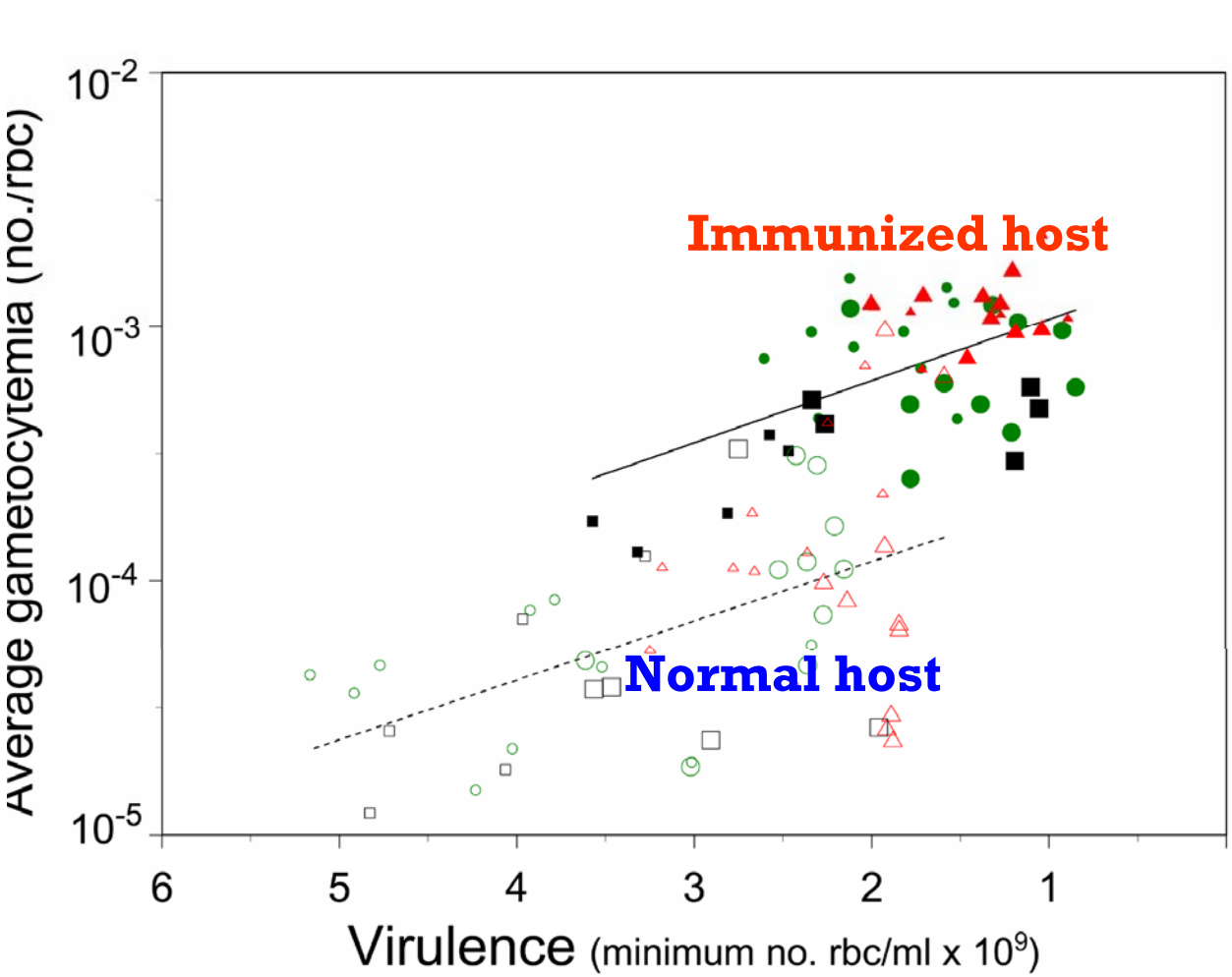
Virulence to resistant mouse of parasite from normal host

Virulence to naïve mouse of parasite from immunized host

Virulence to naïve mouse of parasite from normal host

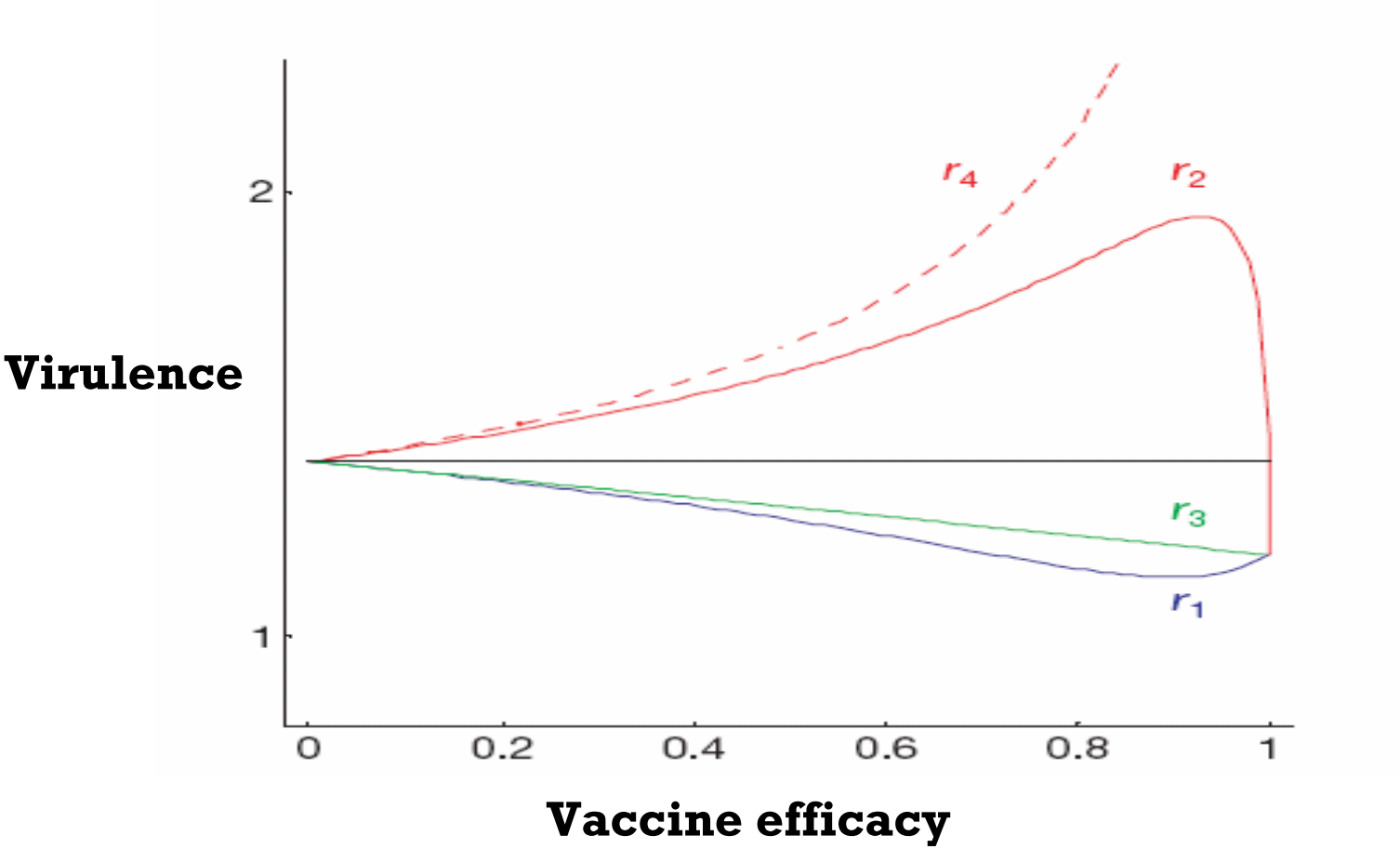
Mackinnon & Read 2004

Increased virulence may be due to a higher multiplication rate



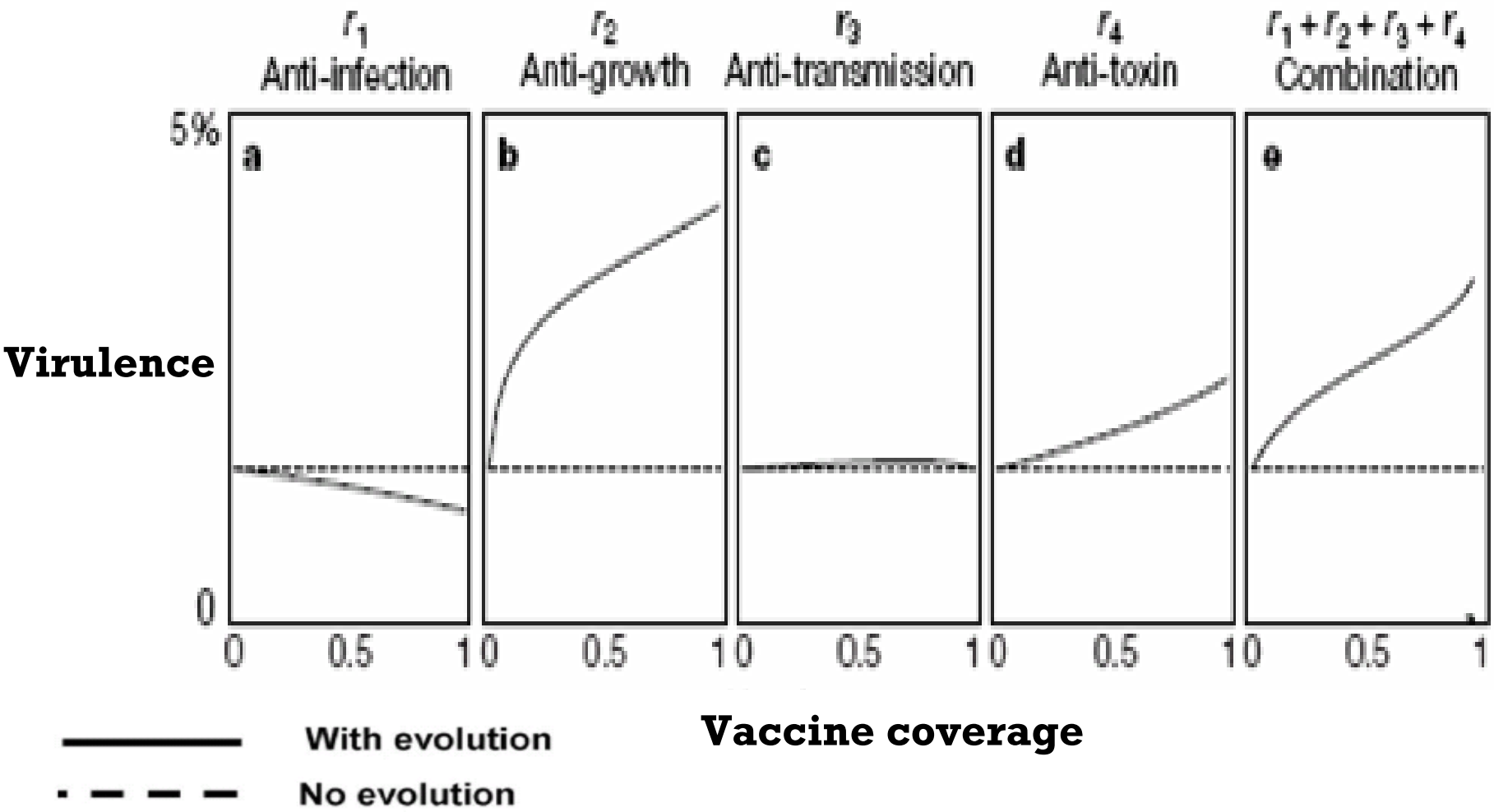
Mackinnon & Read 2004

Different evolution directions (r_1 and r_3 *vs.* r_2 and r_4)



Gandon *et al.* 2001; Mackinnon *et al.* 2009

Different evolution directions (r1 and r3 *vs.* r2 and r4)



Gandon *et al.* 2001; Mackinnon *et al.* 2009

Conclusion

• Parasite eradication becomes less feasible using imperfect vaccines

• Vaccination promotes evolution of higher virulence

• Some types of vaccines (i.e., r_1, r_3) may limit virulence evolution

Develop perfect vaccine

or

Dominate the parasites


Thank you