Population Subdivision

What if we aren't all one big happy group?

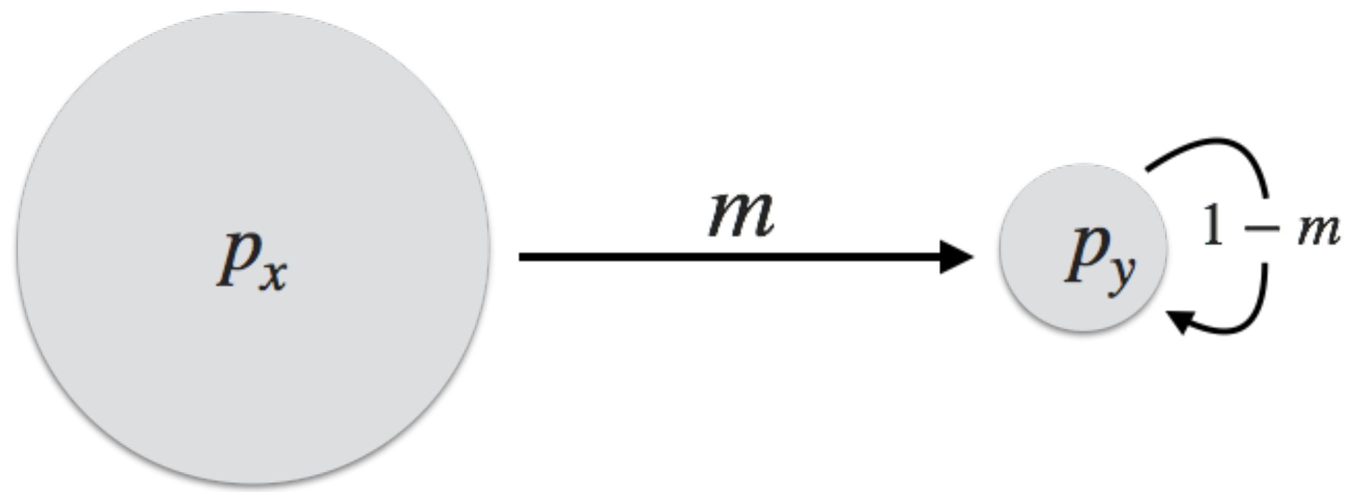
Jargon

Migration: Migration is the movement of individuals among spatial locations.

Gene Flow: Gene flow is a process of genetic material moving between locales or populations that results in modification of standing genetic variation.

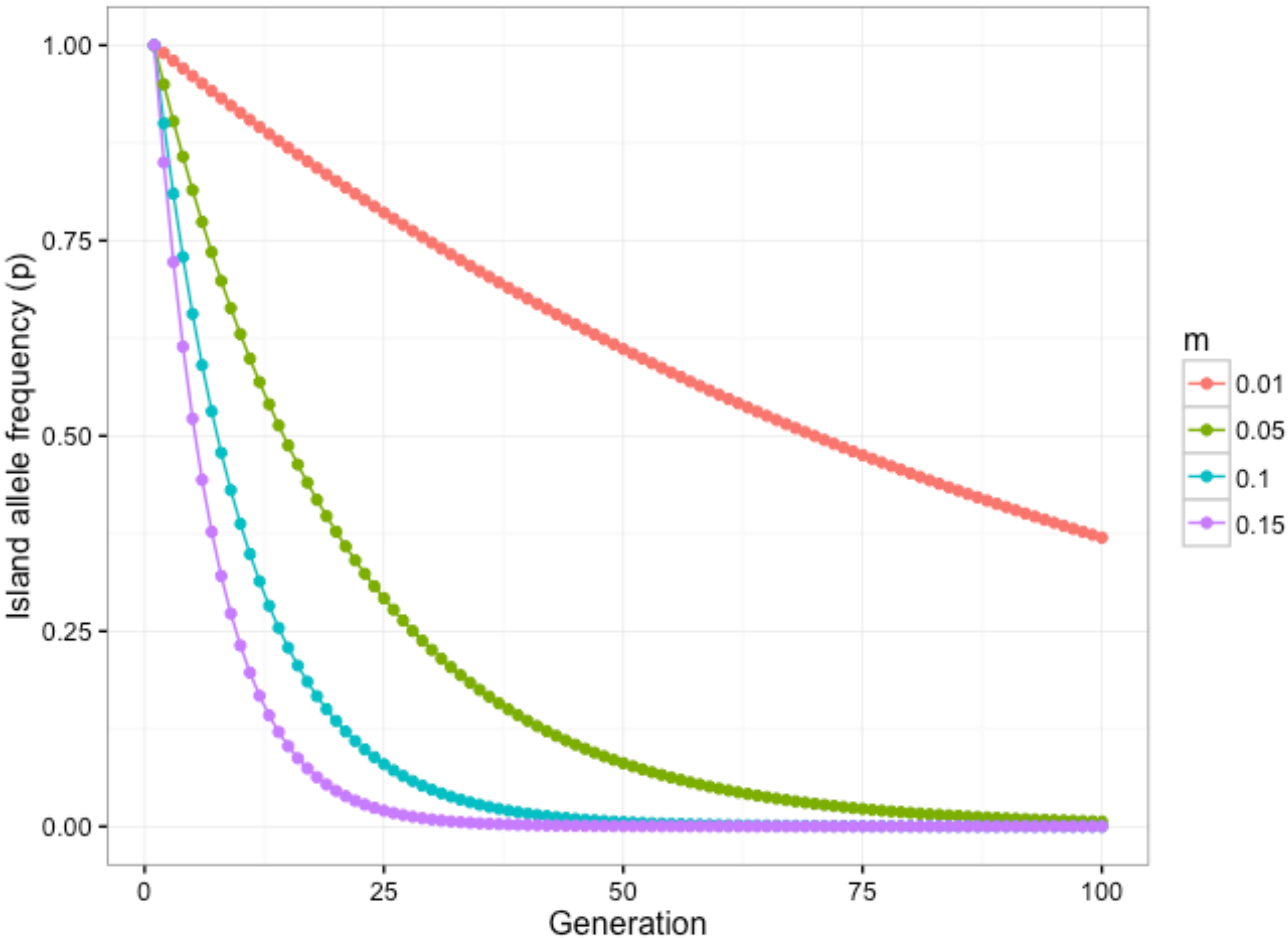
Population Models

Island Mainland Model



$$p_{y,t+1} = (1-m)p_{y,t} + mp_x$$

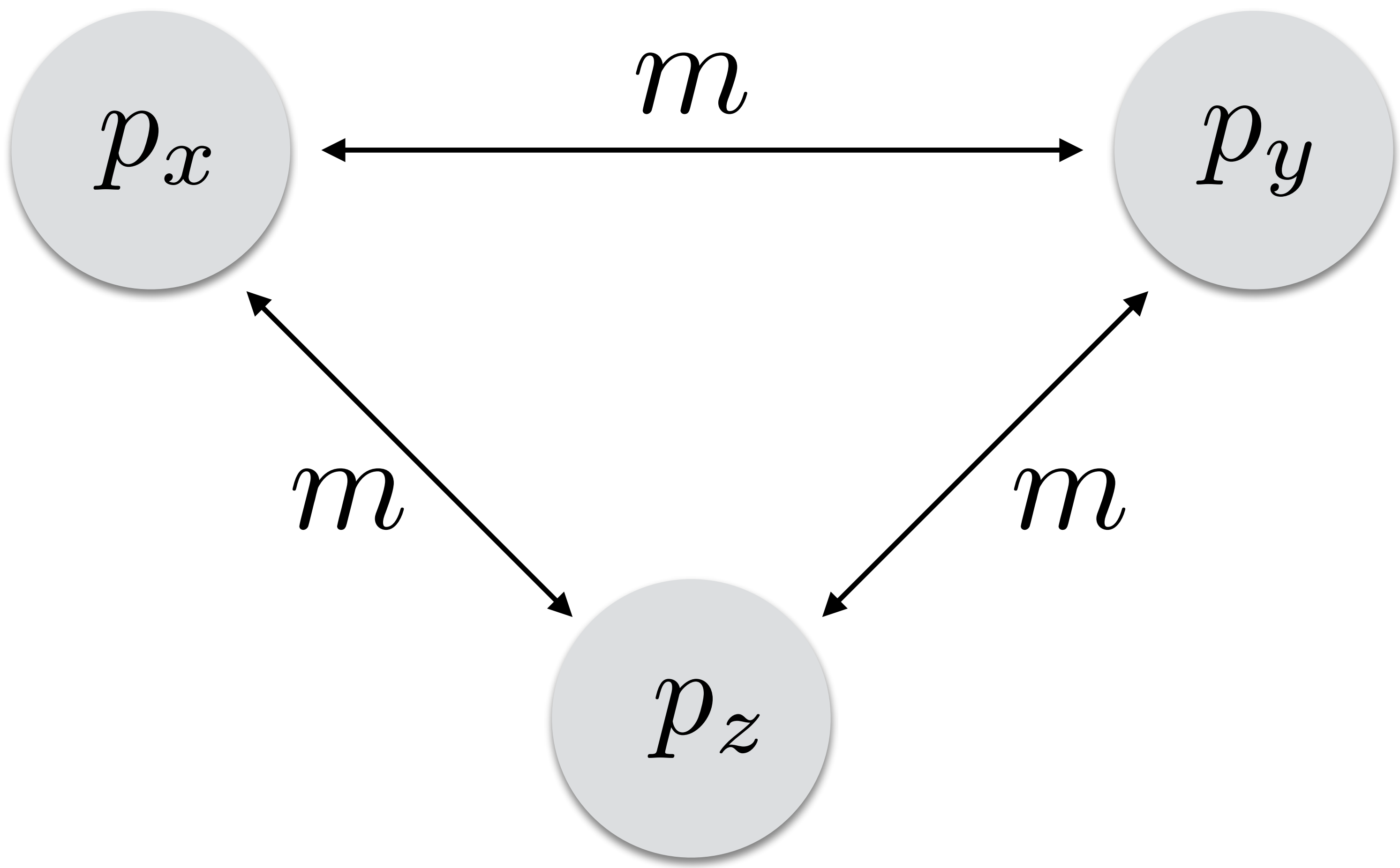
```
migration_rates <- c(.01,.05,.10,.15)
results <- data.frame(m=rep(migration_rates,each=100),
                      Generation=rep(1:100,times=4),
                      p=NA)
for( m in migration_rates) {
  px <- 0
  py <- 1
  results$p[ results$m==m ] <- py
  for( t in 2:100){
    p.0 <- results$p[ results$m==m & results$Generation == (t-1) ]
    p.1 <- (1-m)*p.0 + px*m
    results$p[ results$m==m & results$Generation == t ] <- p.1
  }
}
results$m <- factor(results$m)
```


Island allele frequency (p)
1.00
0.75
0.50
0.25
0.00
0
25
50
75
100
Generation
m
0.01
0.05
0.1
0.15

Underlying Assumptions

- Generations do not overlap so that we can use a difference equation approach for understanding connectivity.
- Populations are discrete in that there are breaks between populations.
- Migration rates are constant through both space and time.
- Migration is symmetric in both directions.

Island Model



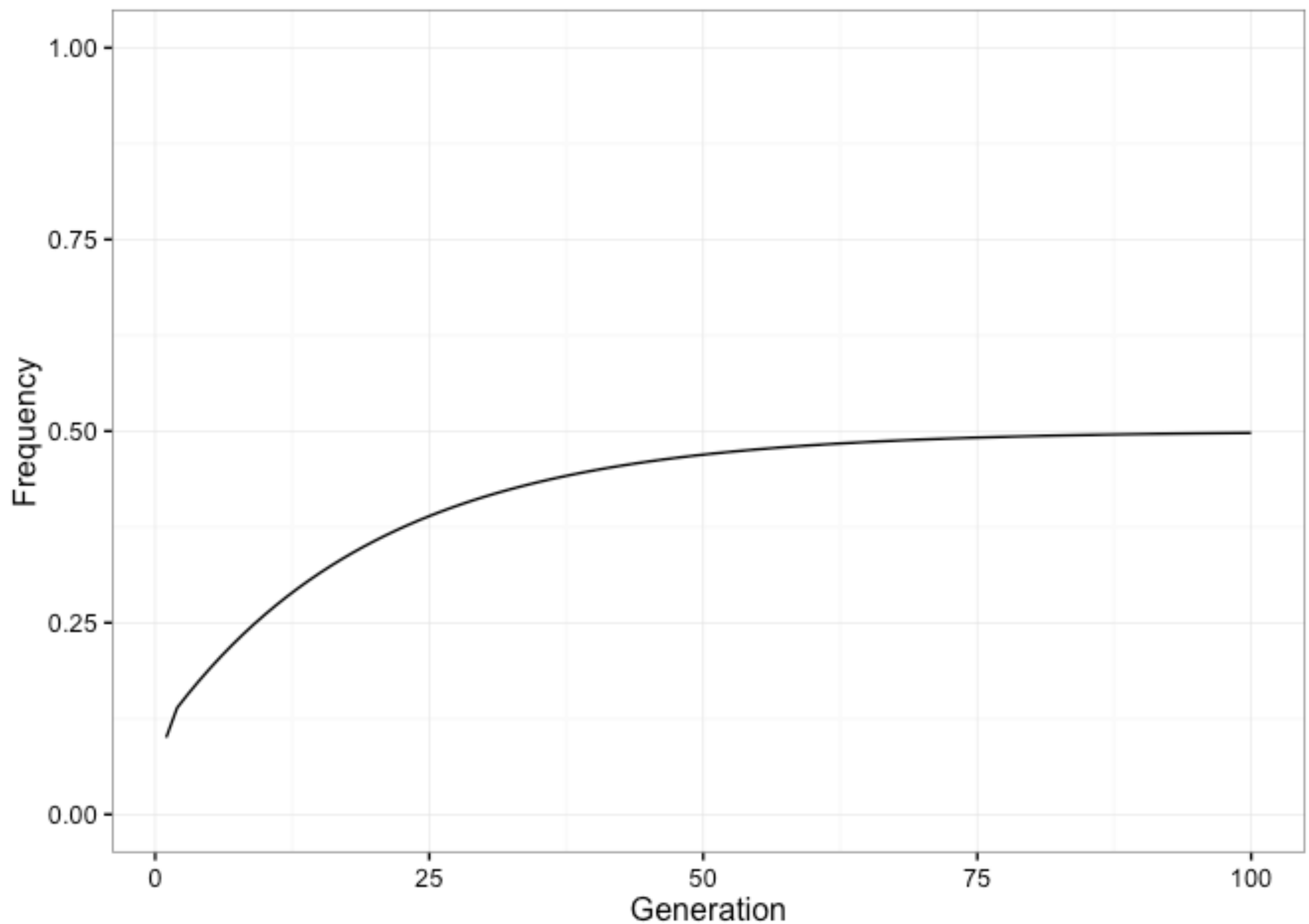
$$p_{x,t+1} = (1-m)p_{x,t} + m\bar{p}$$

$$p_t = \bar{p} + (p_0 - \bar{p})(1-m)^t$$

Wright (1931)

```r
T <- 100
pX <- rep(NA,T)
pX[1] <- 0.1
pbar <- 0.5
m <- 0.05
for( t in 2:T)
  pX[t] <- pbar + (pX[1]-pbar)*(1-m)^t
df <- data.frame( Generation = 1:T, Frequency = pX)
```

$$p_0 = 0.1; \;\; m = 0.05; \;\; \bar{p} = 0.5$$

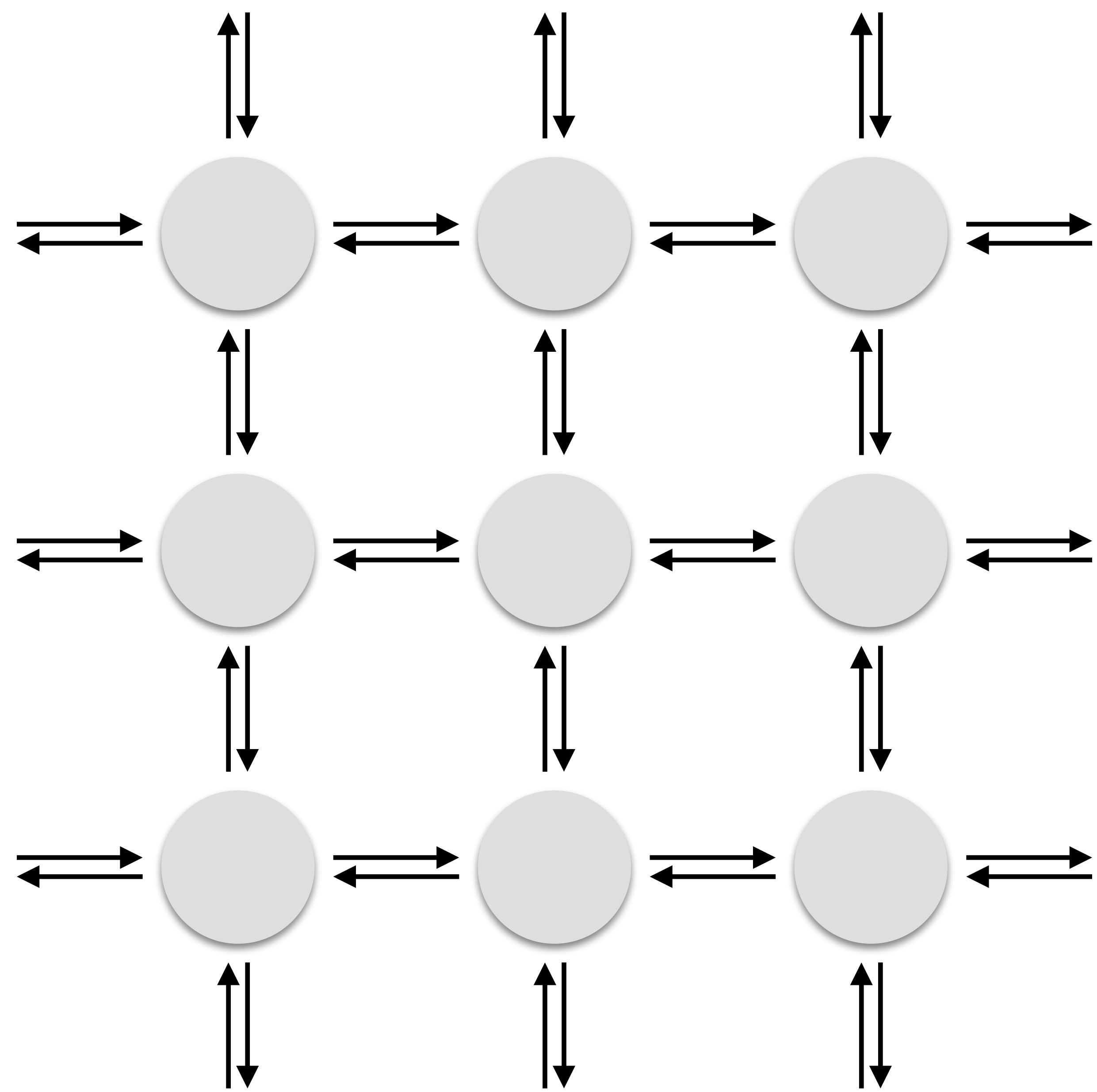


Stepping Stone Model

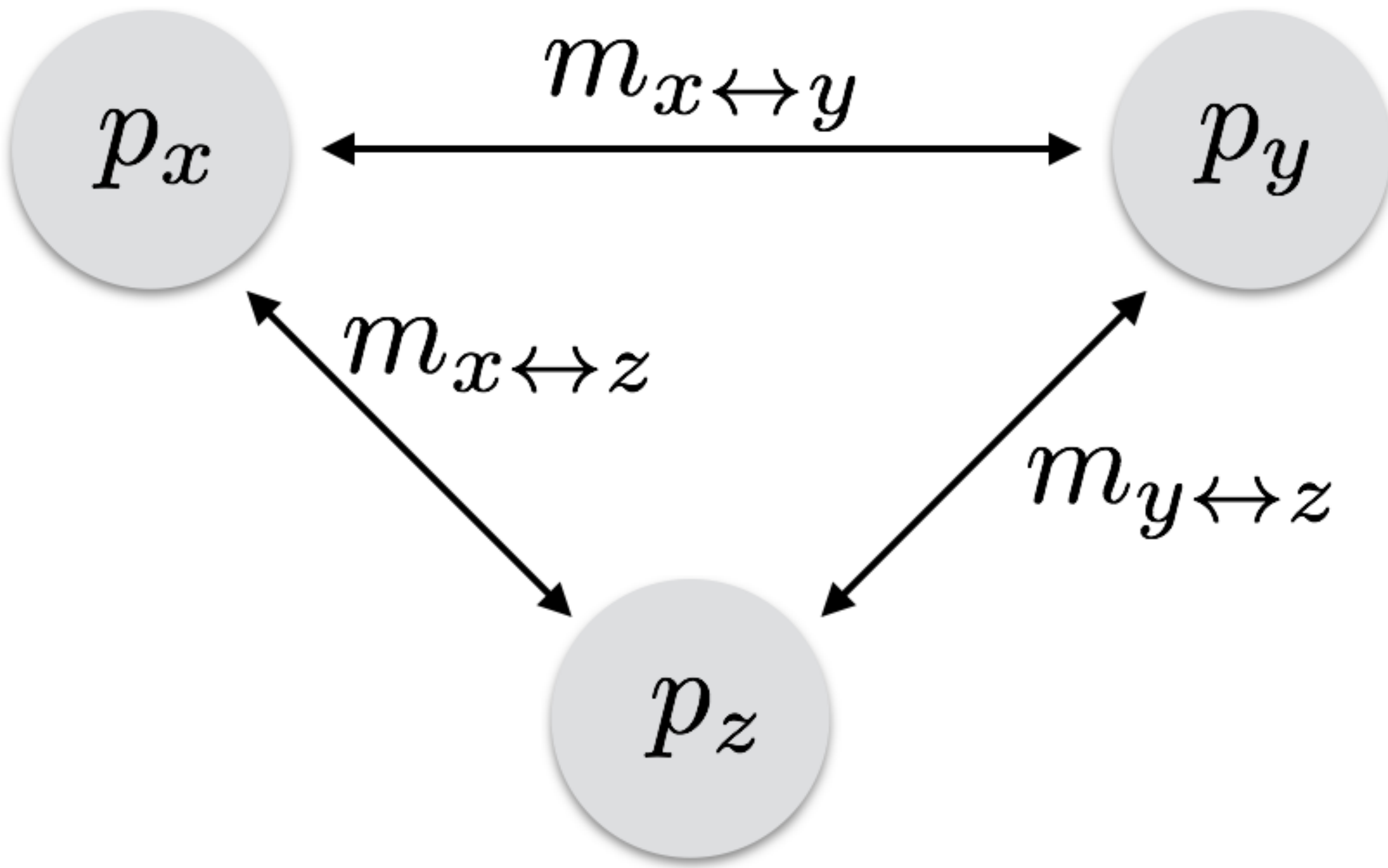
$$p_{i,t+1} = (1 - m_1 - m_\infty) * p_i + \frac{m}{2}(p_{i-1,t} + p_{i+1,t}) + m_\infty \bar{p} + \eta_i$$

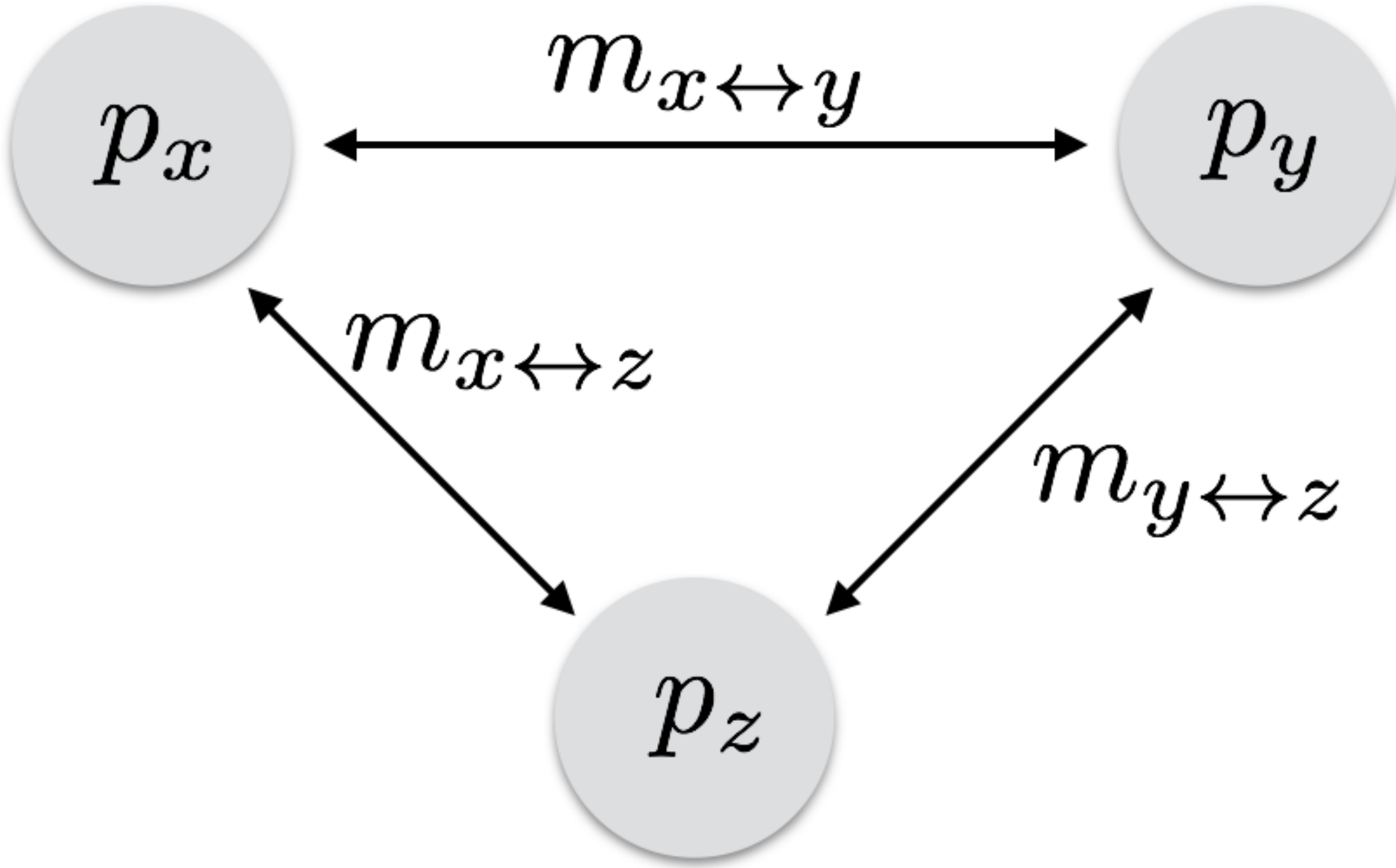
Kimura & Weiss (1964)

2-D Stepping Stone Model



General Model

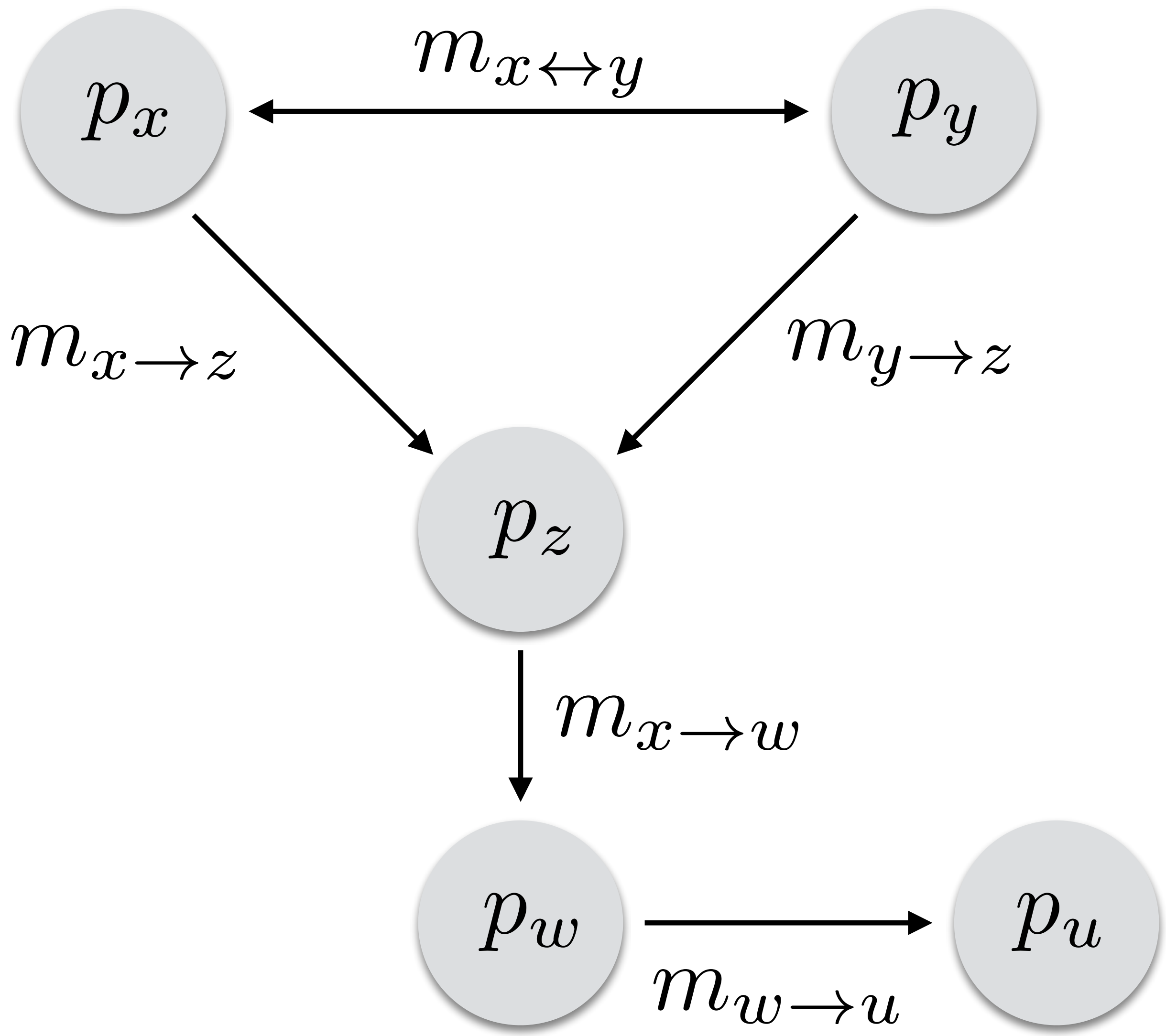




$$p_{x,t+1} = m_{x\leftrightarrow y}p_{y,t} + m_{x\leftrightarrow z}p_{z,t} + [1 - (m_{x\leftrightarrow y} + m_{x\leftrightarrow z})]p_x$$

$$p_{y,t+1} = m_{x\leftrightarrow y}p_{x,t} + m_{y\leftrightarrow z}p_{z,t} + [1 - (m_{x\leftrightarrow y} + m_{y\leftrightarrow z})]p_y$$

$$p_{z,t+1} = m_{x\leftrightarrow z}p_{x,t} + m_{y\leftrightarrow z}p_{y,t} + [1 - (m_{x\leftrightarrow z} + m_{y\leftrightarrow z})]p_z$$


p_x
$m_{x\leftrightarrow y}$
p_y
$m_{x\to z}$
$m_{y\to z}$
p_z
$m_{x\to w}$
p_w
p_u
$m_{w\to u}$