

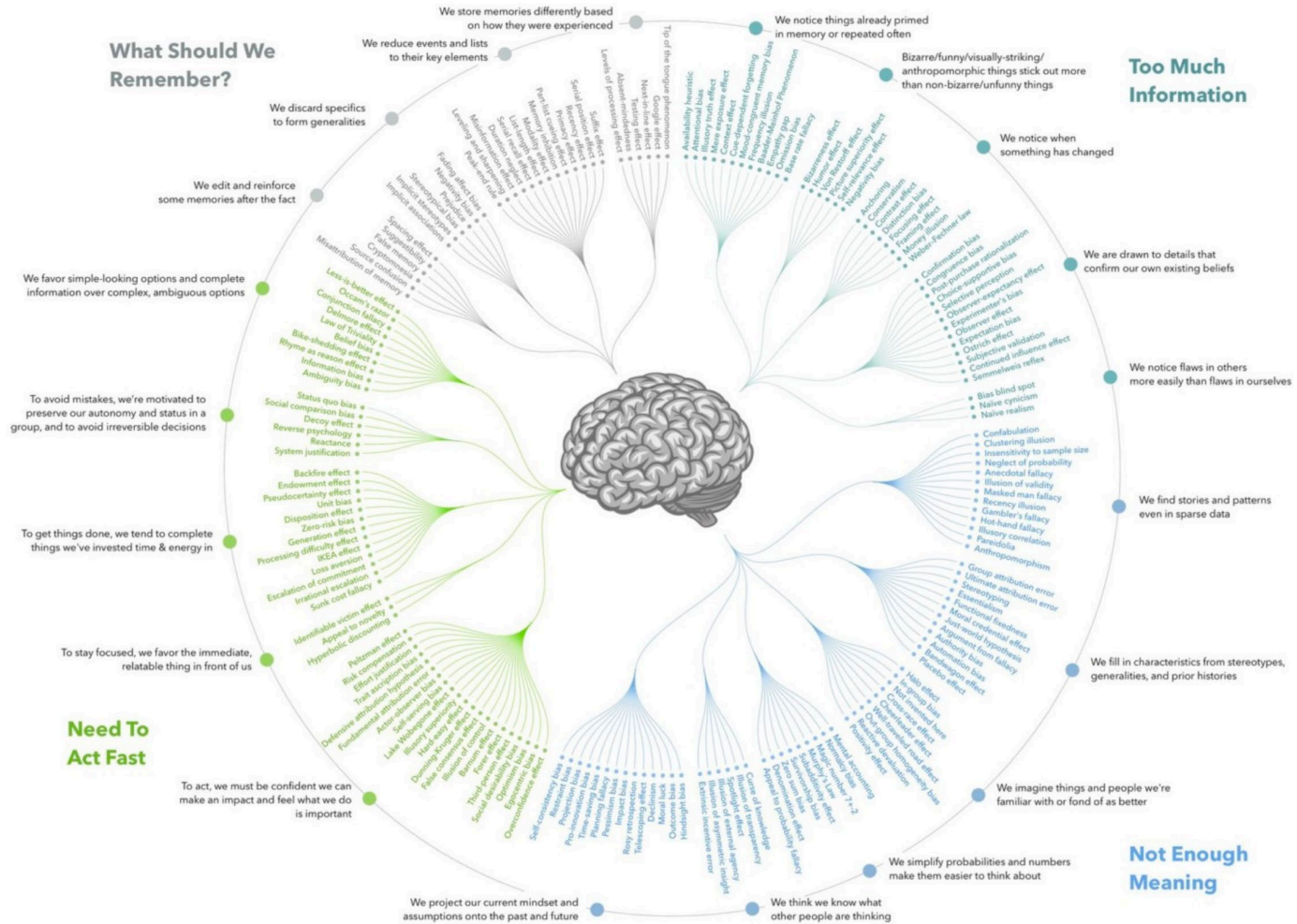
# Bias in medicine and biomedical engineering

How does it happen? What does it look like?  
What is its impact?

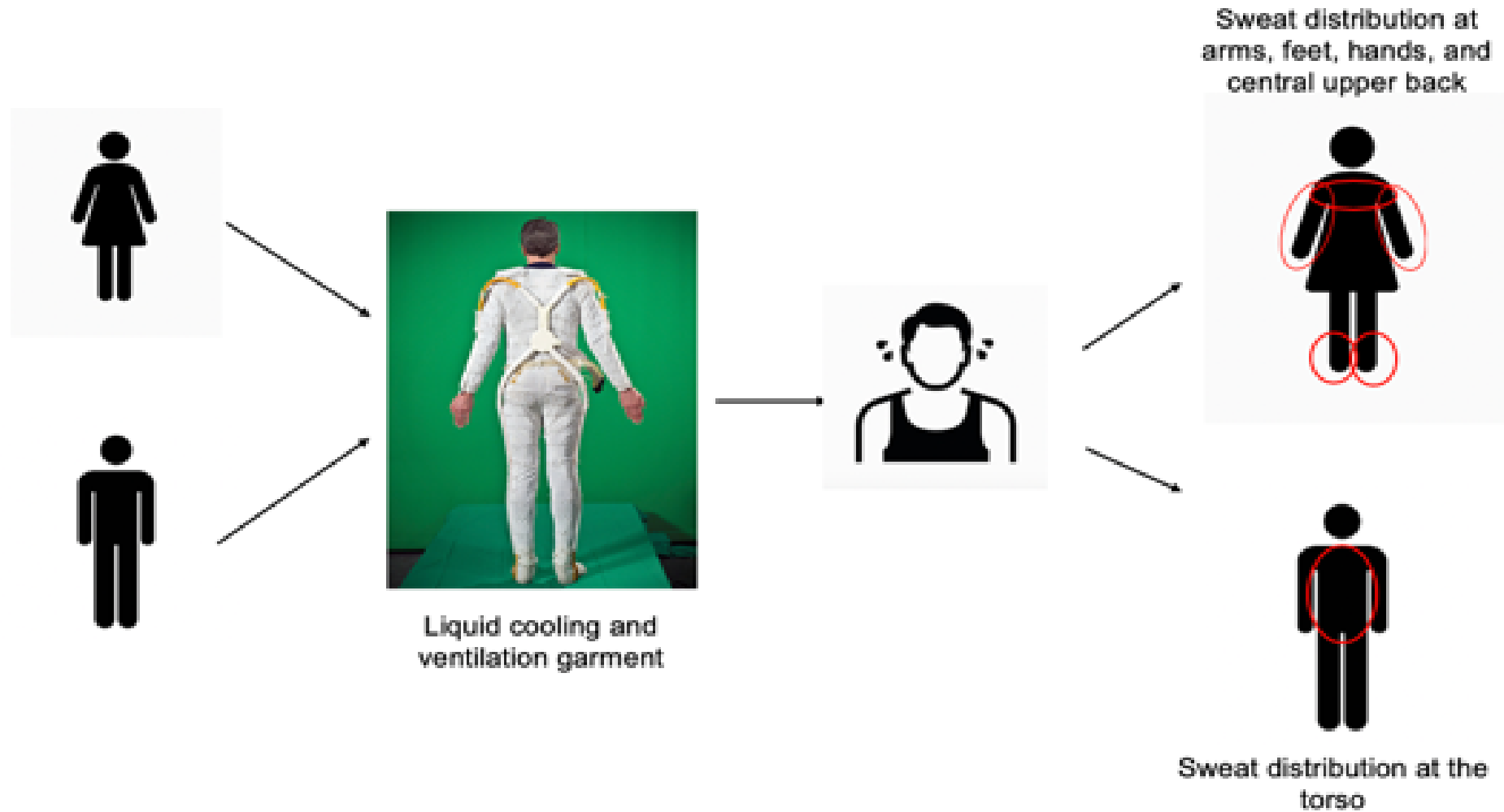


# What is bias?

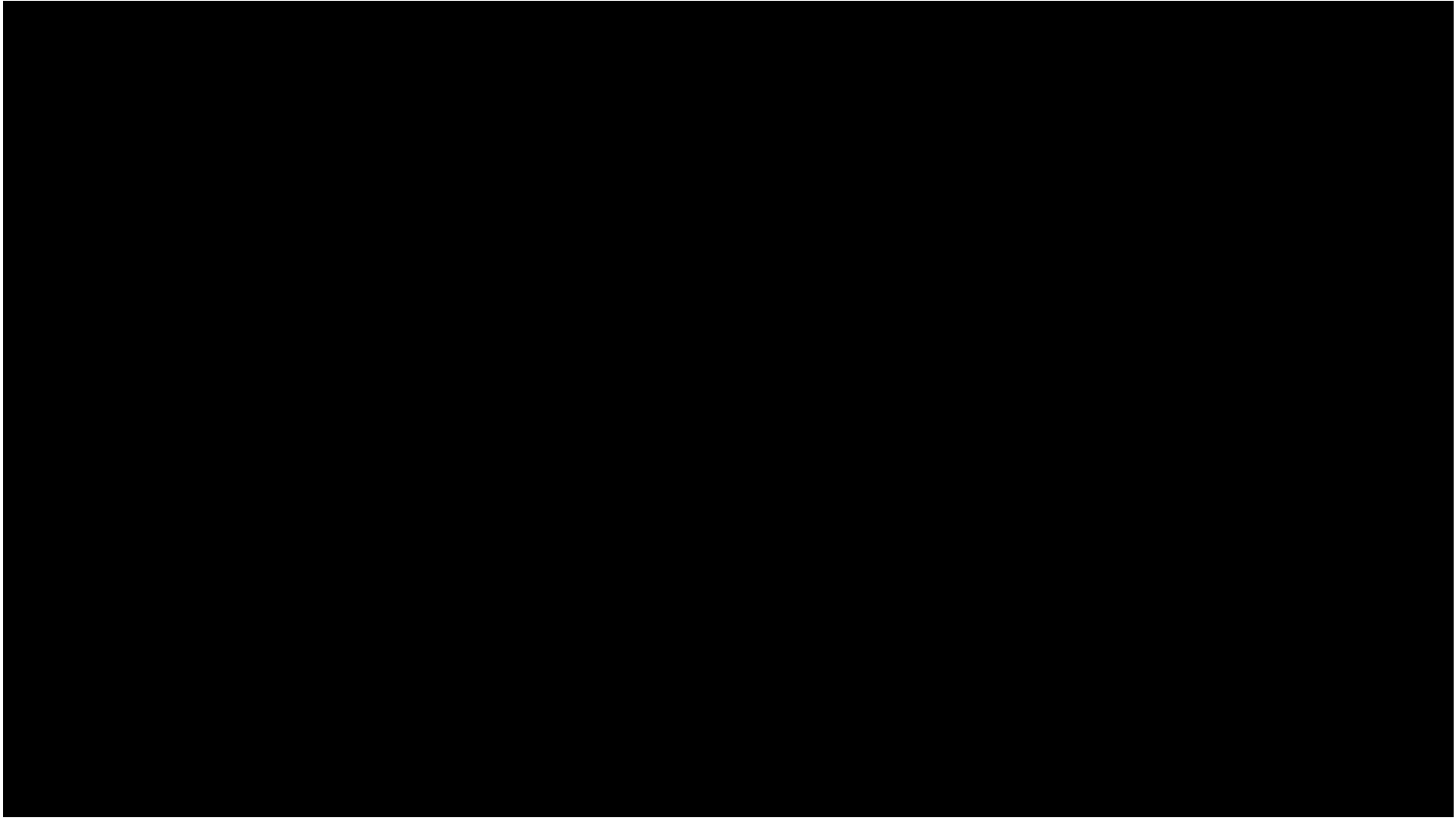
## COGNITIVE BIAS CODEX, 2016



# Bias affects engineering in many ways



Let's watch a video about  
bias in medicine



## Think – Pair - Share

What are some physiological sex differences?



# There are sex differences in:

- weight
- percentage of body fat
- hormonal and enzyme levels
- speed of metabolism
- pharmacokinetics
  - the time course of drug absorption, distribution, metabolism, and excretion
- pharmacodynamics
  - The relationship between drug concentration at the site of action and the intensity of therapeutic and adverse effects.

Now let's connect these  
to 2110 concepts:

physical properties

composition/mass fractions

extents of reaction

behavior of  
multiunit processes



# There is a knowledge gap

- Dr. Janine Austin Clayton, associate director for women's health research at the NIH, said:
- “We literally know less about every aspect of female biology compared to male biology.”
- “This is not just about Ambien — that's just the tip of the iceberg. There are a lot of sex differences for a lot of drugs, some of which are well known and some that are not well recognized.”





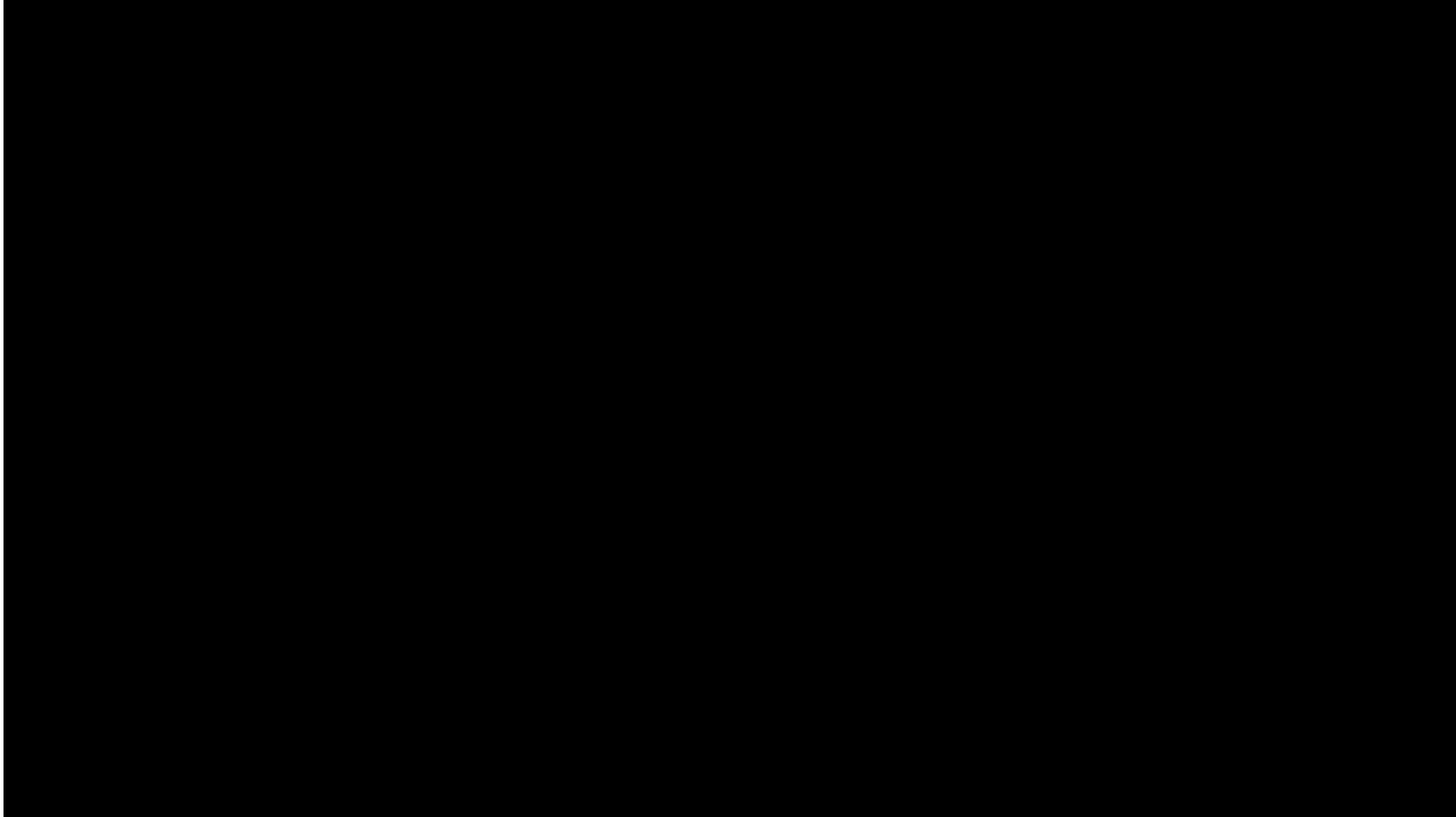
# Think – Pair - Share

Why is there a knowledge gap?



Let's watch a video about  
bias in medicine





# Why knowledge gap? #1 Holes in research:

- Women of childbearing age were excluded from trials of new drugs until 1993
  - Because so many drugs were tested mostly or exclusively in men, scientists may know little of their effects on women until they reach the market.
  - A Government Accountability Office study found that 8 of 10 drugs removed from the market from 1997 through 2000 posed greater health risks to women.
- Even most animal studies used male animals (e.g. rats)
- Sex data, even if tracked, is rarely disaggregated



## #2 Lack of representation:

- In Medicine, women account for only...
  - about 25% emergency medicine physicians, neurologists, and anesthesiologists, < 20% of general surgeons, 12% of cardiologists, 7% of urologists, < 5% of orthopedic surgeons.
- In Academia (at medical schools):
  - Women account of only 21% full professors and 15% of department chairs
  - men were nearly 2.5 times more likely than women to be full professors, even after accounting for factors that affect promotion
  - Only about 30% of researchers receiving NIH funding are women.
  - women make up just 18% of all editorial-board members of sixty major medical journals.



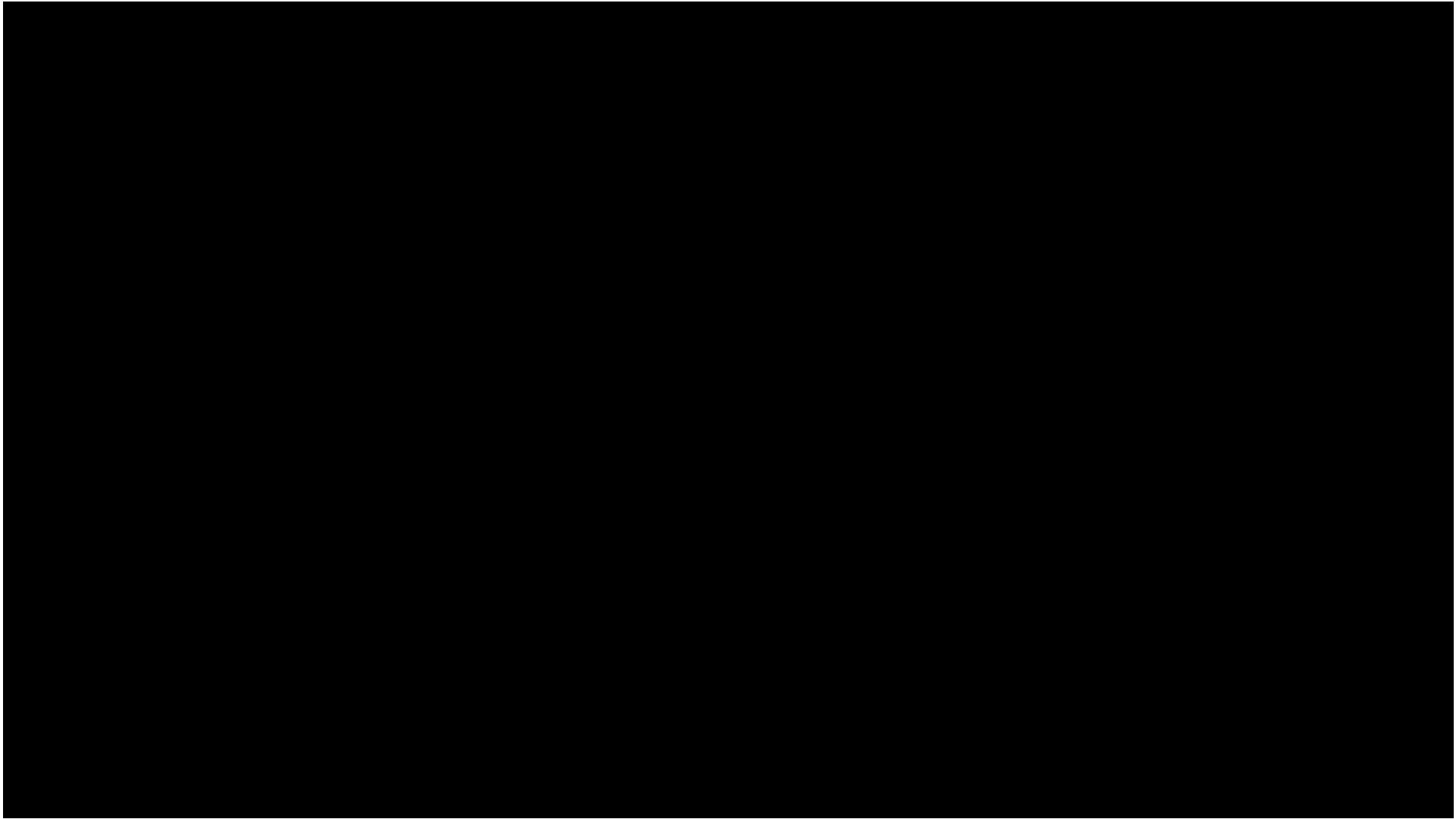
# These gaps can have serious consequences...

- low-dose aspirin lowered the risk of heart attack in men over fifty, but had no effect on women under sixty-five
- women have a greater risk than men of developing a potentially fatal heart arrhythmia that can be triggered by a variety of drugs, including antibiotics, antidepressants, and cholesterol-lowering drugs.
- women tend to wake up from anesthesia faster than men and are more likely to experience side effects
- women may need higher doses of angiotensin receptor blockers to lower blood pressure when estrogen levels are low, because they have higher levels of proteins that cause the blood vessels to constrict



Let's watch a video about  
bias in medicine







# Think – Pair - Share

*What should we do about this?*



# Actions taken to improve representation:

- **Government** have catalyzed institutional change through programs such as the ADVANCE program which challenges gender bias
- **Academia** has worked to remove gender bias from hiring and promotion, advance women in leadership, accommodate dual-career academic couples, and facilitate work/life balance.
- **Industry** have programs aimed at improving the representation of women in upper management.



# Actions taken to close knowledge gap:

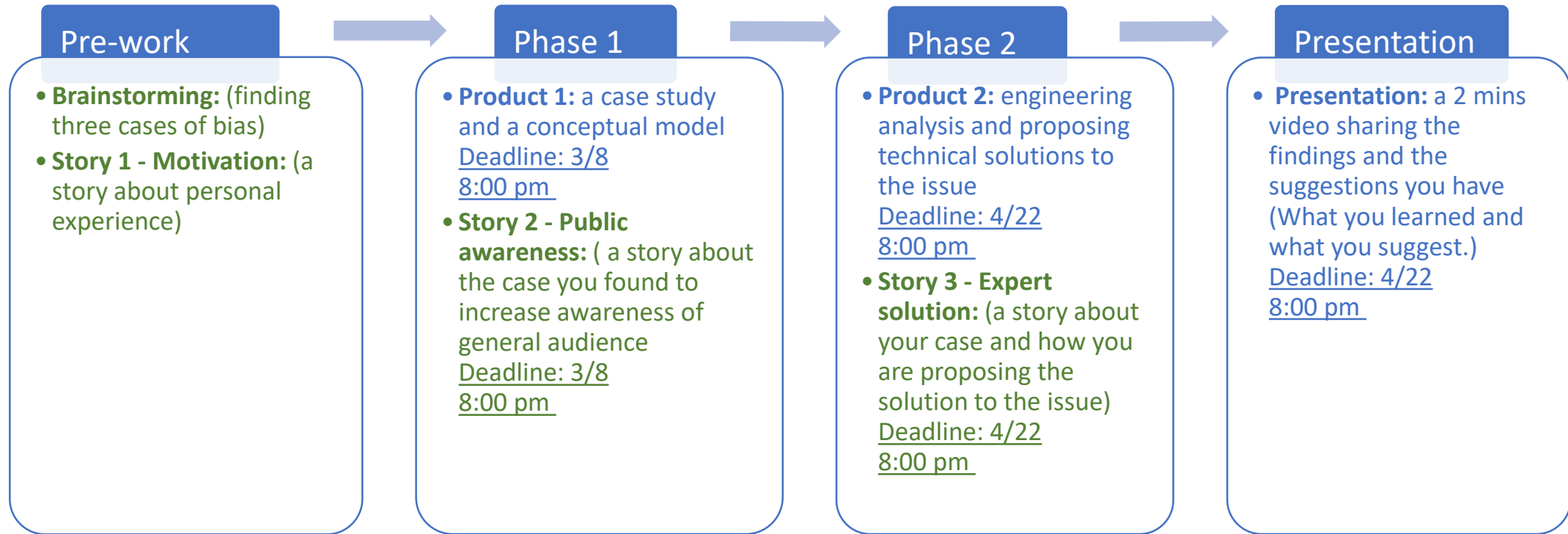
- **NIH** expects that sex as a biological variable will be factored into research designs, analyses, and reporting in vertebrate animal and human studies. Strong justification from the scientific literature, preliminary data, or other relevant considerations must be provided for applications proposing to study only one sex.
- **Editorial boards** of several peer-reviewed journals have begun requiring sophisticated sex and gender analysis when selecting papers for publication to ensure the quality of research.
- The United Nations member states passed resolutions in March 2011 which call for "gender-based analysis ... in science and technology" and for the integrations of a "gender perspective in science and technology curricula"



# BMED 2110 Project: An introduction

This week you will begin a project designed to give you a chance to learn more about the *impact of bias* in biomedical engineering and to practice having an *entrepreneurial mindset*





The assignments marked as “Blue” are group assignments.  
The assignments marked as “Green” are individual assignments.

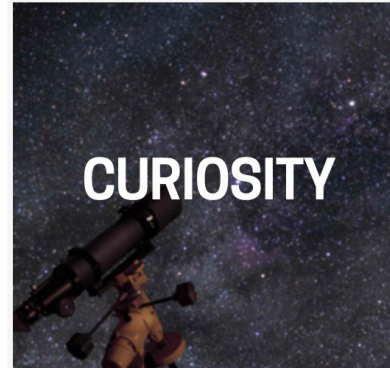


For engineers with an entrepreneurial mindset....



**MINDSET + SKILLSET**  
A TANDEM DEVELOPMENT

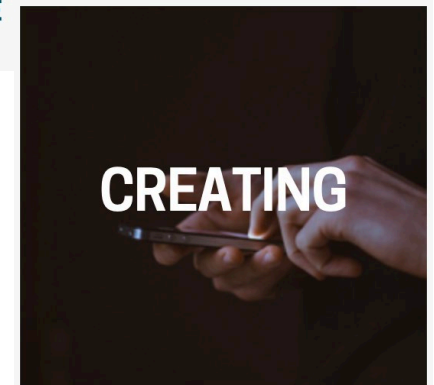
This is a chance to create value...



QUESTION WITH BOLDNESS.  
EXPLORE CONTRARIAN  
PERSPECTIVES.



THINK OUTSIDE THE BOX. PLACE  
OLD IDEAS IN NEW CONTEXTS.



THINK OPPORTUNITY.  
STAKEHOLDERS. IMPACT.



# This week you will have an opportunity to...

- Be **curious** by:
  - working with your partner to identify a historical case of bias in BME/medicine
- Make **connections** by:
  - building on your new knowledge of model-based reasoning from BMED 2110 and from your prior experiences in other courses and elsewhere to....
  - Identify
    - where bias impacted the engineering design process
    - how bias impacted the design, leading to its shortcomings
- Create a conceptual **model** that illustrates the key points of the case



# What is a model?

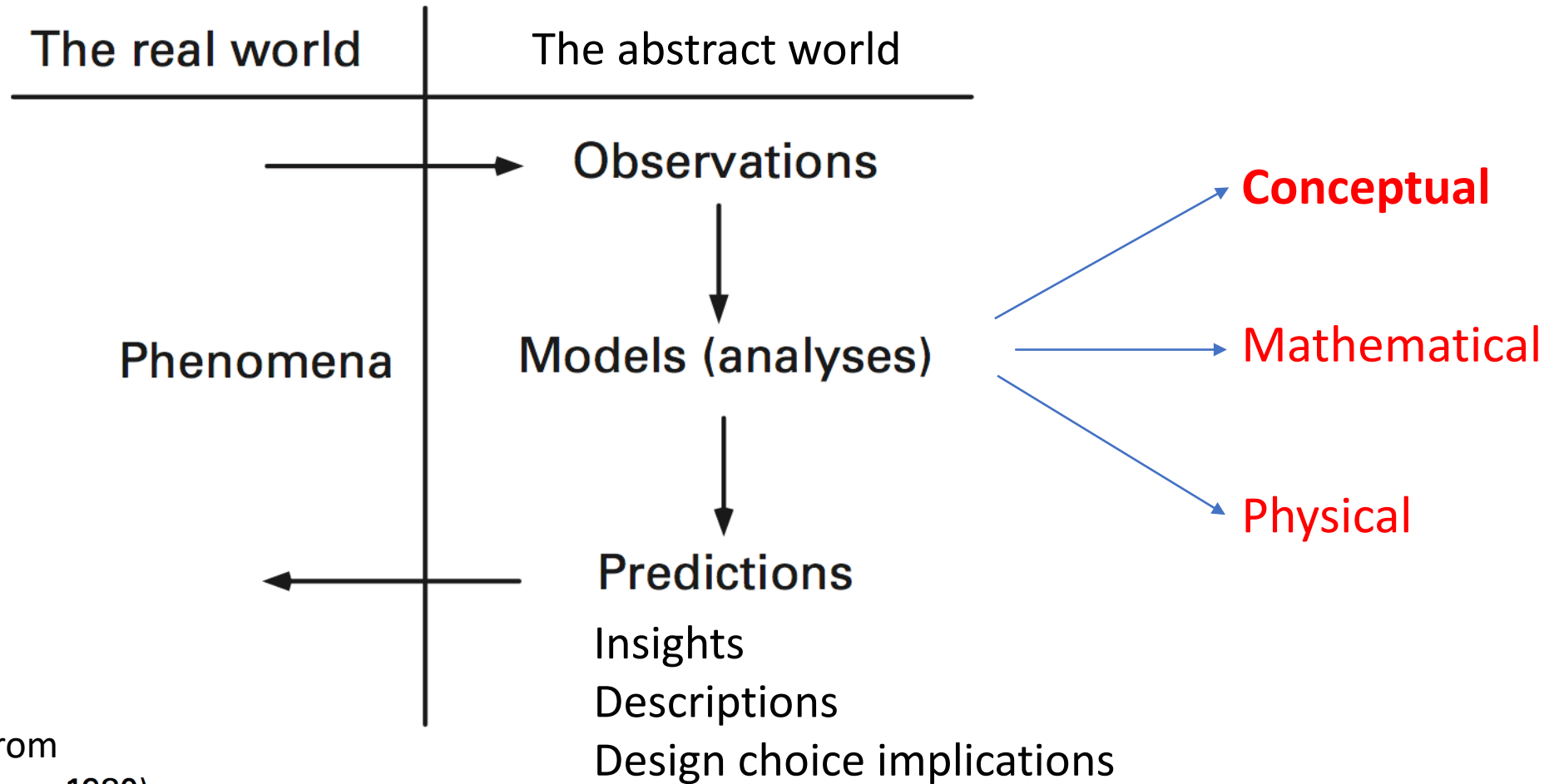
- A simplified representation of a real-world situation used to help answer a specific question
- Simplifying
  - It is important to preserve the properties of the system that are relevant to the question
- Detail vs complexity
  - A good model has a low a complexity as possible while retaining the relevant details needed to answer the specific question the model is designed to examine

**“All models are wrong, but some are useful” - George B**





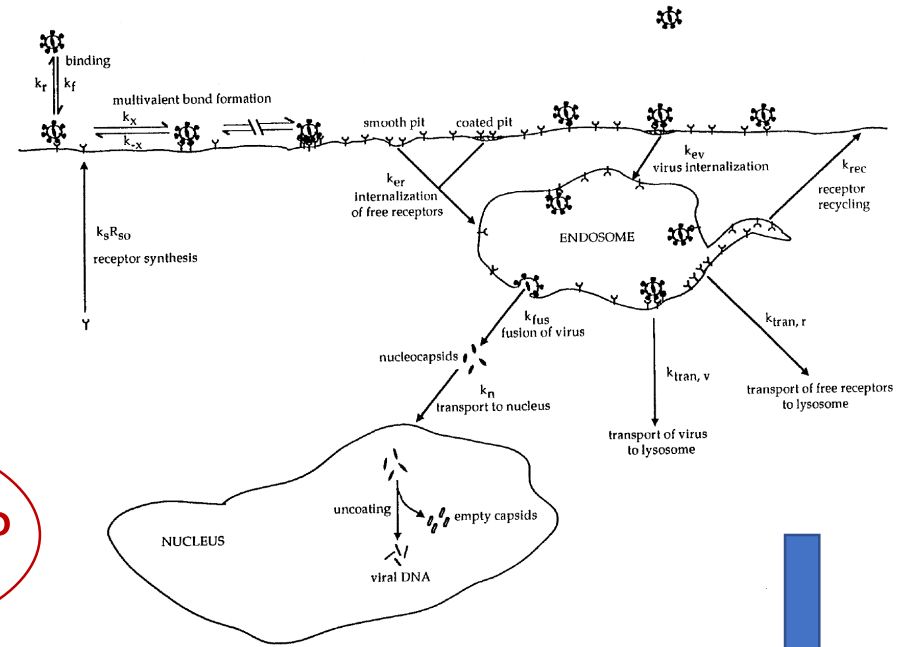
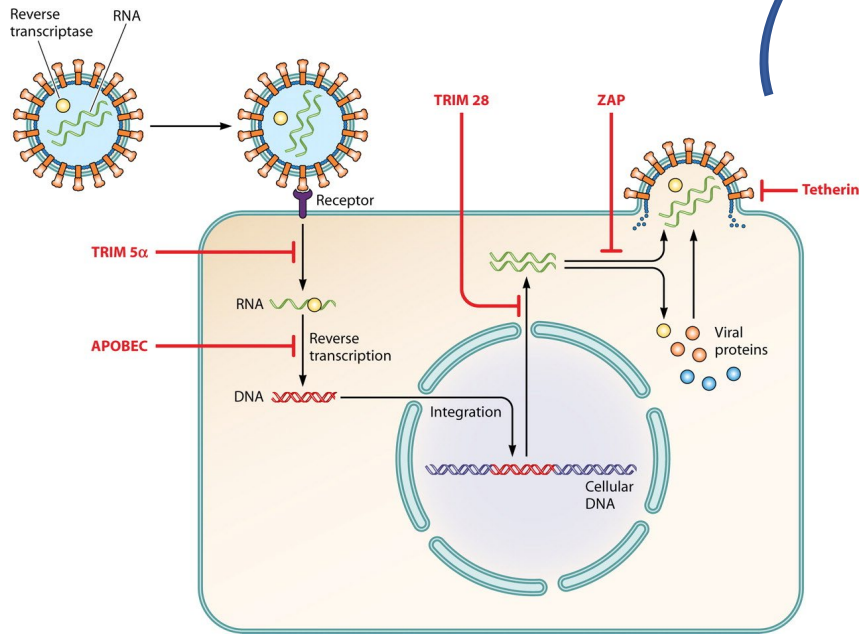
# There are multiple kinds of models



Modified from  
(Dym and Ivey, 1980)



# Conceptual

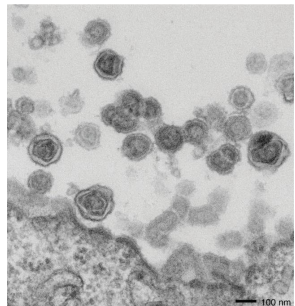


REAL WORLD?

DATA / OBSERVATIONS

# Mathematical

$$\frac{dV_1}{dt} = (\alpha k_f C) V_{ex} R_{sf} - k_r V_1 - (j - 1) k_x V_1 R_{sf} + 2k_{-x} V_2 - k_{ev} V_1$$



PHYSICAL MODELS



# Some final notes about the project

- This is a course-wide project
  - We will assemble the team reports and share on the web.
  - In this way, you will contribute to the goal of improving our understanding of how bias influences engineering analyses, models, and designs.
  - The more we understand the impact of biases, the more we can minimize their adverse impacts on biomedical engineering designs.
- Project will be graded using "specifications grading"
  - Graders look for specific features in the stories, the phase 1 product, phase 2 product and presentation to ensure they are present and meet minimum quality requirements



*Good luck and have fun!*

