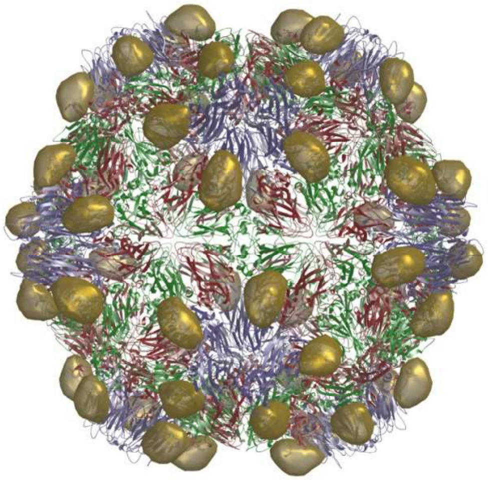
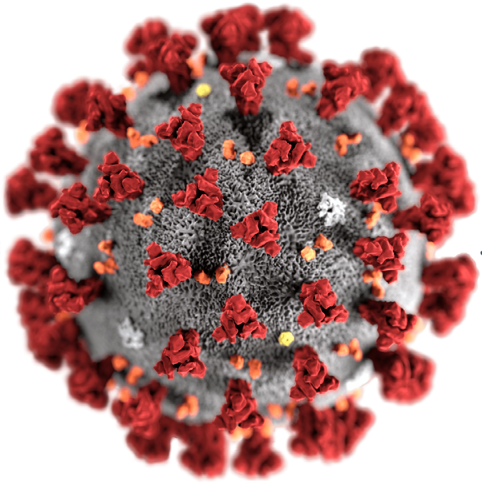
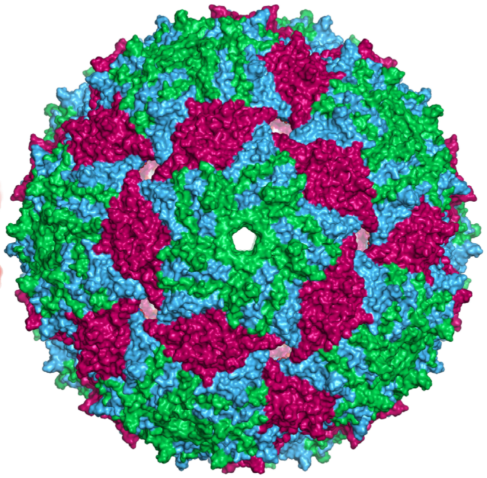
- Viruses
- Immune system
- Screening clinics
- SIR model
  - time independent variable
  - space and time independent variables

- Submicroscopic: $\sim\mathcal{O}(20 - 300\,\mathrm{nm})$, cannot be seen with optical microscope
- Pathogen: Greek "producer of suffering", any organism that produces disease
- Host replication: only reproduces in another life form (bacteria, archaea, ...)
- Various shapes, sizes (morphology): helical, icosahedral, prolate, corona
- Genetic information: from 2Kbases to 2Mbases

- Innate immune system: react to wide classes of pathogens through pattern recognition receptors (PRRs)

Cell PRRs:	Transmembrane (TLRs)	Cystolic	Inflammasome
Surface:	Cuticle, shells, skin	Chemical	Biological (flora)
Cells:	Leukocytes	Phagocytes	Dendritic
Inflammation:	swelling	heat	pain

- Adaptive immune system: specific to each pathogen, antigen-specific
  - Specialized leukocytes, "lymphocytes":
    - → B-cells: humoral immune response, i.e.,extracellular fluids
    - → T-cells: cell-mediated immune response:
      - killer T-cells: kill infected cells (cytotoxic)
      - helper T-cells: regulate the immune system response

Independent variable t

Dependent variables $A(t), B(t)$

$A, B\colon \mathbb{R} \to \mathbb{R}$

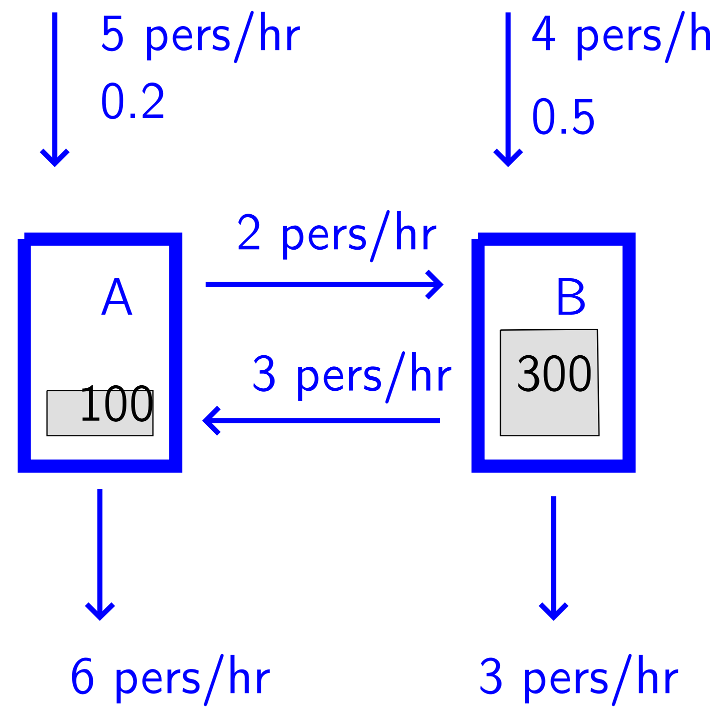
$$A' = 0.2 \times 5 - \frac{8}{100}A + \frac{3}{300}B$$

$$B' = 0.5 \times 4 + \frac{2}{100}A - \frac{6}{300}B$$

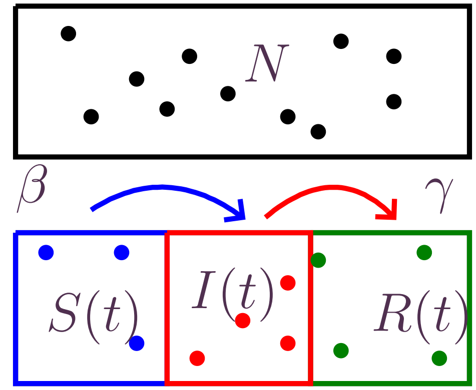
$$\begin{cases} A' = 1 - .08A + .01B \\ B' = 2 + .02A - .02B \end{cases}$$

$$\boldsymbol{y}(t) = \begin{pmatrix} A(t) \\ B(t) \end{pmatrix}, \boldsymbol{y}' = \boldsymbol{M}\boldsymbol{y} + \boldsymbol{f}, \Rightarrow \boldsymbol{M}\boldsymbol{y} = -\boldsymbol{f}$$

$$\boldsymbol{M} = \begin{pmatrix} -.08 & .01 \\ .02 & -.02 \end{pmatrix} \quad \boldsymbol{f} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$$



$$S' = -\beta I S$$
$$I' = \beta I S - \gamma I$$
$$R' = \gamma I$$
$$S, I, R\colon \mathbb{R} \to \mathbb{R}$$



$$S' = -\beta I S$$
$$I' = \beta I S - \gamma I$$
$$R' = \gamma I$$
$$S, I, R: \mathbb{R} \to \mathbb{R}$$

$$\frac{\partial S}{\partial t} = -\beta S \left(I + \alpha \nabla^2 I\right) + \delta \nabla^2 S$$
$$\frac{\partial I}{\partial t} = \beta S \left(I + \alpha \nabla^2 I\right) - \gamma I + \epsilon \nabla^2 I$$
$$\frac{\partial R}{\partial t} = \varphi \nabla^2 R + \gamma I$$
$$S, I, R: \mathbb{R} \times \mathbb{R}^d \to \mathbb{R}$$