Evolutionary insights from mathematical modelling of vaccine escape

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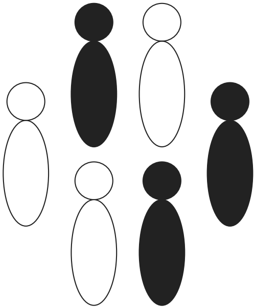
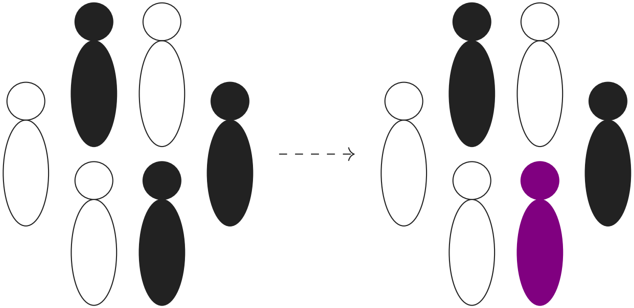
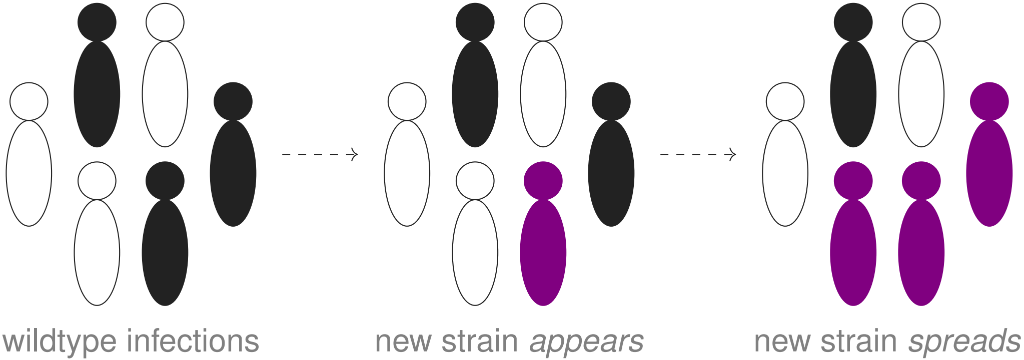
GATES Cambridge

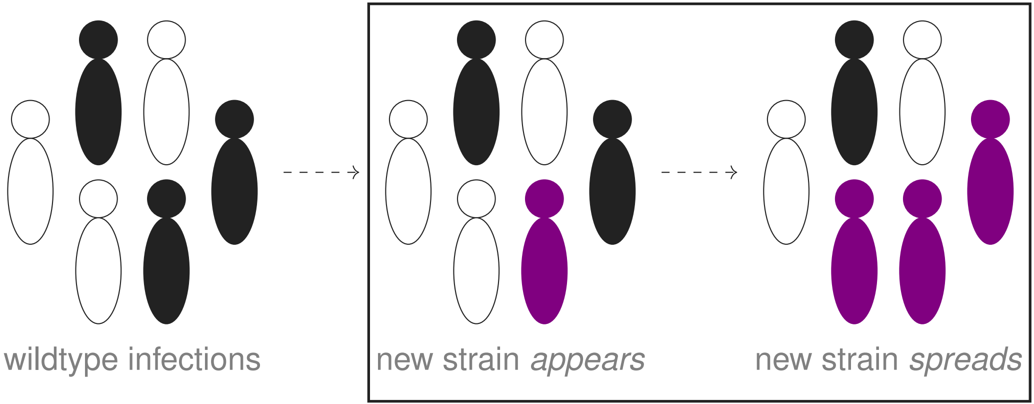


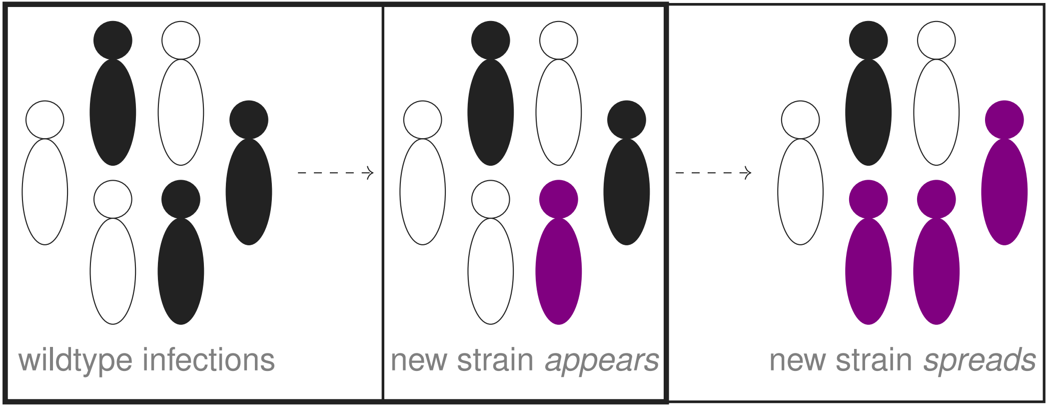
wildtype infections

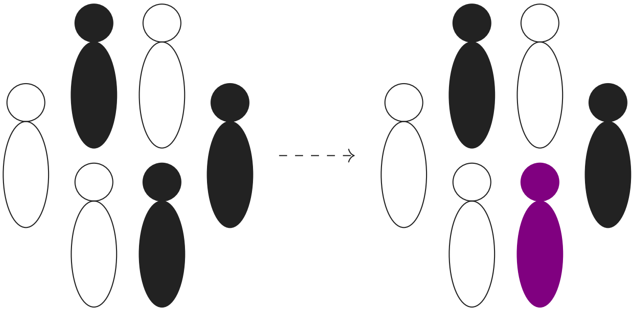


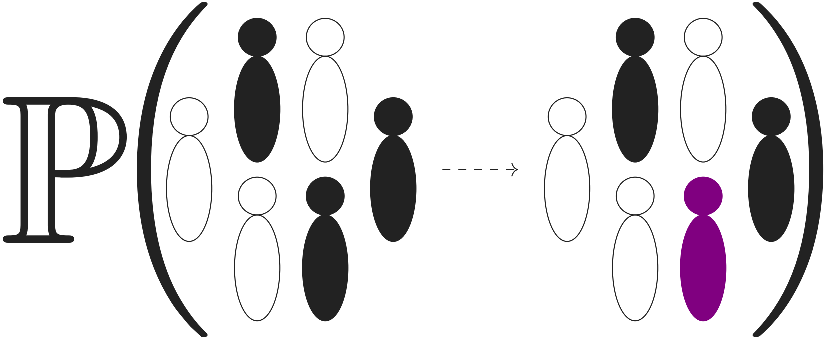
wildtype infections new strain *appears*

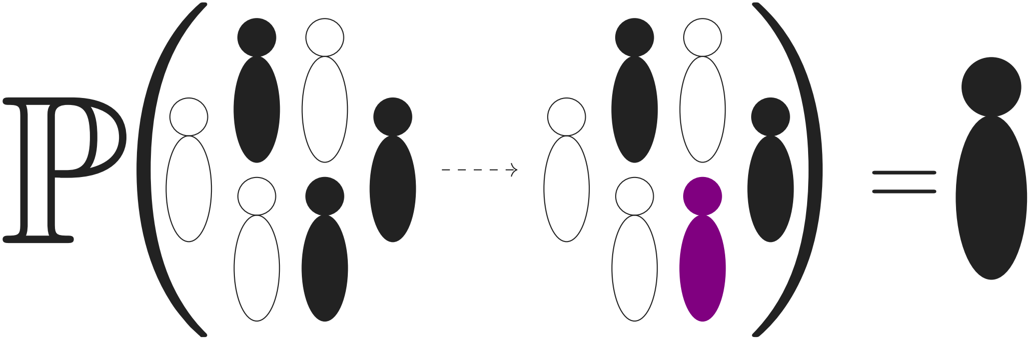

wildtype infections
new strain *appears*
new strain *spreads*


wildtype infections
new strain *appears*
new strain *spreads*

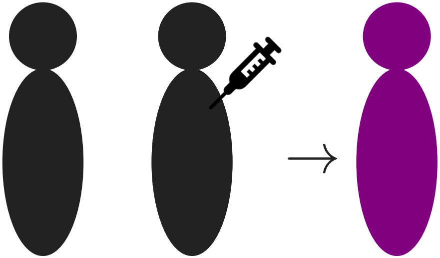

wildtype infections
new strain *appears*
new strain *spreads*

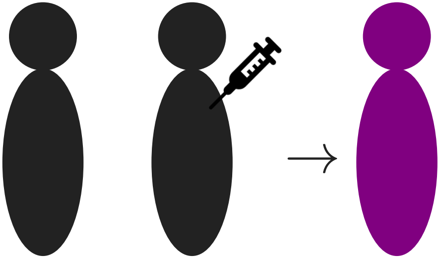


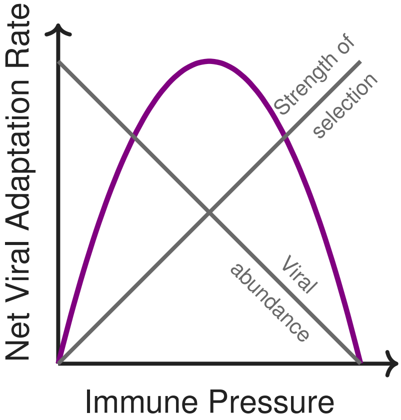




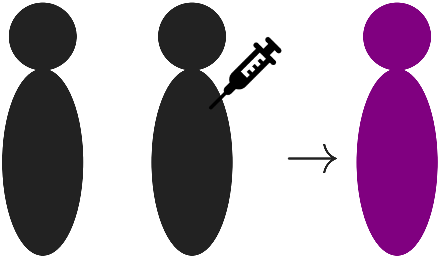
Hartfield et al. 2014, Gog et al. 2021,
Rella et al. 2021, Saad-Roy et al. 2021

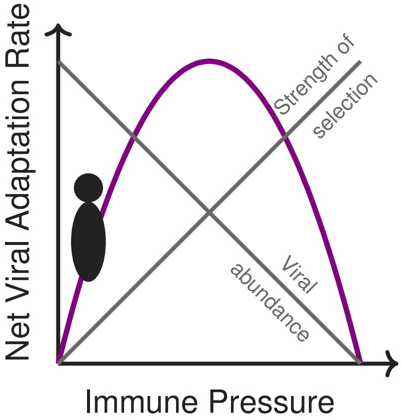




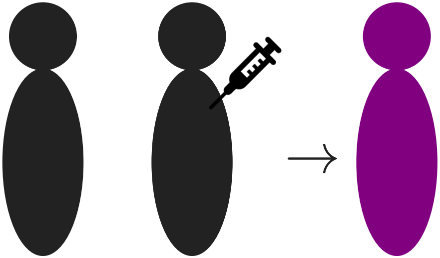


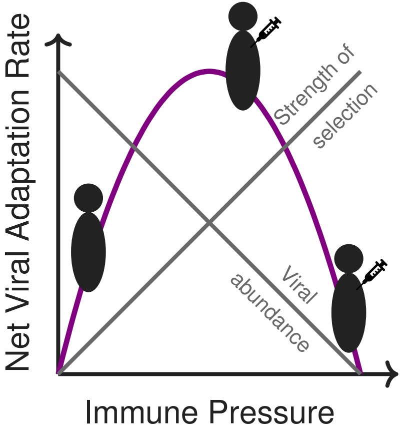
Grenfell *et al.*, Science 2004



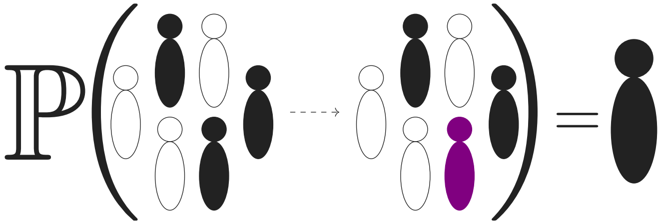


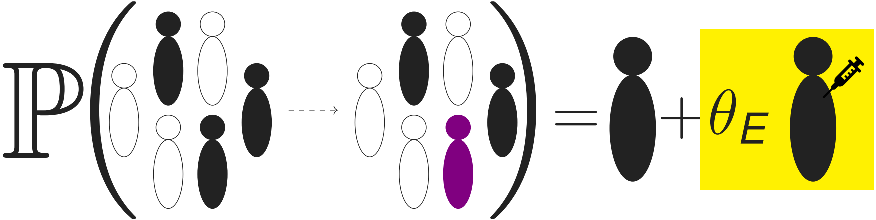
Grenfell *et al.*, Science 2004

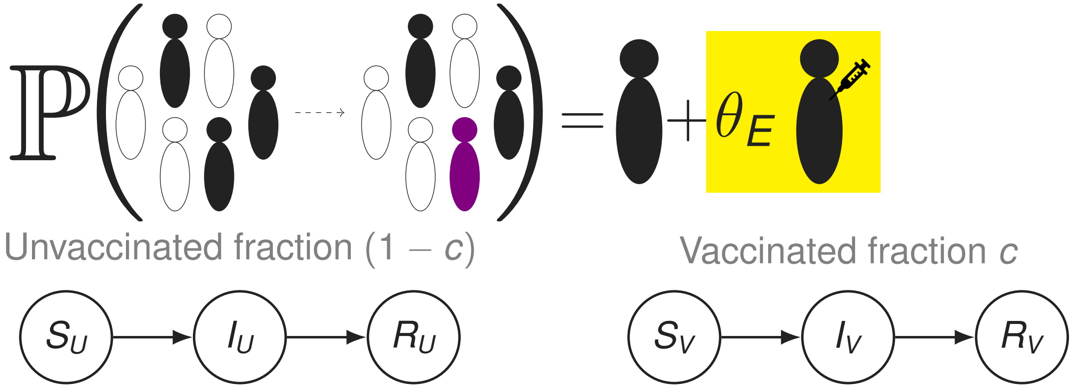




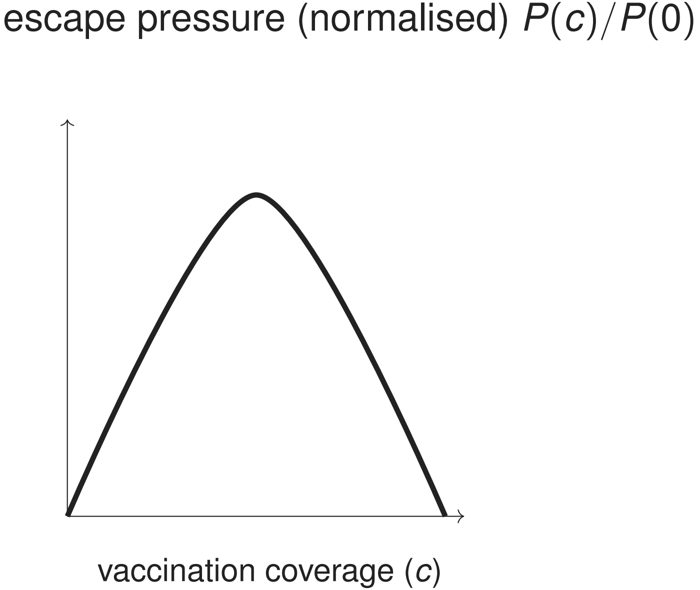
Grenfell *et al.*, Science 2004

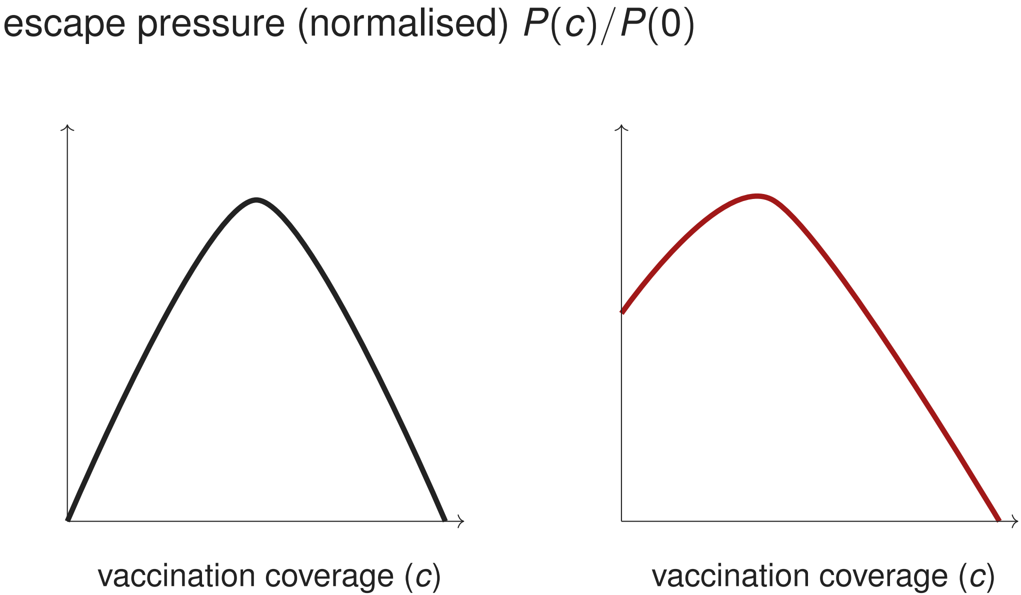


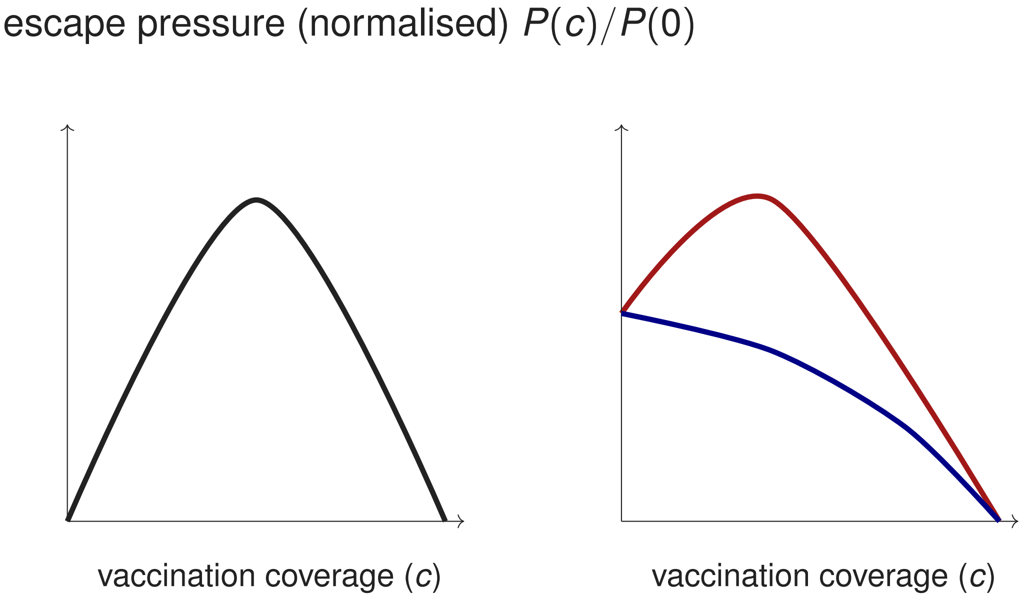

$\mathbb{P}$
=
+
θ_E



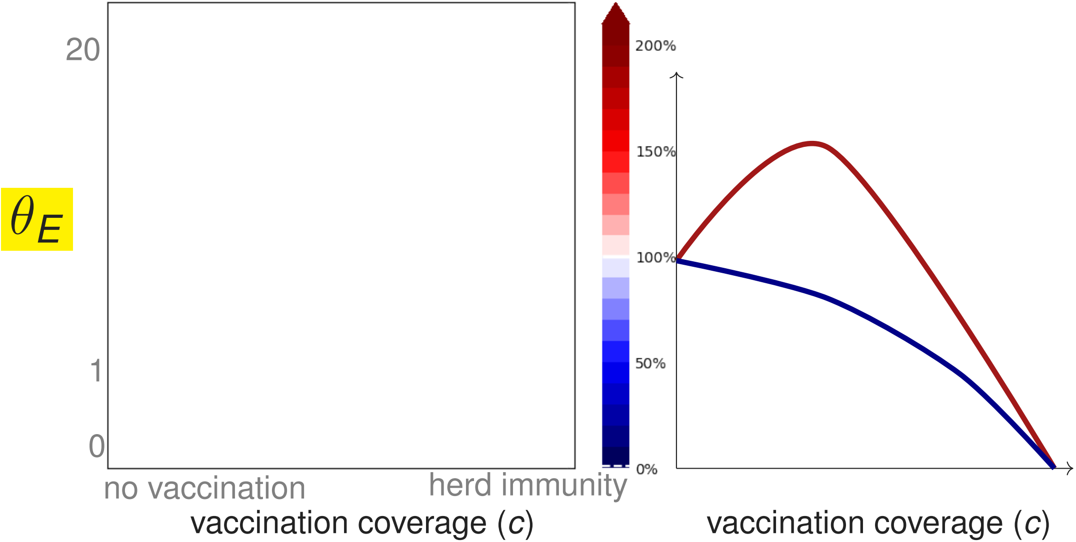
θ_E
Unvaccinated fraction (1 − c)
Vaccinated fraction c
S_U
I_U
R_U
S_V
I_V
R_V


escape pressure (normalised) $P(c)/P(0)$
vaccination coverage (c)

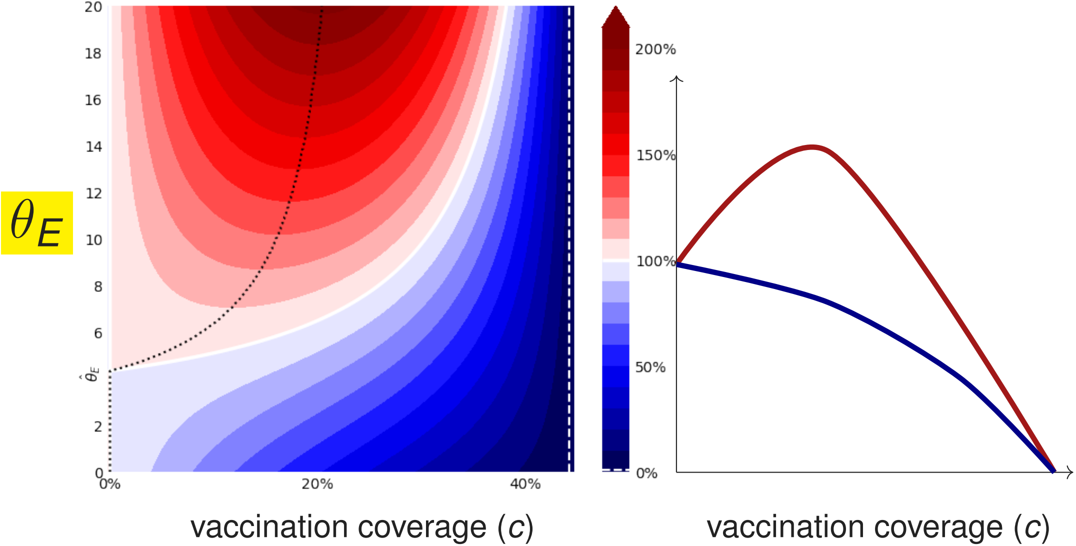

escape pressure (normalised) $P(c)/P(0)$
vaccination coverage (c)
vaccination coverage (c)

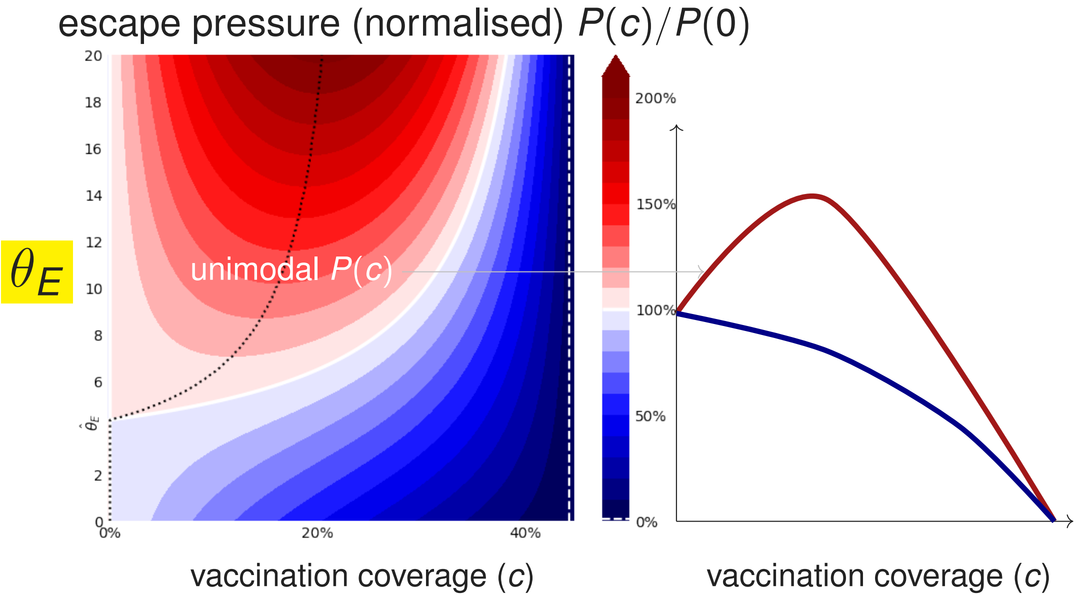

escape pressure (normalised) $P(c)/P(0)$
vaccination coverage (c)
vaccination coverage (c)

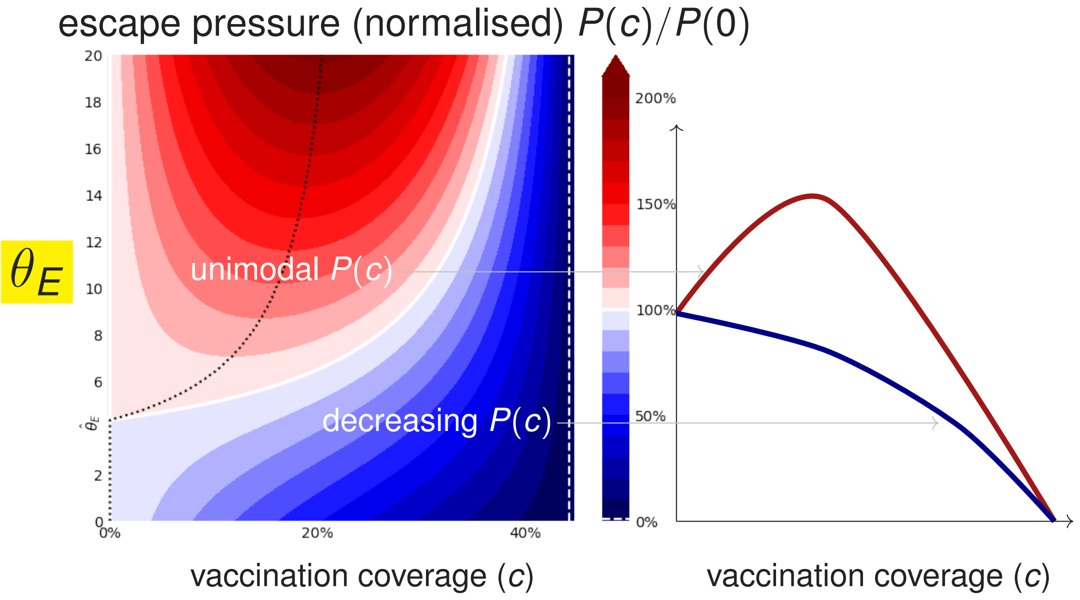
escape pressure (normalised) $P(c)/P(0)$



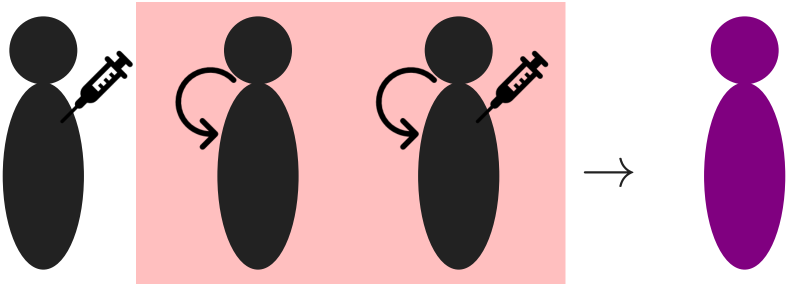
escape pressure (normalised) $P(c)/P(0)$

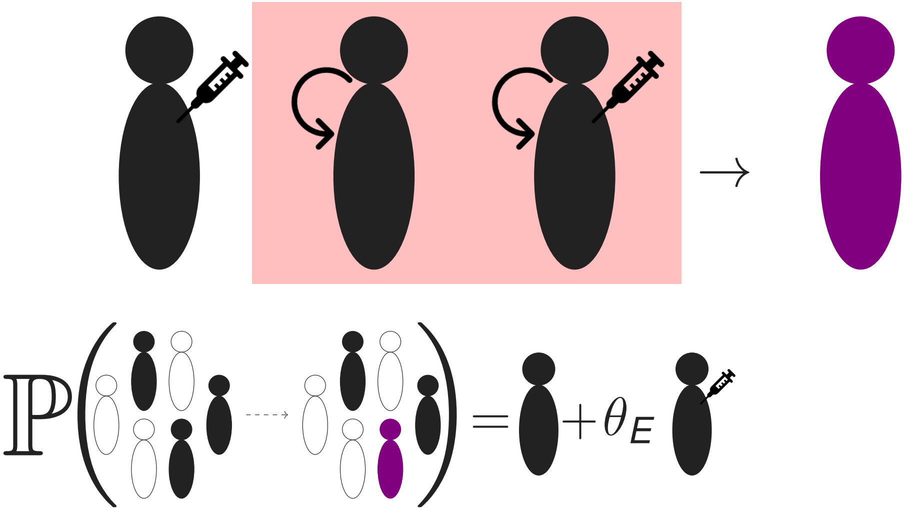


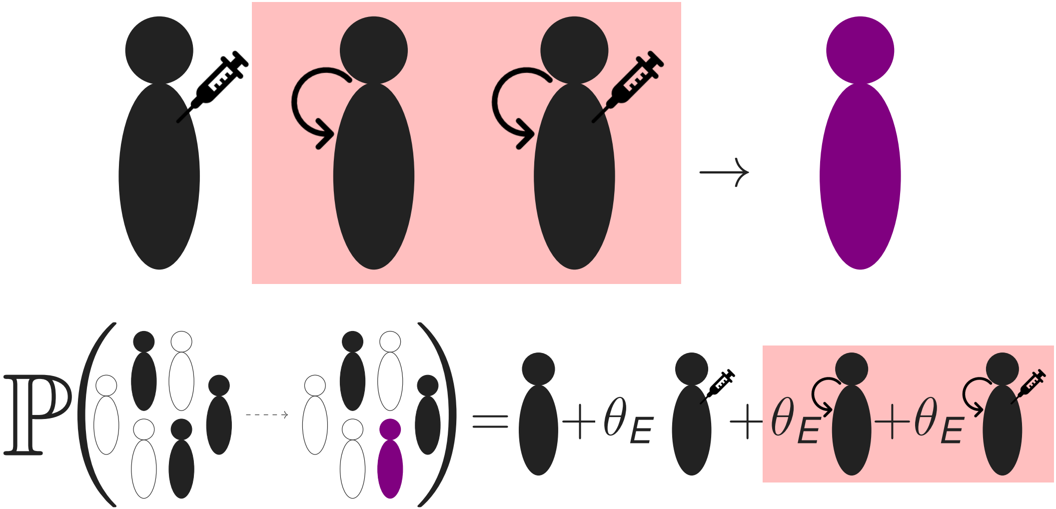

escape pressure (normalised) $P(c)/P(0)$
θ_E
unimodal $P(c)$
20
18
16
14
12
10
8
6
$\hat{\theta}_E$
2
0
0%
20%
40%
200%
150%
100%
50%
0%
vaccination coverage (c)
vaccination coverage (c)

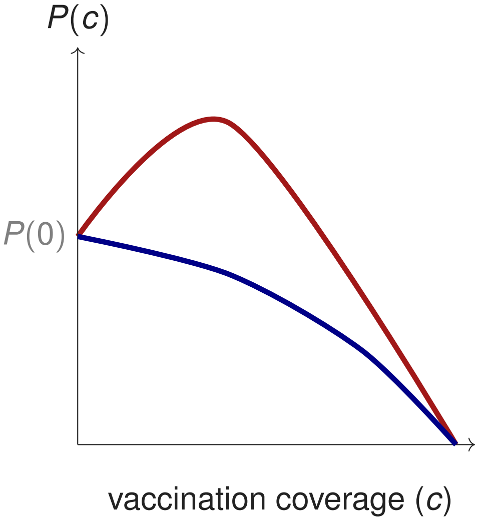

escape pressure (normalised) P(c)/P(0)
θ_E
unimodal P(c)
decreasing P(c)
20
18
16
14
12
10
8
6
θ̂_E
2
0
0%
20%
40%
200%
150%
100%
50%
0%
vaccination coverage (c)
vaccination coverage (c)


θ_E

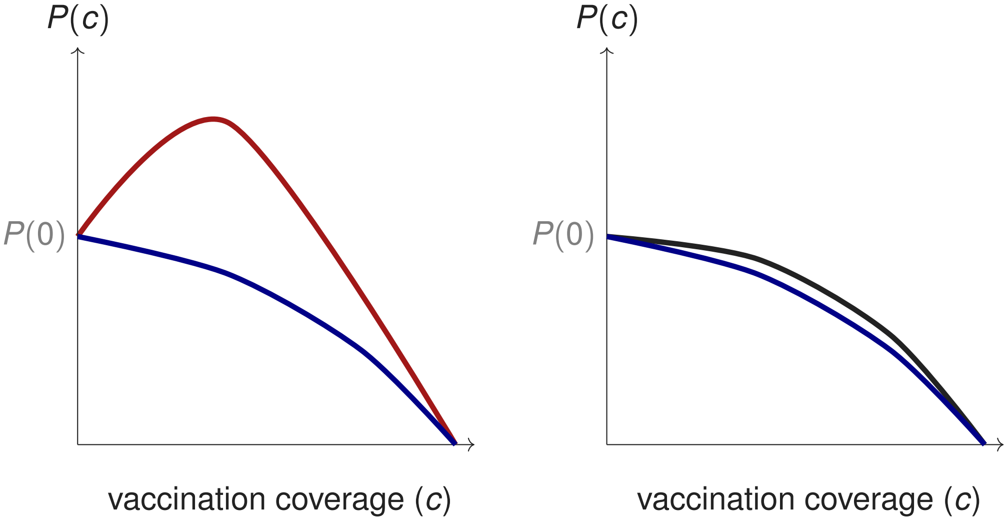


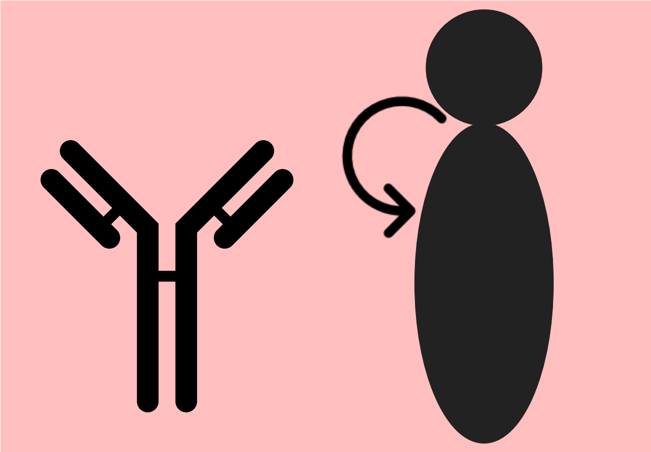

$\mathbb{P}$
$=$
$+\theta_E$

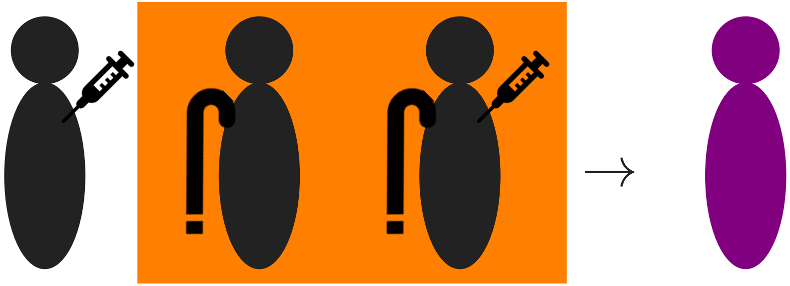


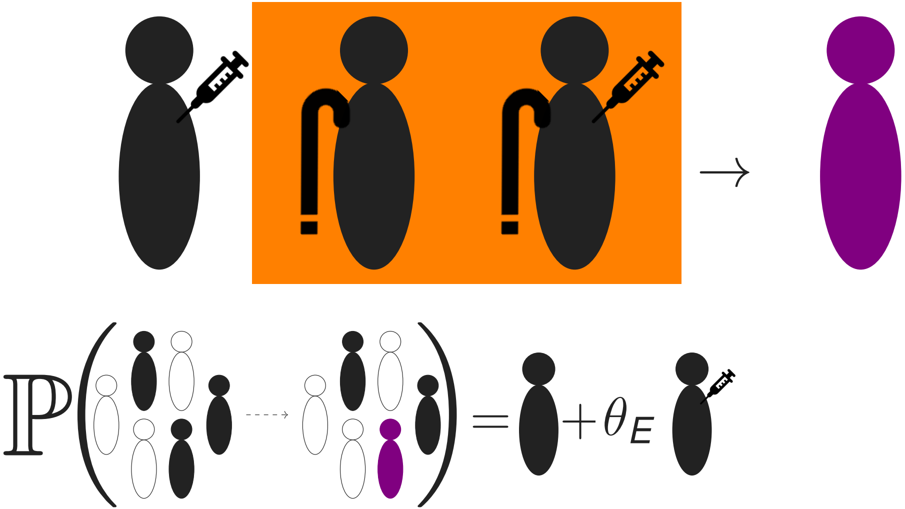


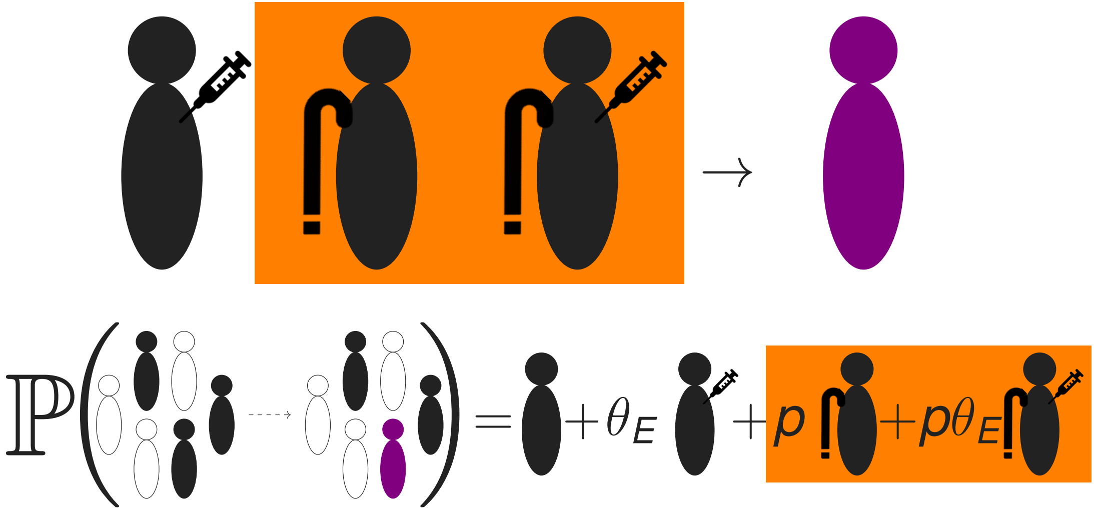
$P(c)$
$P(0)$
vaccination coverage (c)

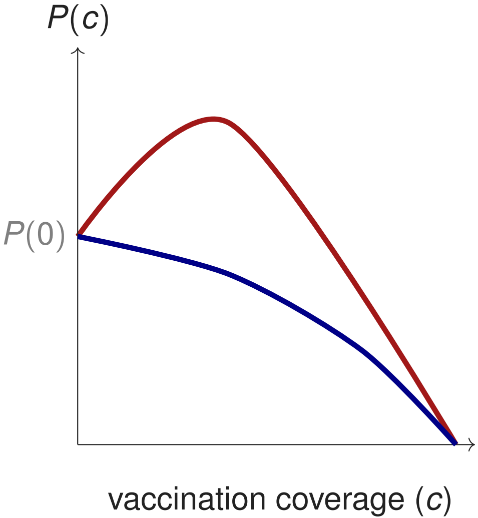

P(c)
P(0)
vaccination coverage (c)
P(c)
P(0)
vaccination coverage (c)



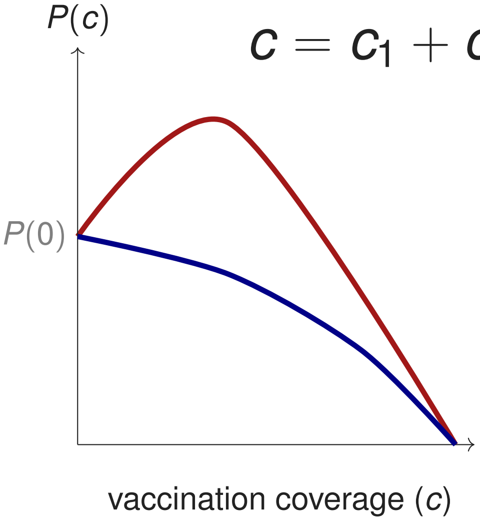


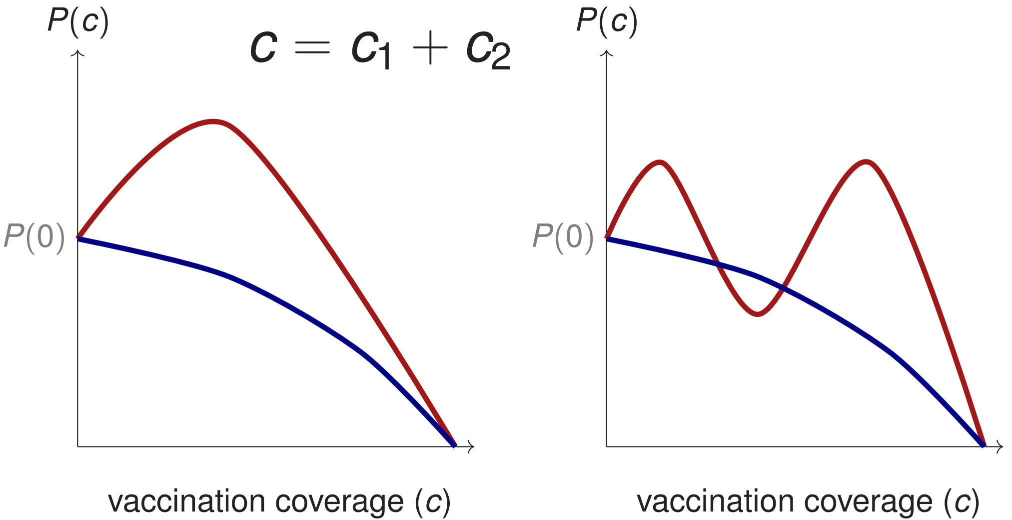

$\mathbb{P}$
$=$
$+\theta_E$


θ_E
p
$p\theta_E$

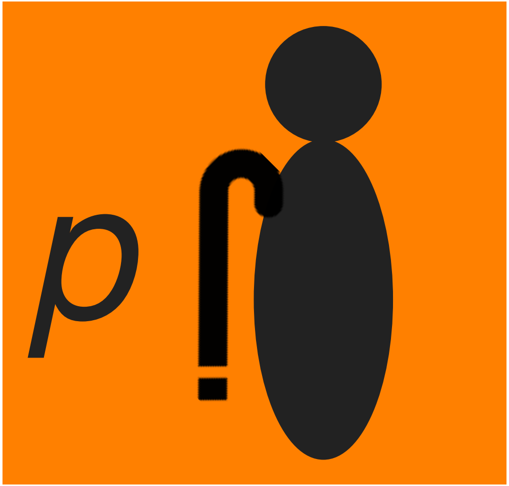

$P(c)$
$P(0)$
vaccination coverage (c)

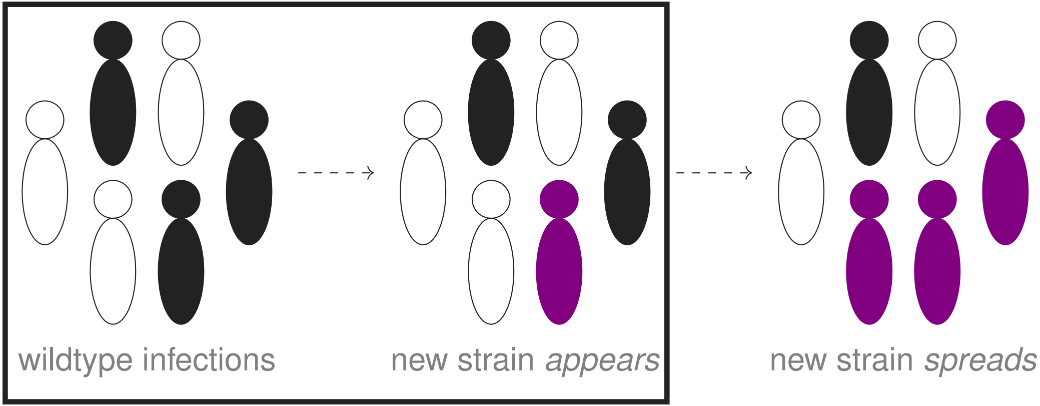
$$c = c_1 + c_2$$

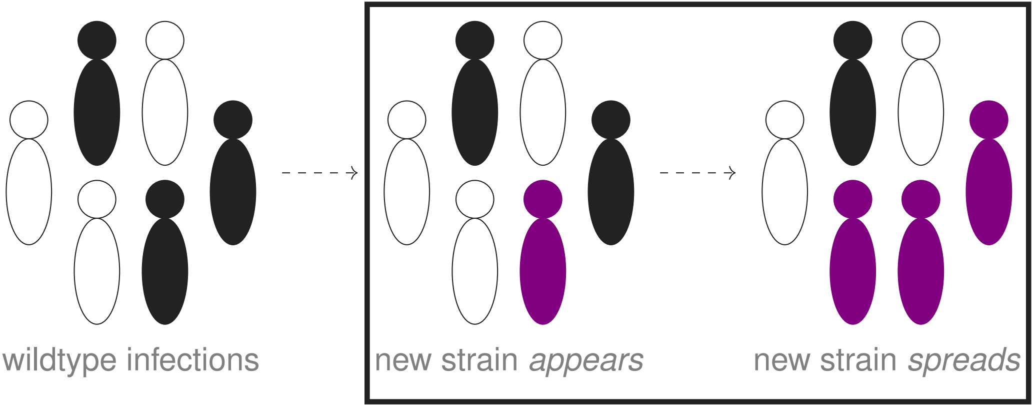


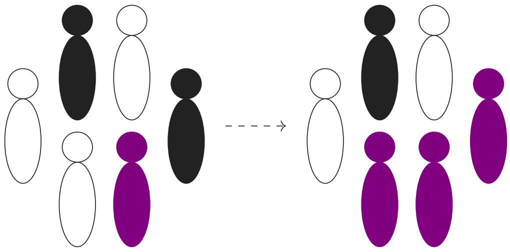


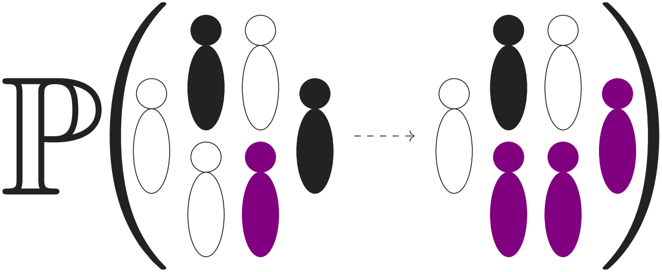
$P(c)$
$c = c_1 + c_2$
$P(0)$
vaccination coverage (c)
$P(c)$
$P(0)$
vaccination coverage (c)

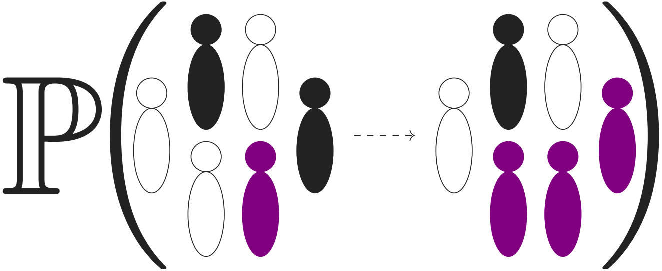

p


wildtype infections
new strain *appears*
new strain *spreads*

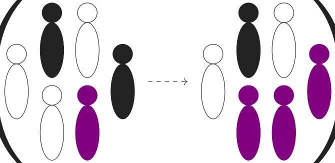

wildtype infections
new strain *appears*
new strain *spreads*

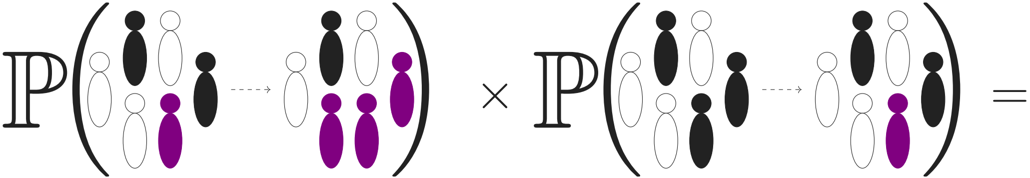


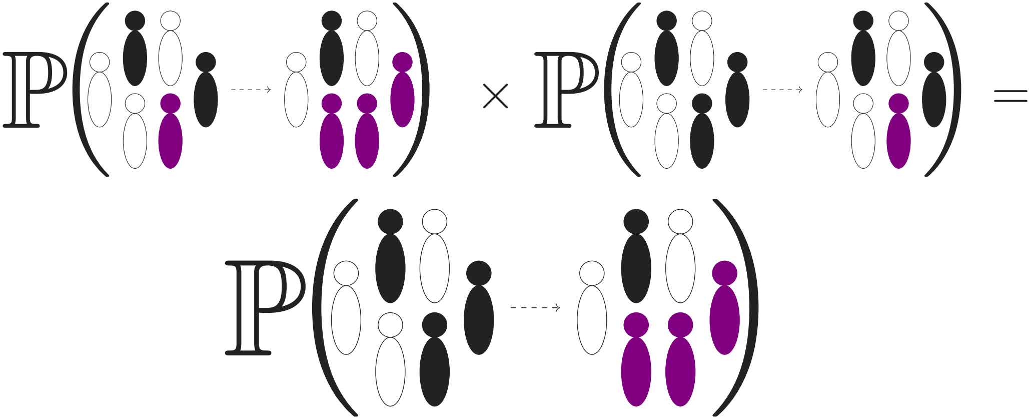


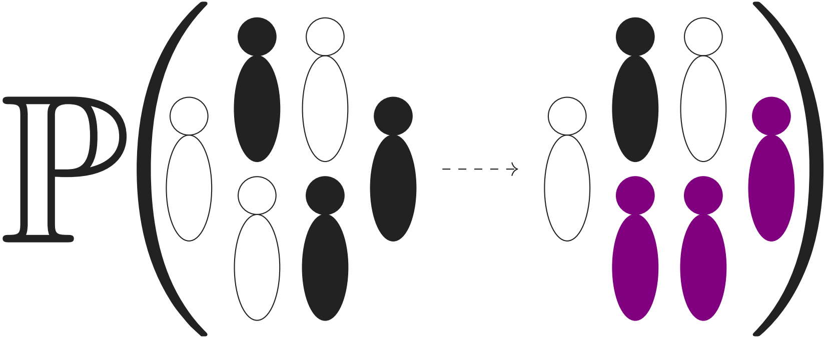


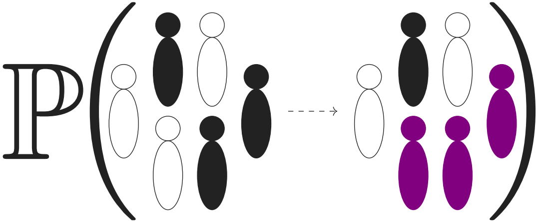
$$\neq 1 - \frac{1}{R(t)}$$

$\mathbb{P}\Bigg($  $\Bigg)$

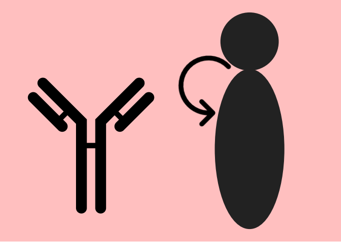







P


θ_E




p