Properties of Exponential Growth

- Population will always increase by the same Percent in any two periods of time of the same length
  - Simplest example assume population doubles each year
    - \(2 \rightarrow 4 \rightarrow 8 \rightarrow 16 \rightarrow 32 \rightarrow 64 \rightarrow 128 \rightarrow 256 \rightarrow 512\)
    - If \(r=0.05\)
      - \(2 \rightarrow 2.10 \rightarrow 2.21 \rightarrow 2.32 \rightarrow 2.43 \rightarrow 2.55 \rightarrow 2.68 \rightarrow 2.81\)
  - Still J-shaped.

Calculating \(r\) if doubling time is known

\[
t_{\text{double}} = \frac{\ln(2)}{r}
\]

\[
r \times t_{\text{double}} = \ln(2)
\]

\[
r = \ln(2) / t_{\text{double}}
\]
Density

- Population Density = # of individuals / unit area

- Density Independent Population Growth
  - Per capita growth is unaffected by population density (exponential growth)

- Density Dependent Population Growth
  - Per capita growth rates change depending on the population density.
  - Usually per capita growth rates decrease as population density increases. (logistic growth)

Population Density

- Arable land is not increasing
- Population is increasing
- Population density will increase as population size increases
- Leading to
  - More conflict over resources
  - Less area for none human intensive use
  - More people affected by “local” disasters
  - Increased opportunity for spread of infectious diseases
Logistic growth

- Assumes that resources may limit growth
- As density increases competition for resources will cause either decreased **fecundity** or increased **mortality** or both
- Population growth declines as density increases
- Population growth stops a Carrying capacity
- \( K = \text{Carrying capacity} \)

\[
\frac{dN}{dt} = rN \left( \frac{K - N}{K} \right)
\]

Allee Effect

Logistic growth assumes that as population density increases, the rate of population growth decreases (i.e. birth rates decrease or death rates increase, or both).

In a few population the opposite is observed across a limited range of population densities
- Meerkats
- Passenger pigeon
- Cougars

Why –
- Predator avoidance
- Social interactions
- Mating problems