Week 3: Building & Assessing Models

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Week 3 Overview

- Monday, August 9:
  - ~~Guest lecture & R session by Megan O’Driscoll~~
  - ~~Stochastic models~~
  - ~~Guided practice in R~~
- Tuesday, August 10:
  - Step-by-step model building
  - Building a COVID-19 model
  - Guided practice in R
- Wednesday, August 11:
  - Comparing models to data & evaluating models
  - Guided practice in R

Post Questions in the Chat!

(or ask over microphone)

Workshop Schedule

Time	Topics
2:00—2:10 pm	~~Greetings~~
2:10—2:40 pm	R Demonstration
2:40—2:50 pm	Break
2:50—3:30	Steps for Model Building
3:30—3:40 pm	Break
3:40—5:00 pm	Building a COVID-19 Model

Objectives

- Understand the steps involved in developing models
- Practice building a model of COVID-19

Steps for Building a Model

Model Development

- Important to reflect on purpose of model & wider considerations

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- 9-step process from Habbema *et al.*, 1996

1. Identify the question
2. Identify existing knowledge
3. Choose model structure
4. Choose modeling method
5. Model quantification
6. Model validation
7. Prediction & optimization
8. Decision making
9. Model transfer

Model Development

- Important to reflect on purpose of model & wider considerations
- 9-step process from Habbema et al., 1996
- Not every model will go through all 9 steps
  - full process likely takes many years

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- Important to reflect on purpose of model & wider considerations
- 9-step process from Habbema et al., 1996
- Not every model will go through all 9 steps
  - full process likely takes many years
- Use measles as example

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Identify the Question

- What is our research question?
  - Inference versus prediction

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- Common questions/goals
  - Natural history of disease
  - Epidemiology of infections
  - Impact of control or treatment
  - Comparison of different controls

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- Measles Scenario
  - closed population of 100,000 susceptibles
  - How will number of susceptible, infected, recovered change over time?

Identify Existing Knowledge

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  - What inputs do we know?
  - Demographic rates
  - Natural history parameters
  - Control options & impact

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  - Similar disease?
  - Similar scenario?
  - Distributions/values for parameters?

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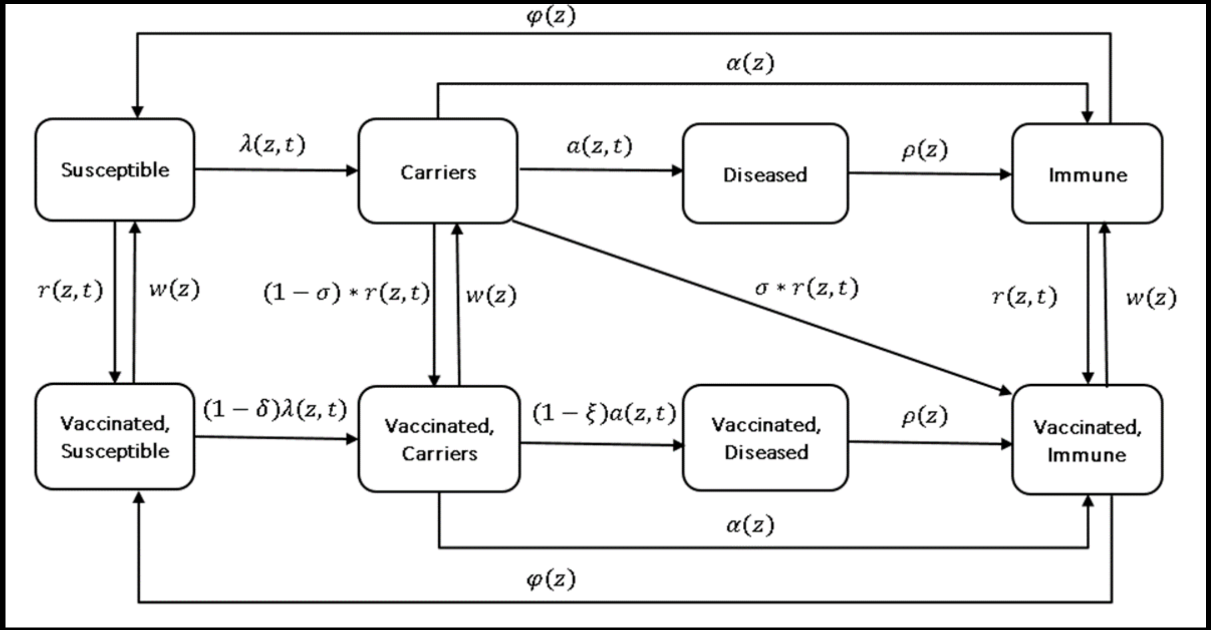

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- Measles Scenario
  - near-permanent immunity
  - contact: 1.5 other people/day
  - latent period: 8 days
  - duration of infection: 7 days

Choose Model Structure

- Identify the question
- Identify existing knowledge
- **Choose model structure**

Identify the question

Identify existing knowledge

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Choose Model Structure

- What compartments are important?
  - Infection categories
  - Population categories/subgroups
- *"Models should be as simple as possible and no simpler."*
  - What compartments are necessary to answer our research question?

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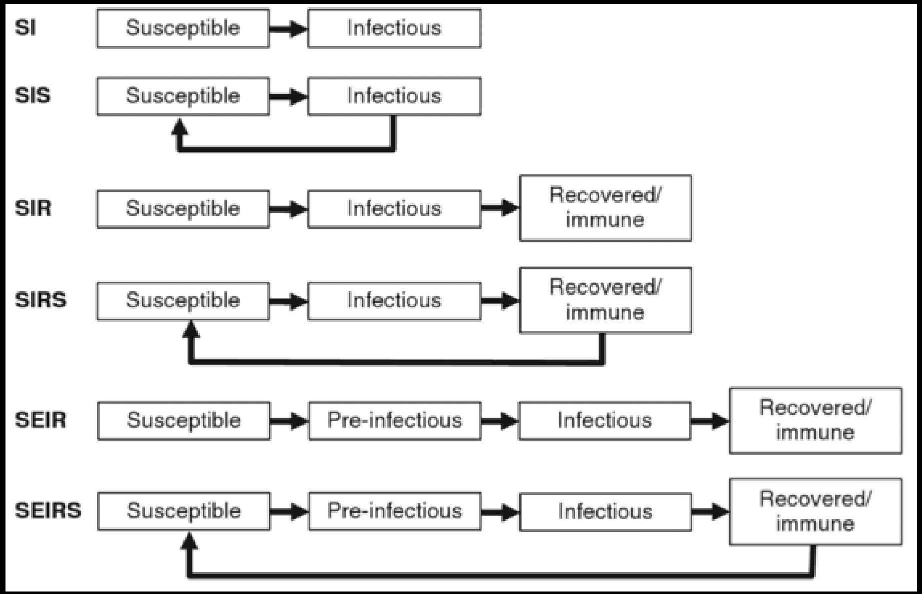

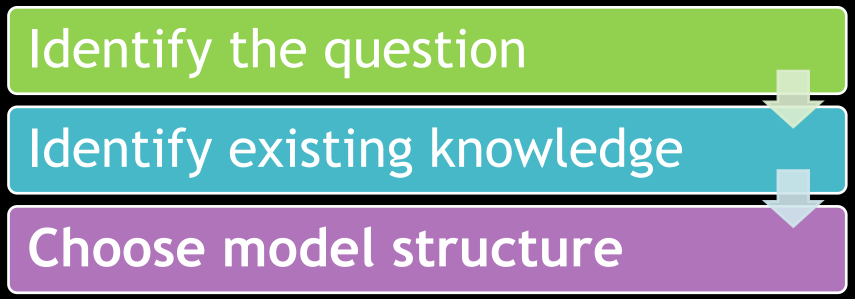

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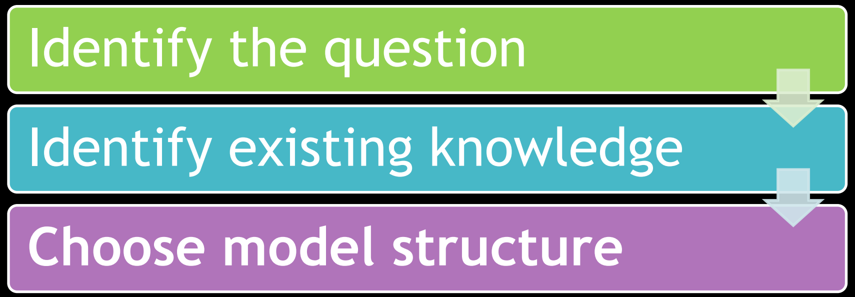

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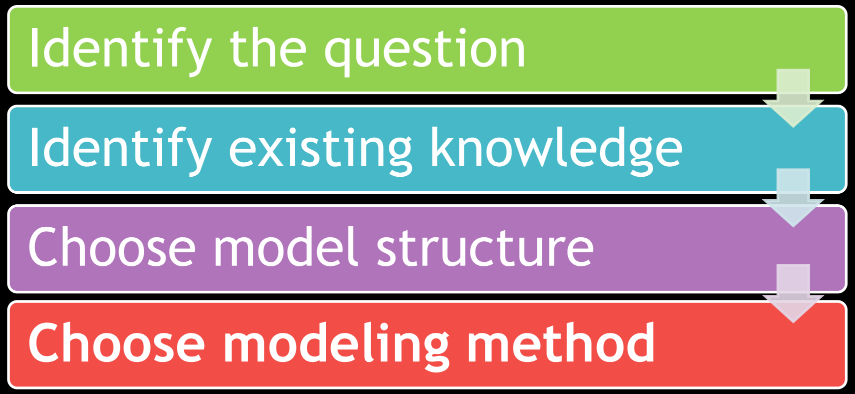
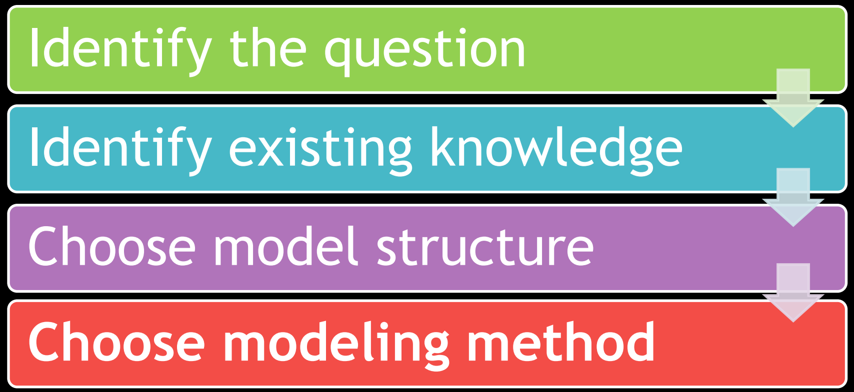
- Measles Scenario
  - short term question
  - closed SEIR structure

Choose Modeling Method



Choose Modeling Method

- Deterministic?
  - Describes average outcome
  - Uses average transition rates



Choose Modeling Method

- Deterministic?
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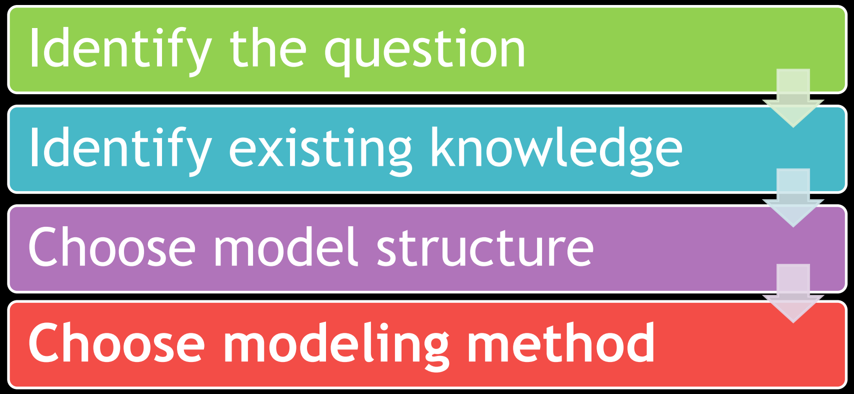
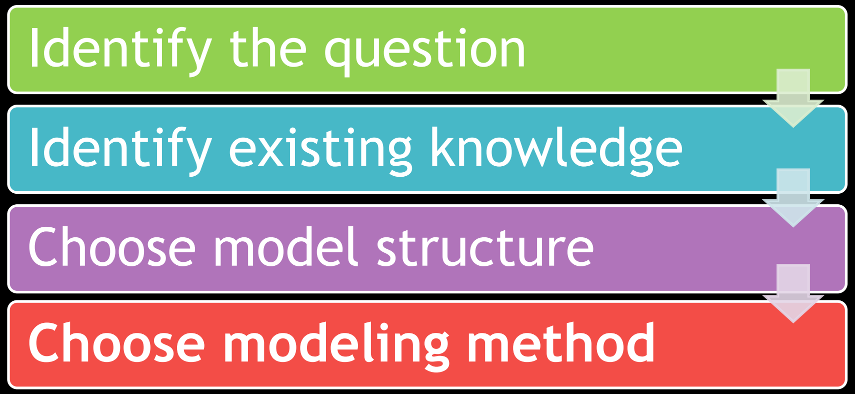
- Stochastic?
  - Incorporate chance variation
  - Range of possible outcomes





Choose Modeling Method

- Deterministic?
  - Describes average outcome
  - Uses average transition rates
- Stochastic?
  - Incorporate chance variation
  - Range of possible outcomes
- Combination?
  - Deterministic models can include stochastic elements and vice versa

Model Quantification

1. Identify the question
2. Identify existing knowledge
3. Choose model structure
4. Choose modeling method
5. **Model quantification**

Model Quantification

- Specify your inputs
  - Range of possible values from review step
  - Make sure time units are correct!

Identify the question

Identify existing knowledge

Choose model structure

Choose modeling method

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Example: mortality rate (μ)

- $\mu = 1/L$
- L: average life expectancy

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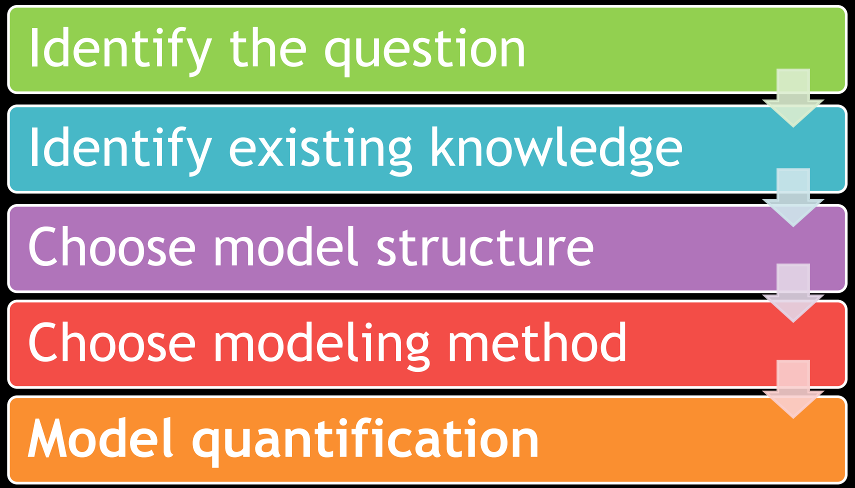
Example: mortality rate (μ)

- $\mu = 1/L$
- L: average life expectancy
- L=60 years
- μ=1/60 per year
- μ=1/(60*365) per day

Model Quantification

- Specify your inputs
  - Range of possible values from review step
  - Make sure time units are correct!
- Estimate from data
  - Collect new data?
  - Statistical model
  - Parameter estimation



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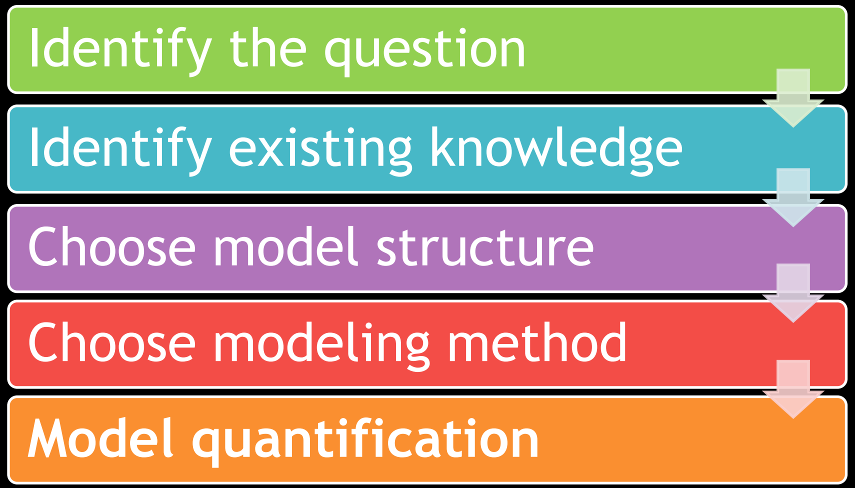

Model Validation

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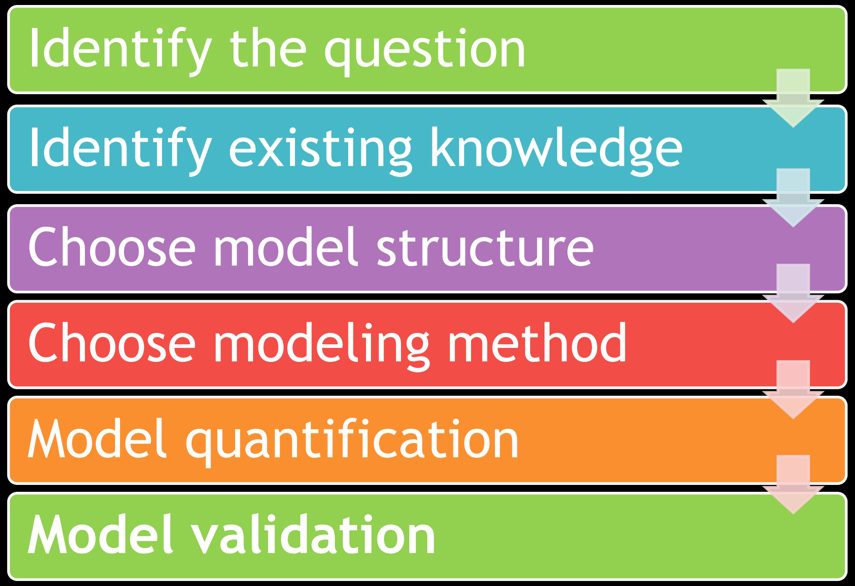
- Choose model structure
- Choose modeling method
- Model quantification
- **Model validation**

Model Validation

- Compare model results with real data
  - Ideally with independent datasets
  - Is the behavior you model consistent with reality?
  - Model fitting
- Share with other experts



Prediction & Optimization

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- Model quantification
- Model validation
- **Prediction & optimization**

Prediction & Optimization

- Run your model and make predictions
- Sensitivity analysis
  - Imagine that assumptions are flawed
  - Test boundaries of the model
  - “Try to break the model”
- Report any model limitations

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Prediction & optimization

Decision Making

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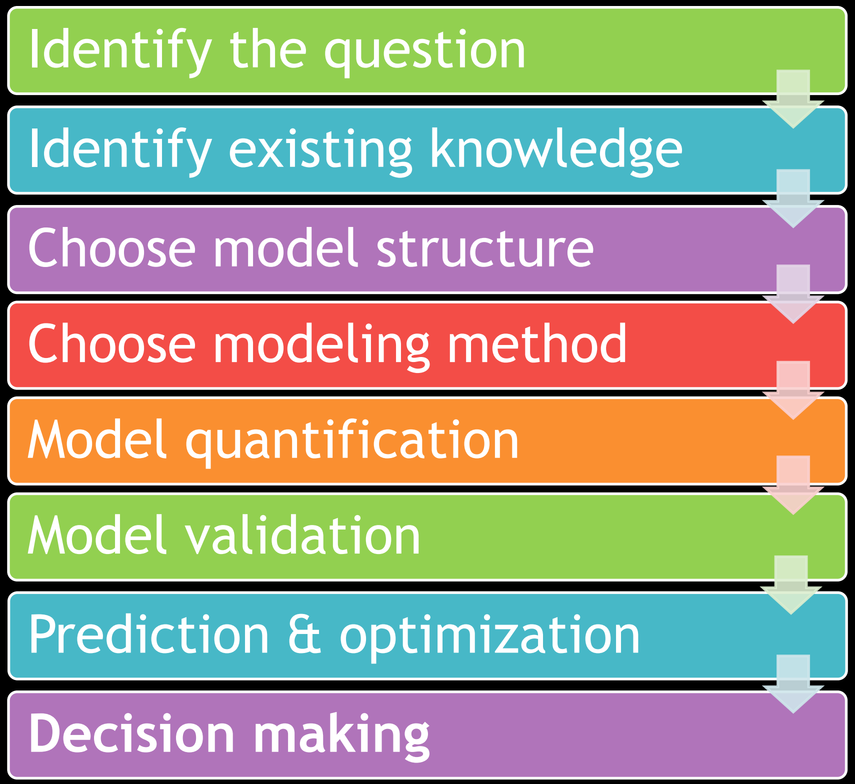
- **Decision making**

Decision Making

- Public health policy decisions require many experts & stakeholders
  - Make sure the model can be explained to broad audiences
  - Be able to explain model limitations



Model Transfer

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Model Transfer

- Ideally model can be used by ministries of health/public health
  - Only if model design and parameters are unlikely to change

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Model Transfer

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  - Only if model design and parameters are unlikely to change
- User-friendly models
  - user's manual
  - user-friendly interface

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Model Development is Non-Linear

- Iterative process

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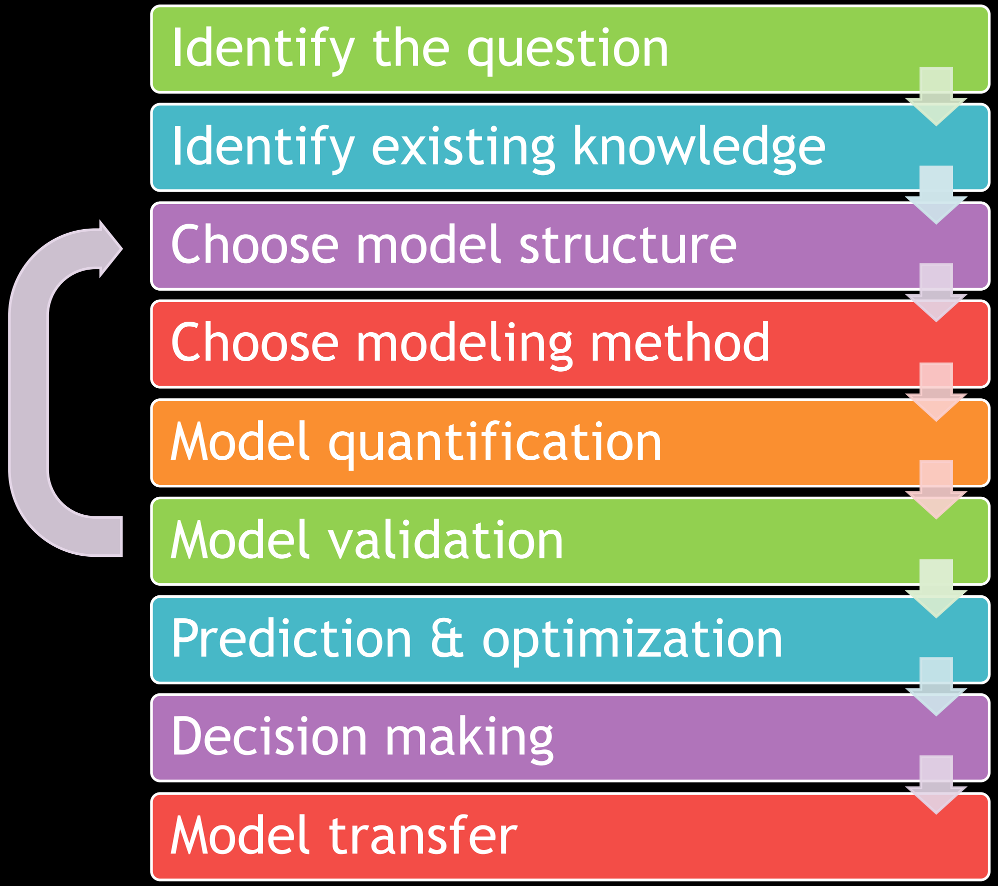

Questions?

10 minute break

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