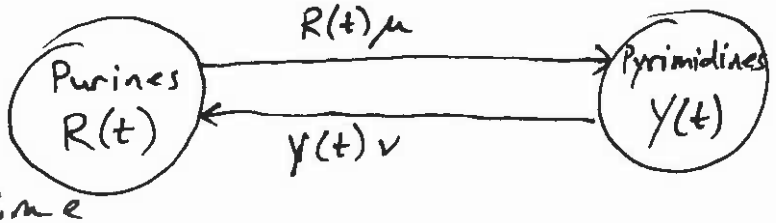
1) The model for transmission is

$$\frac{dS(t)}{dt} = \Theta - \beta S(t) I(t) - m S(t) + \gamma I(t)$$

$$\frac{dI(t)}{dt} = \beta S(t) I(t) - (m + \nu + \gamma) I(t)$$

Given that $\gamma I(t)$ appears in both equations, we can infer that it is a process that moves individuals from the infected class to the susceptible class. Recovery is such a process, so γ is the rate of recovery from infection. $\nu I(t)$ is a process that causes infected individuals to be removed from the population. This is caused by mortality, most likely, or possibly emigration. Thus, ν is the rate of mortality due to disease.

2)



Discrete-time

First, because we are dealing in discrete time, I have to decide on an order of events. I will assume that purines mutate first, then pyrimidines.

Initially, there are $R(t)$ purines and $Y(t)$ pyrimidines.

After the first event,

$$R' = R(t) - \mu R(t) = (1-\mu) R(t)$$

$$Y' = Y(t) + \mu R(t)$$

After the second event,

$$R'' = R' + \nu Y'$$

$$Y'' = Y' - \nu Y' = (1-\nu) Y'$$

Thus the number of purines and pyrimidines is given by the recursion

$$R(t+1) = R'' = (1-\mu) R(t) + \nu (Y(t) + \mu R(t))$$

$$Y(t+1) = Y'' = (1-\nu) (Y(t) + \mu R(t))$$

μ is the fraction of purines that mutate

ν is the fraction of pyrimidines that mutate

Continuous-time

Both mutation processes happen simultaneously, so the differential equations are

$$\frac{dR(t)}{dt} = -\mu R(t) + \nu Y(t) \quad \text{and} \quad \frac{dY(t)}{dt} = \mu R(t) - \nu Y(t)$$

μ is the rate of mutation by purines

ν is the rate of mutation by pyrimidines

3) Variables

$S(t)$ = # of susceptible people

$A_N(t)$ = # of asymptomatic people (not quarantined)

$A_Q(t)$ = # of asymptomatic people who have been quarantined

$I_N(t)$ = # of infected people (not isolated)

$I_Q(t)$ = # of infected people who have been isolated

Processes

Transmission

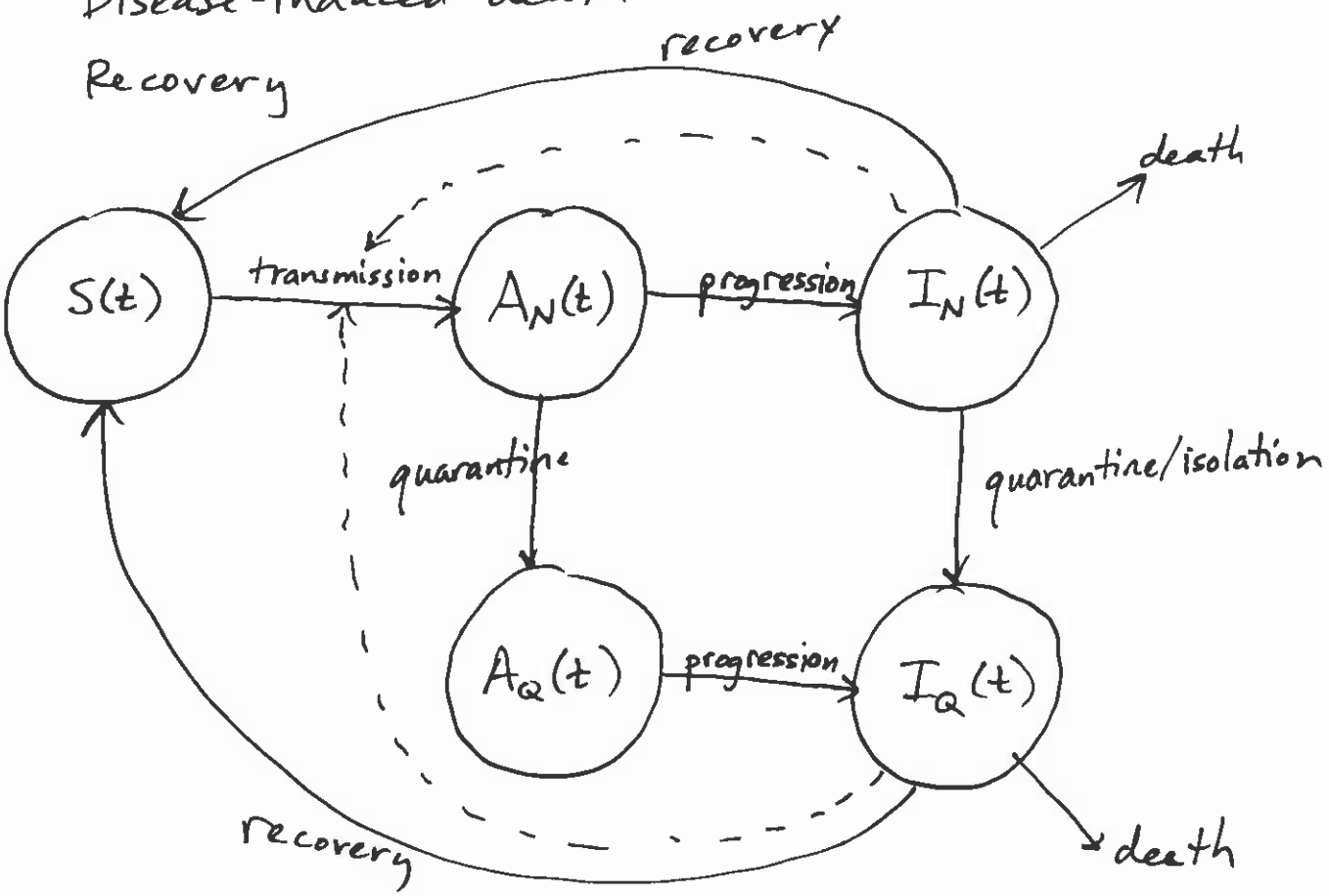
Disease progression

Quarantine

Isolation

Disease-induced death

Recovery



What was necessary in this digram?

- You needed that all asymptomatic individuals will become symptomatic before recovery.
- You cannot be quarantined without first becoming infected. Because infection (transmission) and quarantine are distinct processes, they cannot both happen at exactly the same time, which is what you are assuming by moving from susceptible to quarantined.
  - If you assume that some individuals who are not infected are quarantined, you must also assume that they return to the susceptible population before progressing to the isolated class - otherwise, they will contribute to the size of $I_a(t)$, which affects transmission.
- All quarantined individuals must progress to the isolated class before recovering.

Optional things

- Existence of a recovered class, tracking the number of dead people, births, separating out elderly people.