

Teaching Sex & Gender in Science Education

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SOCIETY *for the* STUDY of EVOLUTION



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Loyola University



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University of
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Duke University

Talk outline

- Why are we talking about this?
- Definition & diversity of sex
- Teaching approaches and resources

Laws and policies are being formulated under the guise of science
Misinformation about sex is rampant in our society



PRESIDENTIAL ACTIONS

DEFENDING WOMEN FROM GENDER IDEOLOGY
EXTREMISM AND RESTORING BIOLOGICAL
TRUTH TO THE FEDERAL GOVERNMENT



PRESIDENTIAL ACTIONS

Keeping Men Out of Women's Sports

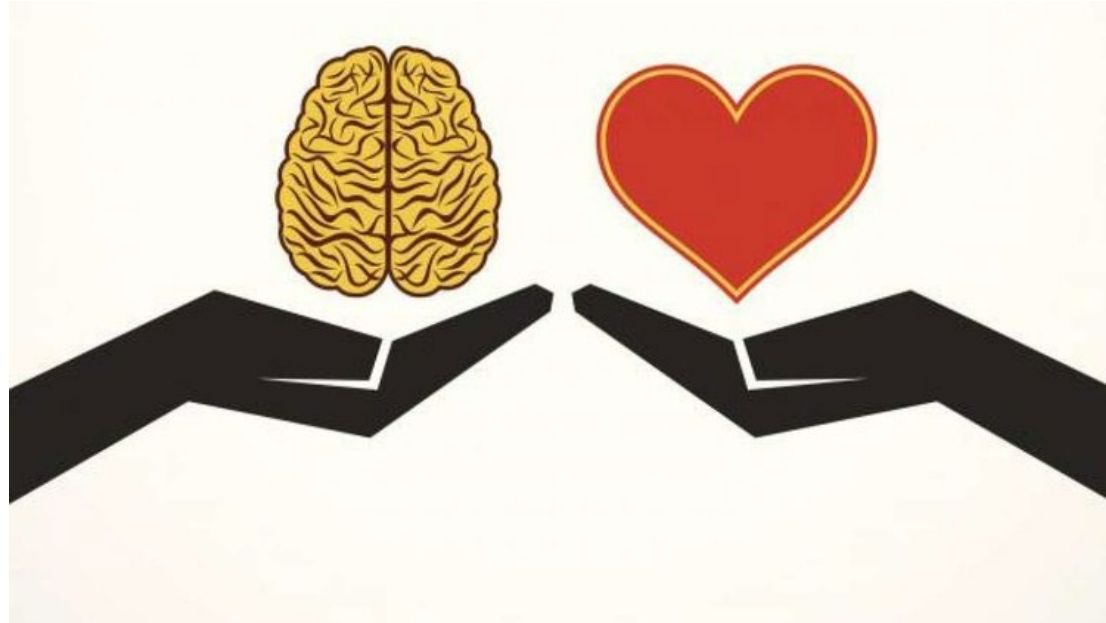
The White House | February 5, 2025

DOD: Gender Dysphoria Incompatible With
Military, Service Members Must Serve in Accordance
With Sex

*As educators and scientists, we have an obligation to speak up
when “science” is being misused to take away people’s rights*

We are taught that science is objective and free of emotion

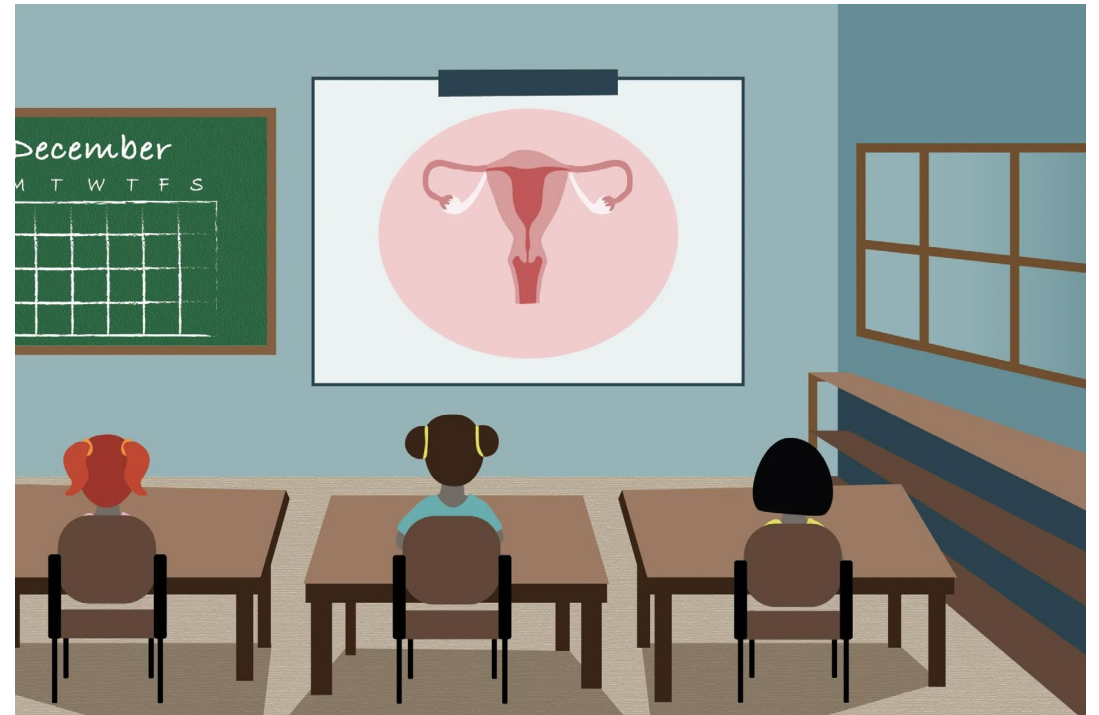
But people have an emotional relationship to sex



This creates a challenge for scientists and educators trying to discuss the biological basis of sex

The challenges of discussing the science of sex

- Public discourse on sex is considered rude or uncomfortable
- Sex education has been stripped or greatly reduced from educational systems



The challenges of discussing the science of sex

Discussion of sex and gender have been politically weaponized and monetized

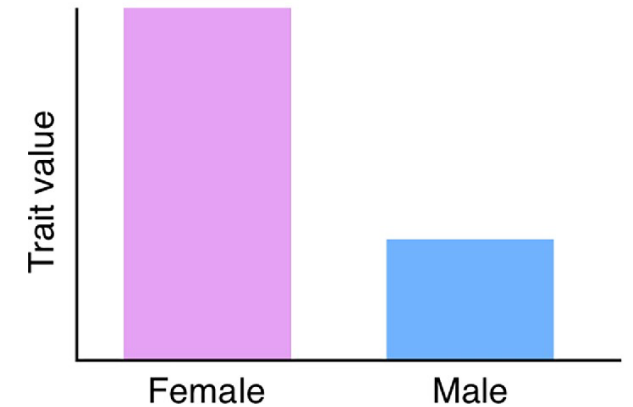
Brandolini's Law

The amount of energy needed to refute bullshit is an order of magnitude greater than that needed to produce it.



Misconceptions and essentialism

- Sex is universal
- Sex is determined genetically
- Sex and sexual traits are binary
- Sex = gender



**Essentialism - the belief that objects and beings have an inherent, unchanging essence or nature*

Talk outline

- Why are we talking about this?
- Definition & diversity of sex
- Teaching approaches and resources

Sex is universal

- Most organisms are asexual
- They do not produce gametes
- They have no sex chromosomes

Setting that aside.....

Domain Bacteria



Domain Archaea



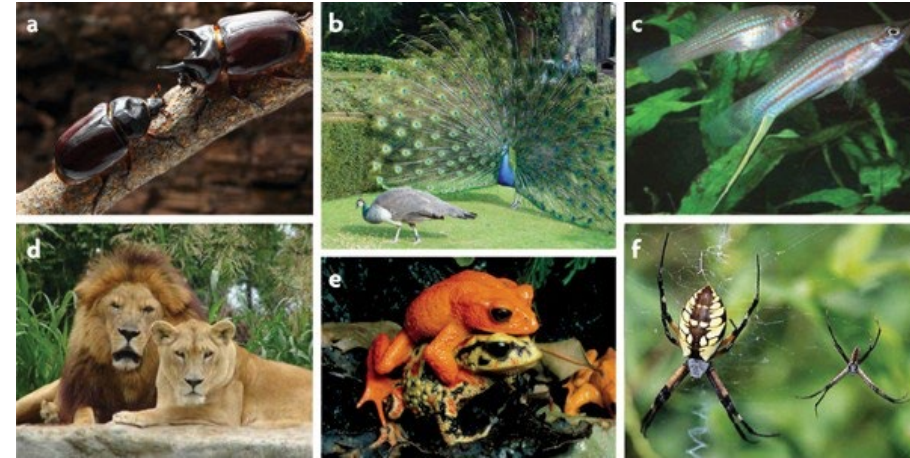
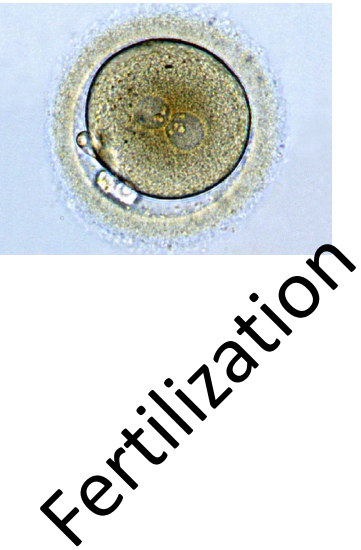
Domain Eukarya



Differences between males and females arise through **sexual differentiation**

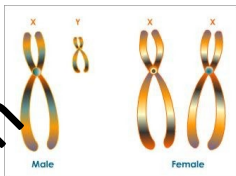
Sexual diversity emerges from evolutionary changes to the process of sexual differentiation

*What defines &
determines
sex???*

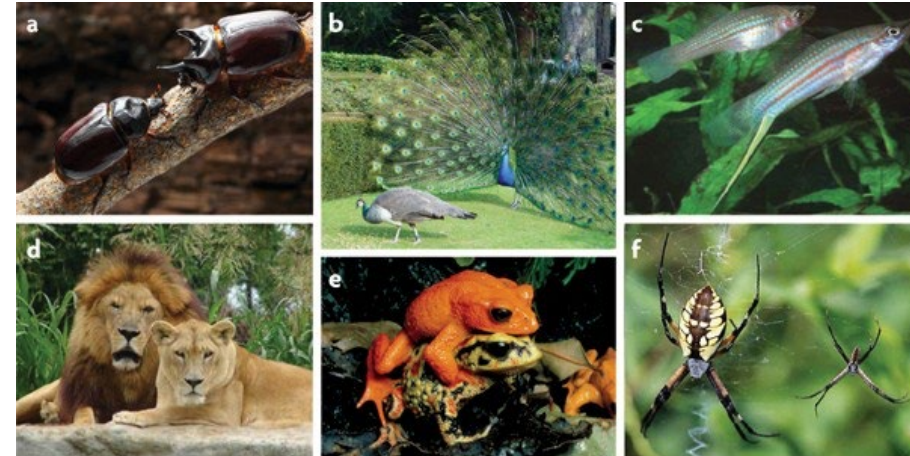


Differences between males and females arise through **sexual differentiation**

Sexual diversity emerges from evolutionary changes to the process of sexual differentiation



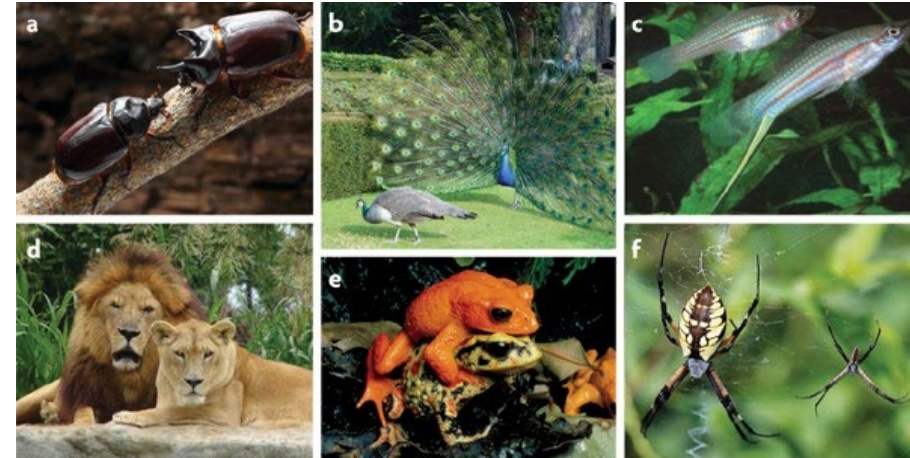
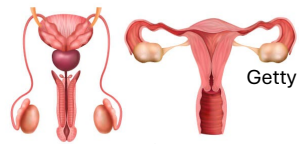
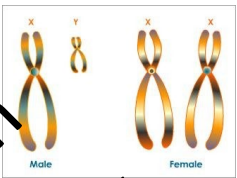
Fertilization
XY or XX



Secondary
Sex Traits

Differences between males and females arise through **sexual differentiation**

Sexual diversity emerges from evolutionary changes to the process of sexual differentiation

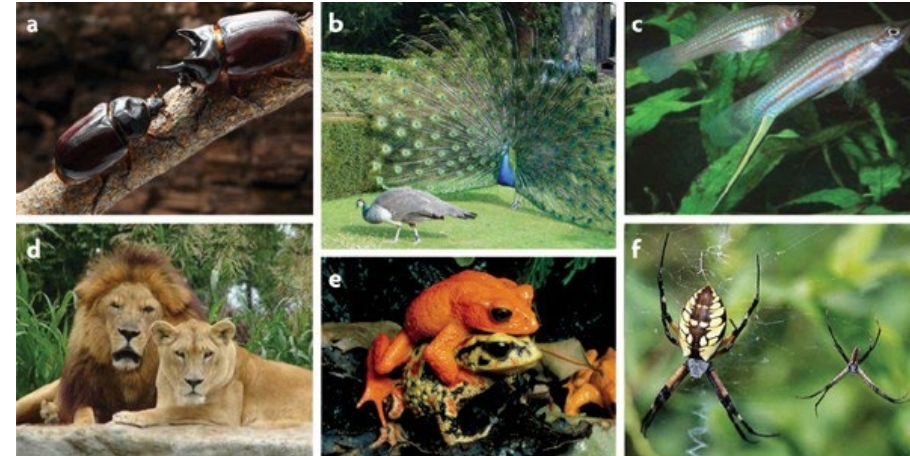
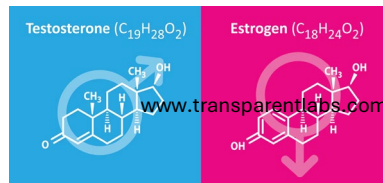
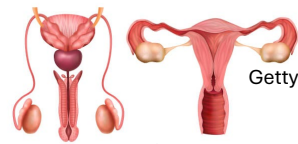
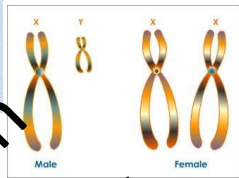


Fertilization
XY or XX
Testes or
Ovaries

Secondary
Sex Traits

Differences between males and females arise through **sexual differentiation**

Sexual diversity emerges from evolutionary changes to the process of sexual differentiation



Fertilization
XY or XX

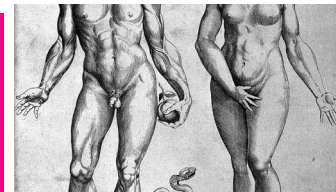
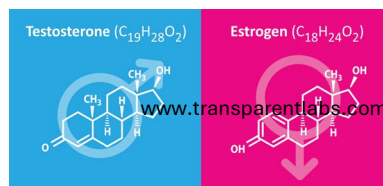
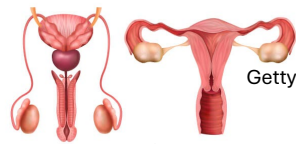
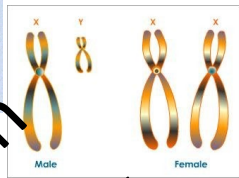
Testes or
Ovaries

Testosterone
or Estrogen

Secondary
Sex Traits

Differences between males and females arise through **sexual differentiation**

Sexual diversity emerges from evolutionary changes to the process of sexual differentiation



Fertilization
XY or XX

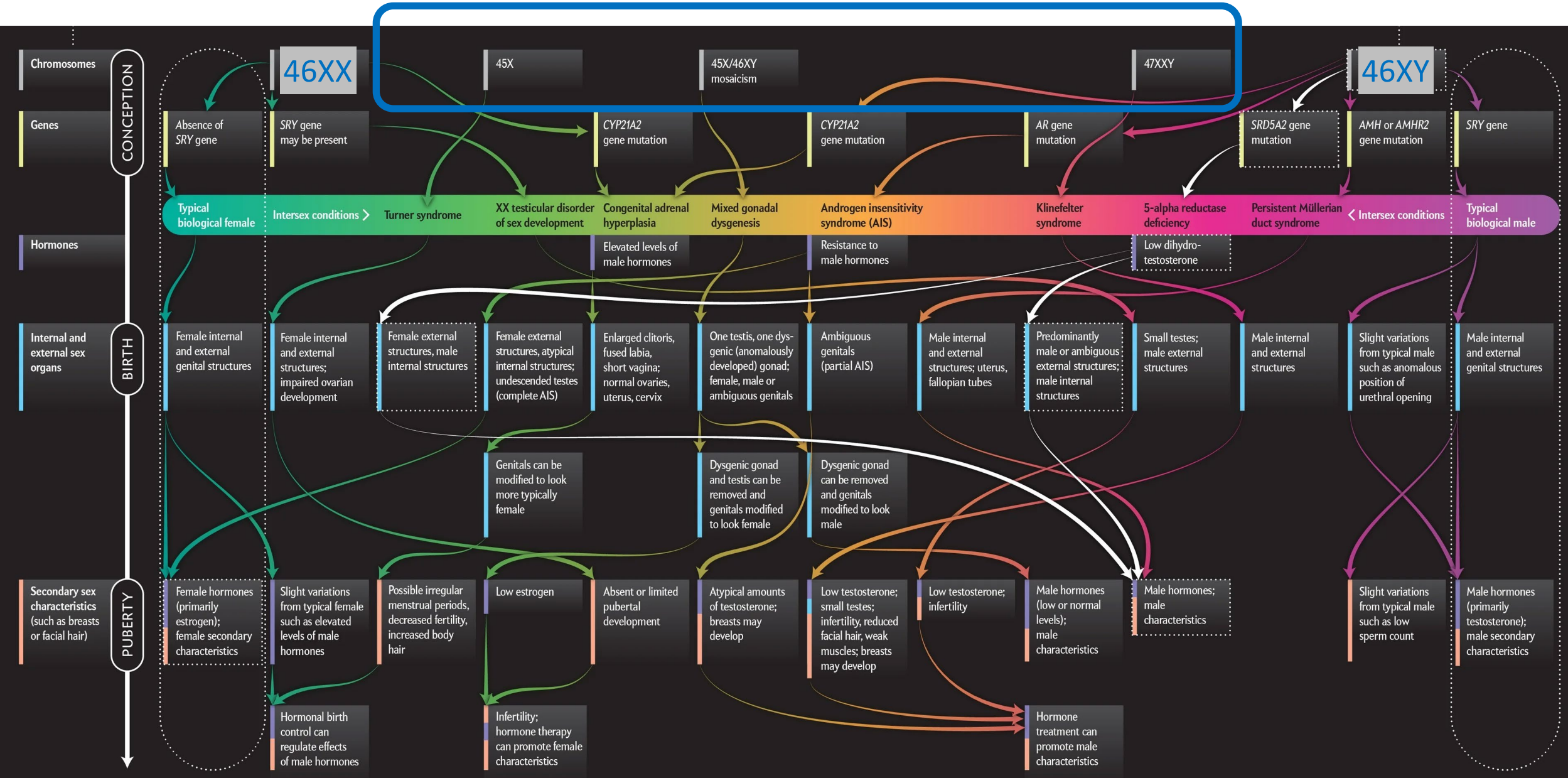
Testes or
Ovaries

Testosterone
or Estrogen

Penis or
Vagina

Secondary
Sex Traits

There are few straight lines when it comes to human sexual differentiation



There are few straight lines when it comes to human sexual differentiation

45X – Turner Syndrome 1 in 2,000 genetic females

- Short growth, short stature, broad chest
- Delayed or absent puberty
- Infertility

47XXY – Klinefelter Syndrome 1 in 500-1,000 genetic males

- Tall stature, reduced muscle tone
- Lack of facial/body hair, enlarged breast tissue
- Infertility

45X / 46XY (mosaicism) – mixed gonadal dysogenesis 1 in 10,000-15,000 live births

- Ambiguous genitalia (underdeveloped penis, small uterus)
- Delayed puberty
- Infertility

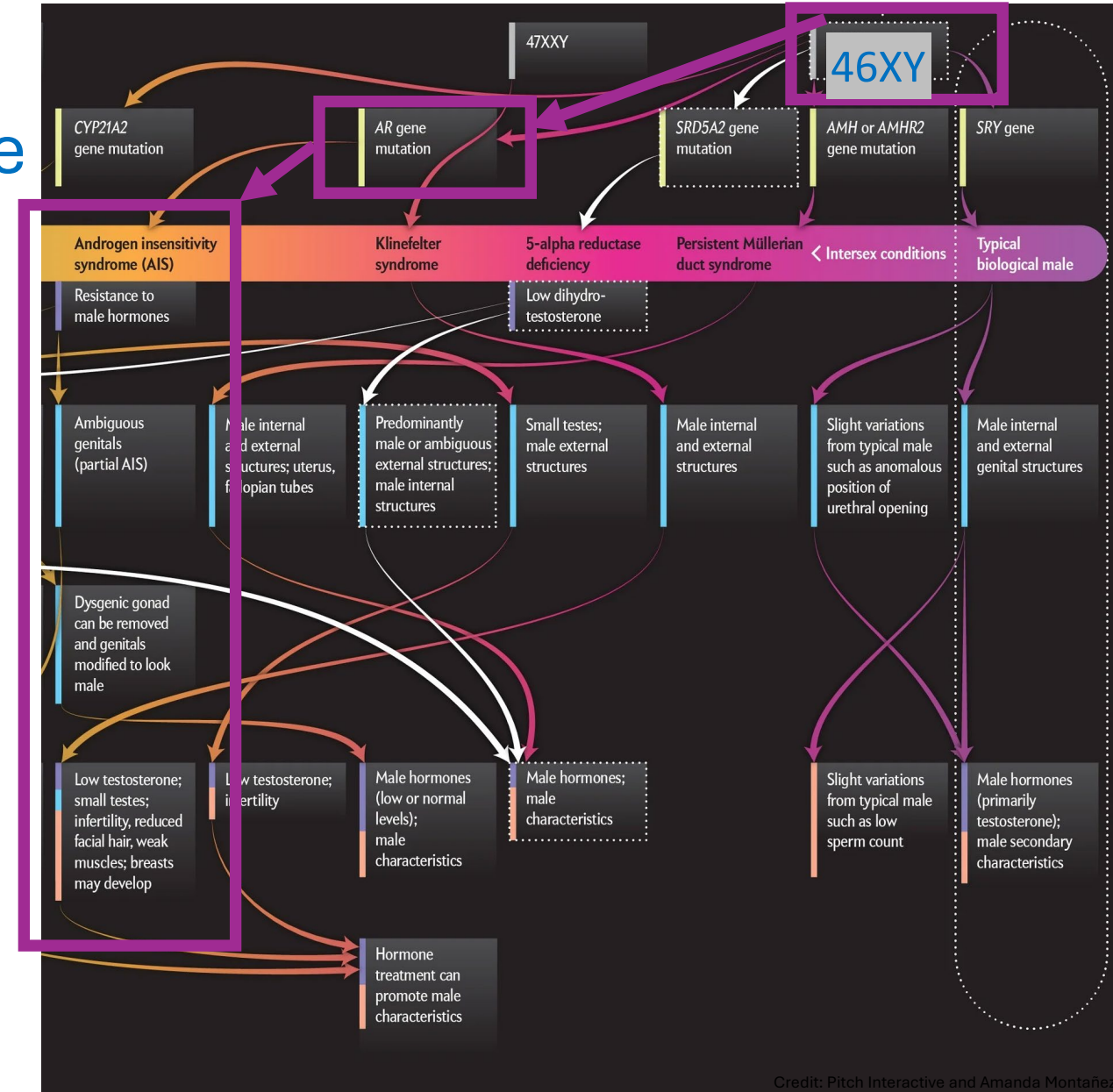
There are few straight lines when it comes to human sexual differentiation

Androgen insensitivity syndrome

Genetically the individual is male

The person has the proper enzymes to produce testosterone

Yet, the body cannot respond to testosterone because of a mutation in its receptor



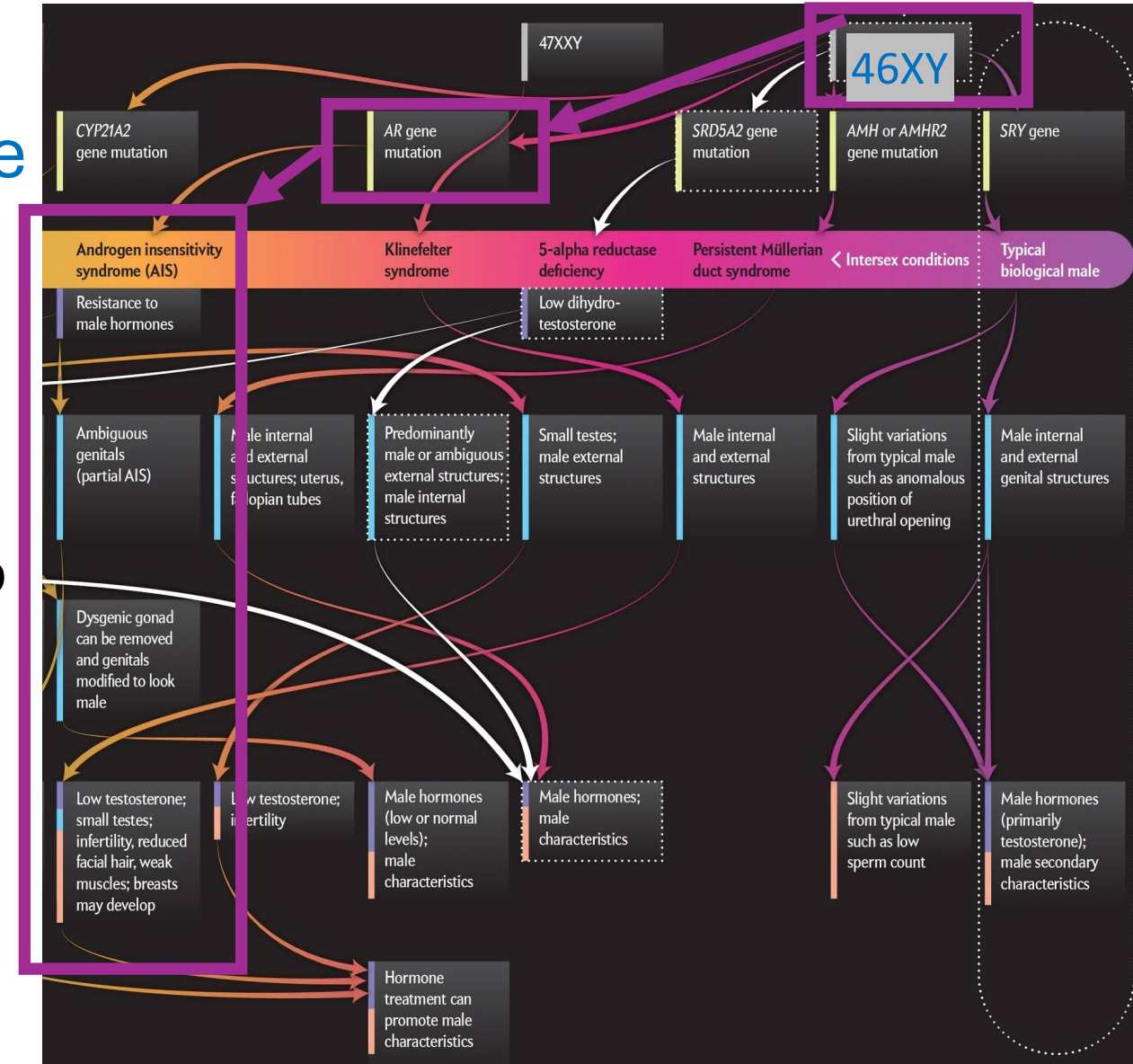
There are few straight lines when it comes to human sexual differentiation

Androgen insensitivity syndrome

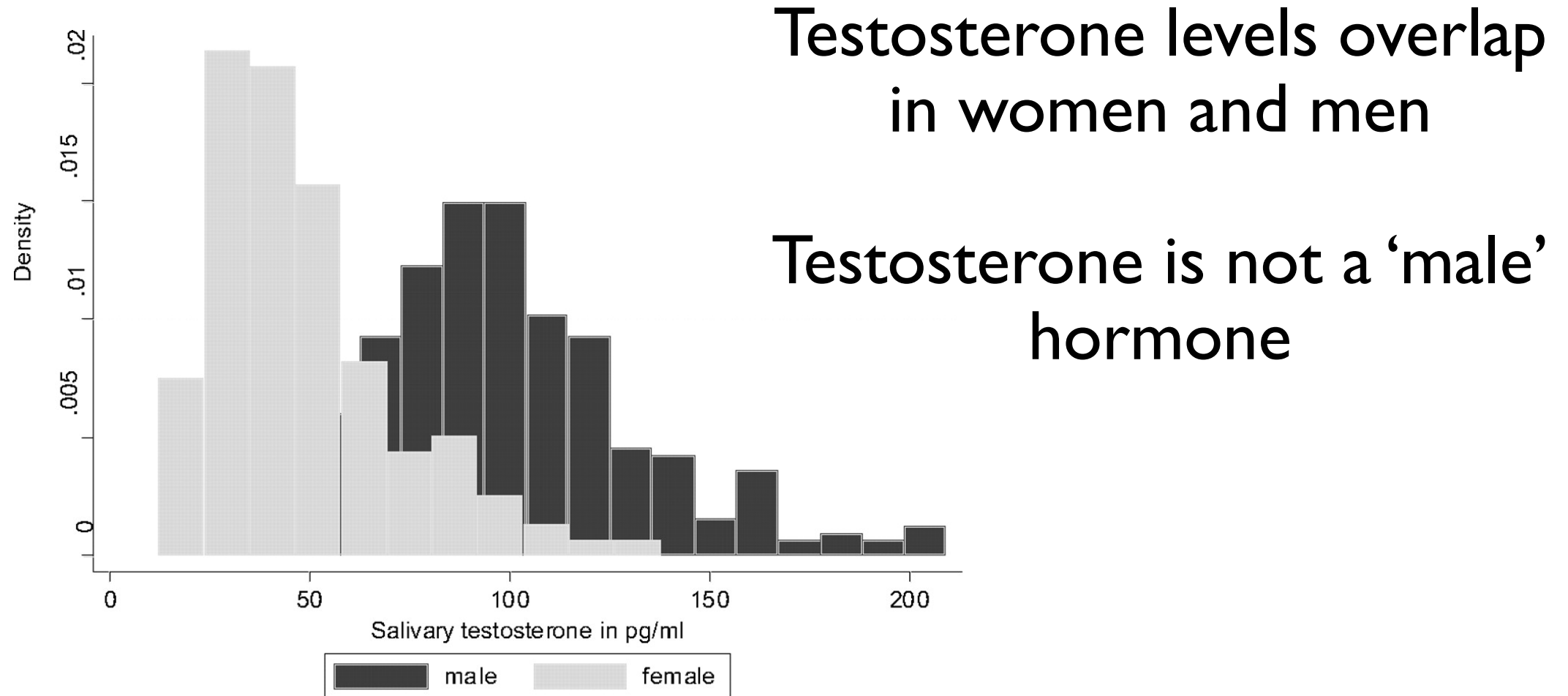
1:20,000 - 1:50,000 XY live births

4 billion XY people on the planet

On a global scale, tens of thousands to hundreds of thousands of people who have this condition



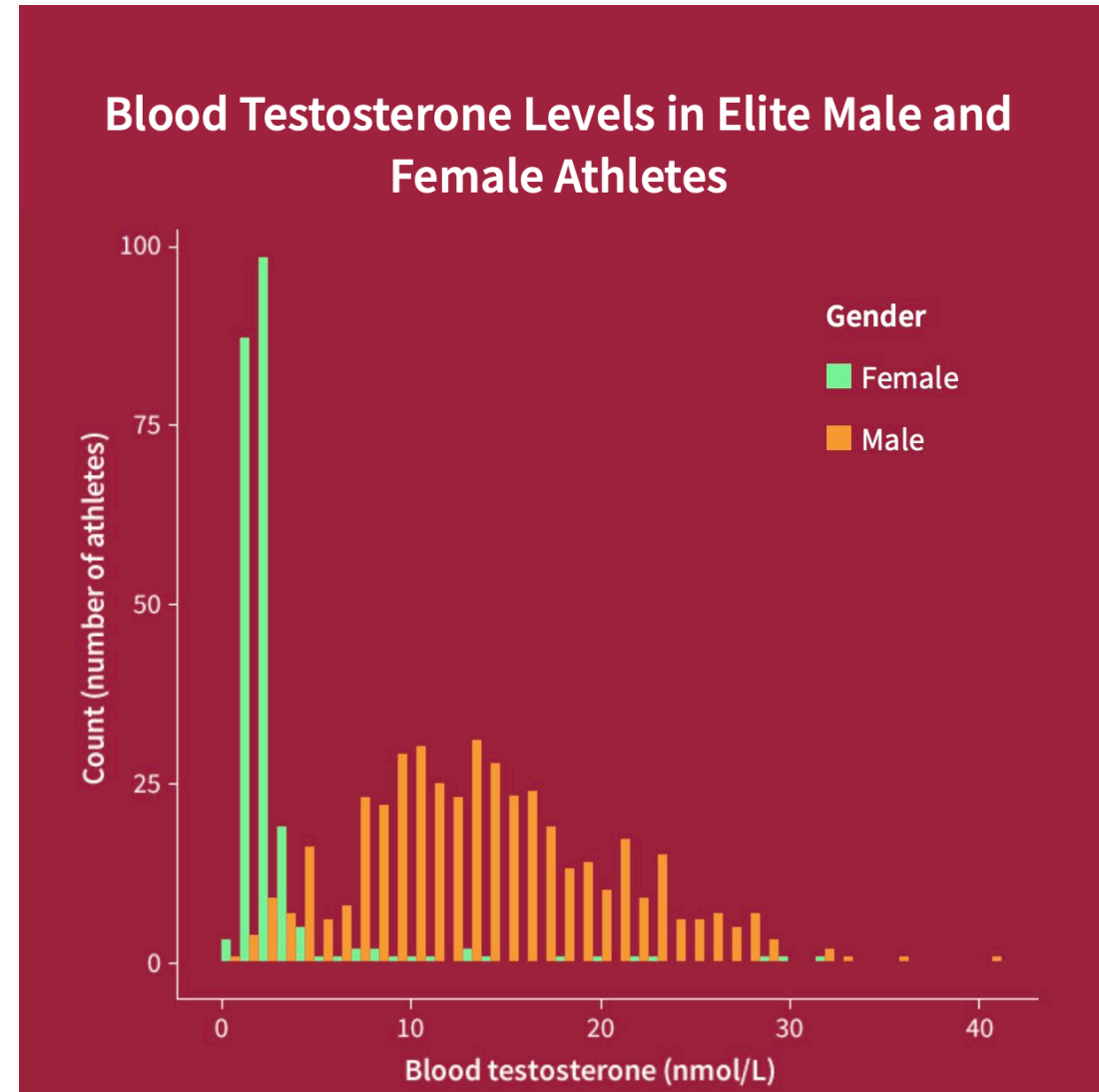
There are few straight lines when it comes to human sexual differentiation



The pattern also holds for “elite athletes”

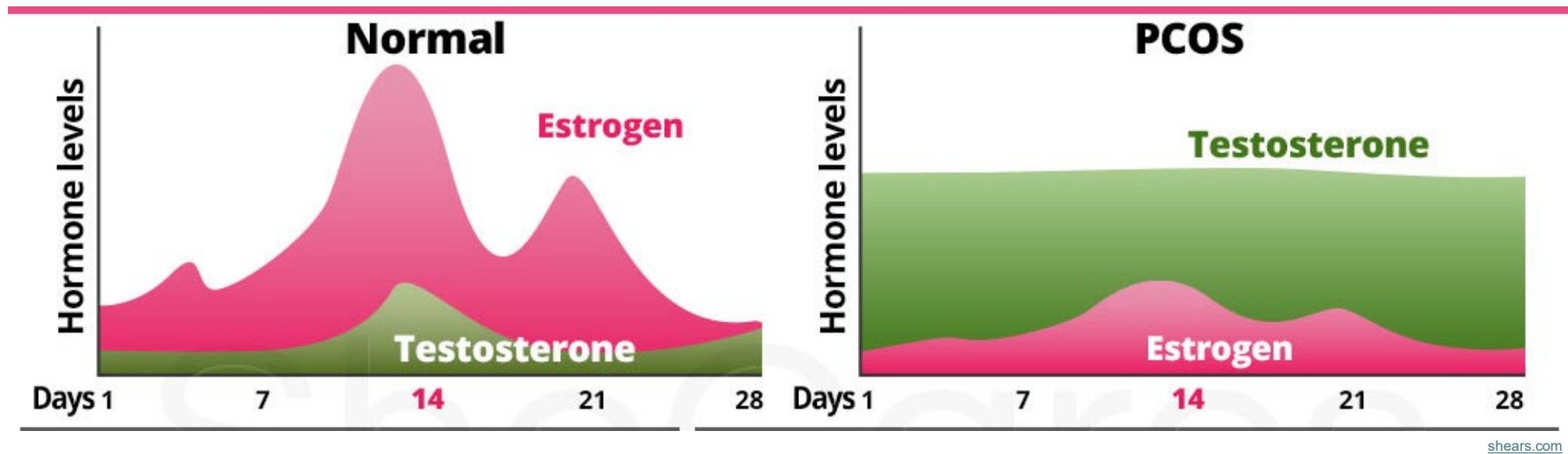
16.5% of male elite athletes had testosterone concentrations less than the lower limit of the laboratory reference range

13.7% of elite female athletes had a testosterone concentration greater than the laboratory reference interval for ‘normal’ women



Data from Healey et al. (2014) and Sönksen et al. 2018,
Figure from HHMI Biointeractive

Polycystic ovary disease



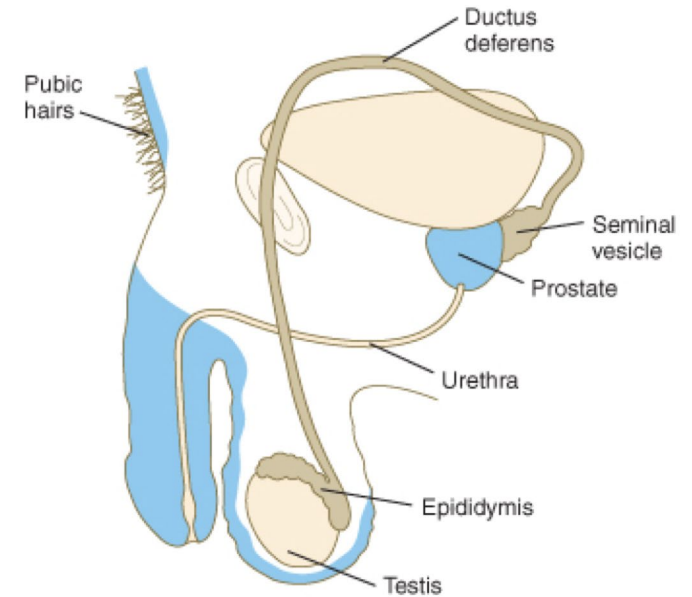
Affects 10% of women of reproductive age

Females with PCOS produce an excessive amount of androgens (testosterone)

High testosterone may lead to periodically missed ovulation, chronic failure to ovulate, patchy baldness, increased facial/body hair

5-Alpha-Reductase Deficiency

- During development, the hormone DHT is needed to properly develop a penis in male embryos
- DHT is produced by the enzyme 5-alpha-reductase

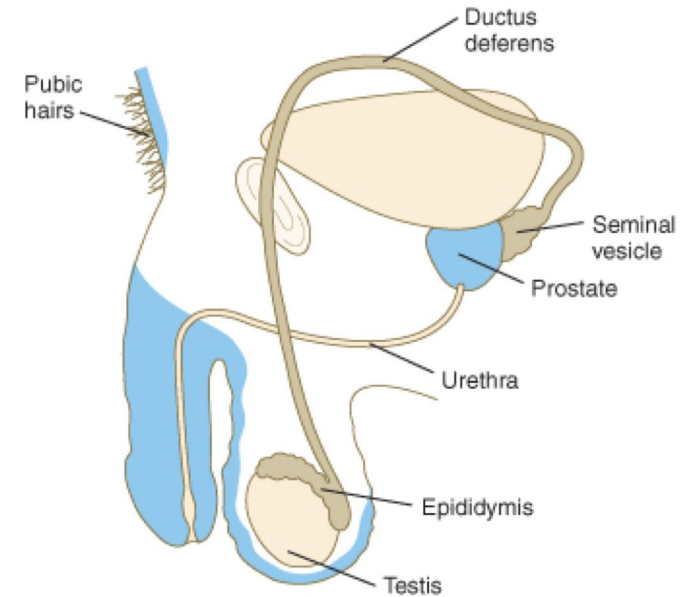


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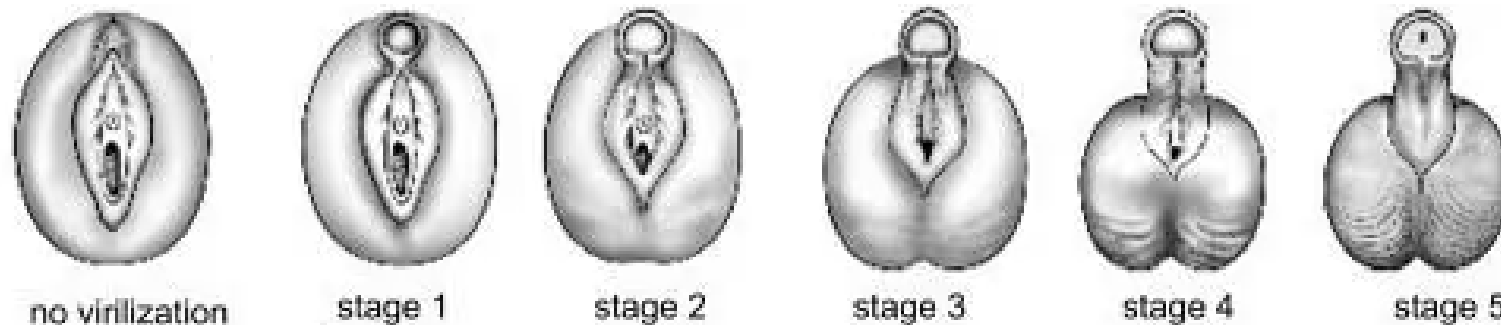
Blue = structure requires DHT to develop

5-Alpha-Reductase Deficiency

- During development, the hormone DHT is needed to properly develop a penis in male embryos
- DHT is produced by the enzyme 5-alpha-reductase
- A surge of testosterone at puberty may cause an enlargement of the phallus



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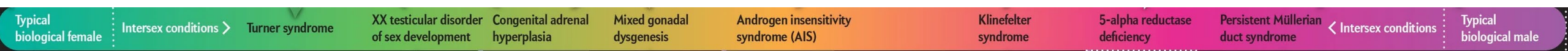
Prader scale of severity for 5-Alpha-Reductase Deficiency

5-Alpha-Reductase Deficiency

- Worldwide: approximately 1 in 15,000 to 20,000 live births.
- Dominican Republic: 1 in 1300 live births.
- Papua New Guinea: 1 in 1000 live births.
- In cultures with high prevalence, these individuals are considered a third gender



The law of averages does not easily apply to sexual differentiation



There are 50-60 variations in sexual development recognized by the medical community

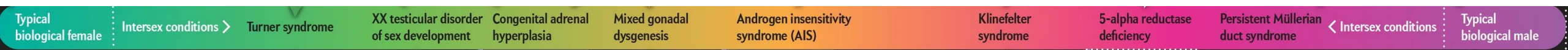
- Chromosomes
- Hormones
- Genitalia and Gonads

On the global scale, this means that there are millions of people that cannot be easily placed in restrictive definitions of male and female.

1-2% of the global population!



The law of averages does not easily apply to sexual differentiation



Intersex conditions are unrecognizable without a medical exam or disclosure by the individual



Caster Semenya
Athlete, Advocate



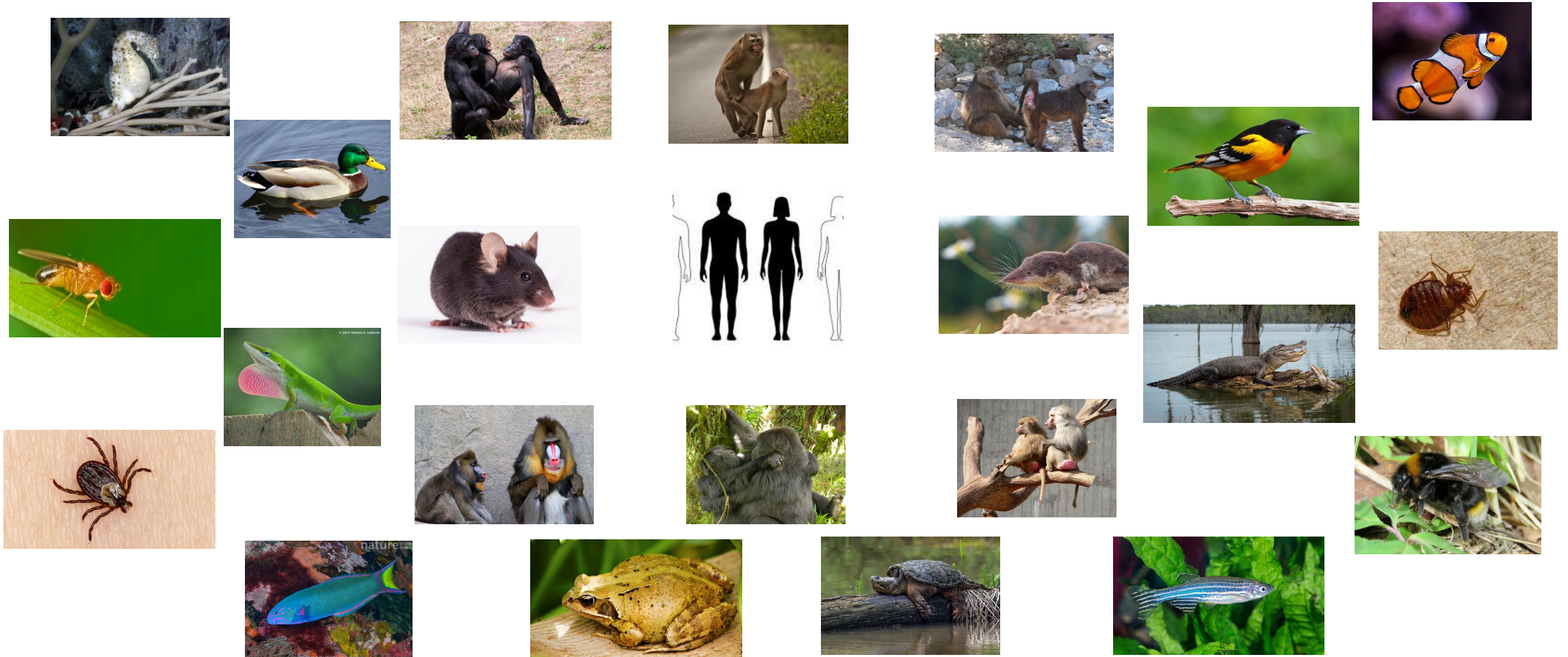
Alicia Roth Weigel
Author, Advocate



Blume
Musician, Advocate

Intersex people exist and they have always existed

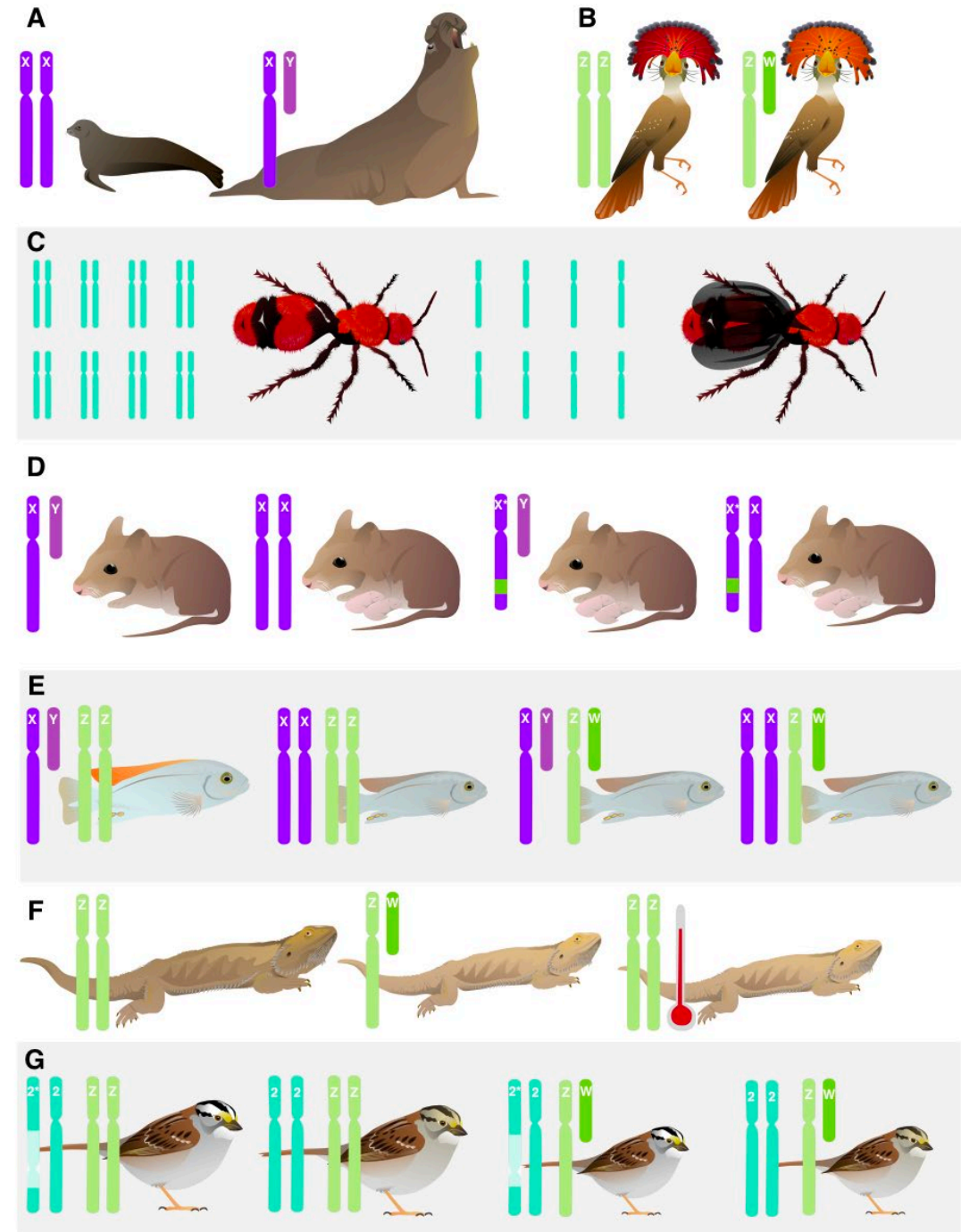
Humans represent a small fraction of the sexual diversity observed among animals



*Using the same hormones and many of the same genes,
the diversity of non-human sex dwarfs what we see in our species*

Diversity of Sex Differentiation

- XX/XY and ZZ/ZW
- Haplodiploid
- Mutation in X overrides Y
- Absences of one chromosome + presence of another chromosome
- Temperature
- Chromosomal inversions



Sex among non-human animals breaks all the textbook norms



Brian Peer

Birds can occasionally be half male/half female

Circulating sex hormones have minimal influence on their sexual differentiation

Sexual differentiation is cell autonomous

Sex among non-human animals breaks all the textbook norms



[r/interestingasfuck](#)

Female deer may possess antlers

Male white-tailed deer may possess antlers, but lack male genitalia



Diego González Dopico

XX female moles possess ovotestes

The testicular tissue lacks sperm, but produces enough androgens to induce a penile-like clitoris

Female moles have a seasonal vagina

Sex among non-human animals breaks all the textbook norms

Social environment



Loss of the female triggers the largest male to transition to the female state

Temperature



Increased temperatures are overriding the genetic switch that determines sex

Chemical



Exposure to agricultural waste led to smaller penises and spermless male alligators

Sex among non-human animals breaks all the textbook norms



Whiptail lizards – no males at all



Echidnas – four headed penis



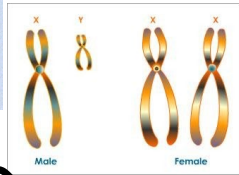
Nudibranchs – hermaphrodites with a disposable penis



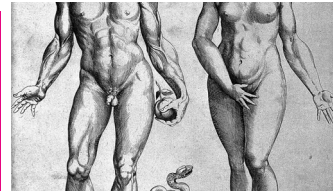
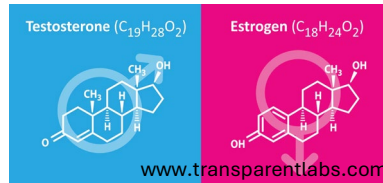
Tuatara – no penis

The simplistic view of sex/sexual differentiation is outdated

Simplistic definitions of sex do not hold up to scrutiny



Getty



Fertilization
XY or XX

Testes or
Ovaries

Testosterone
or Estrogen

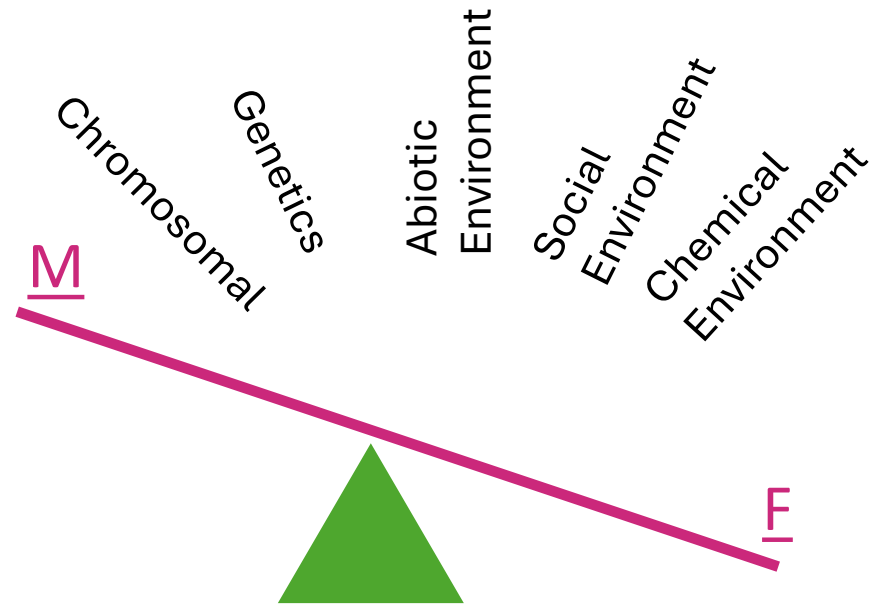
Penis or
Vagina

Secondary
Sex Traits

Sex is **diverse**

Sexual differentiation is **dynamic**

The factors that determine sexual appearances are **context dependent**

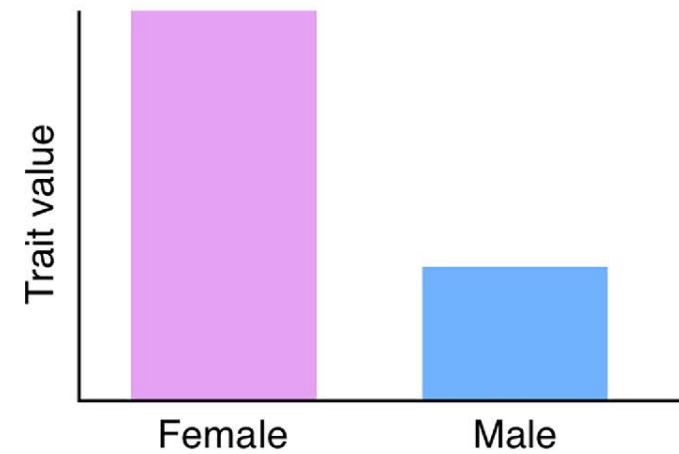


The only “biological truth” is that the biological bases of sex is complex

Reframing our understanding of sex

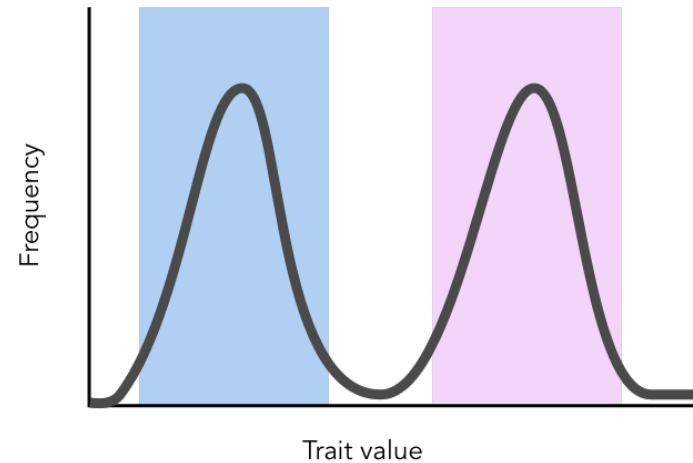
Simplifying many traits to one- "sex" obscures the actual mechanisms we're trying to teach

(A)



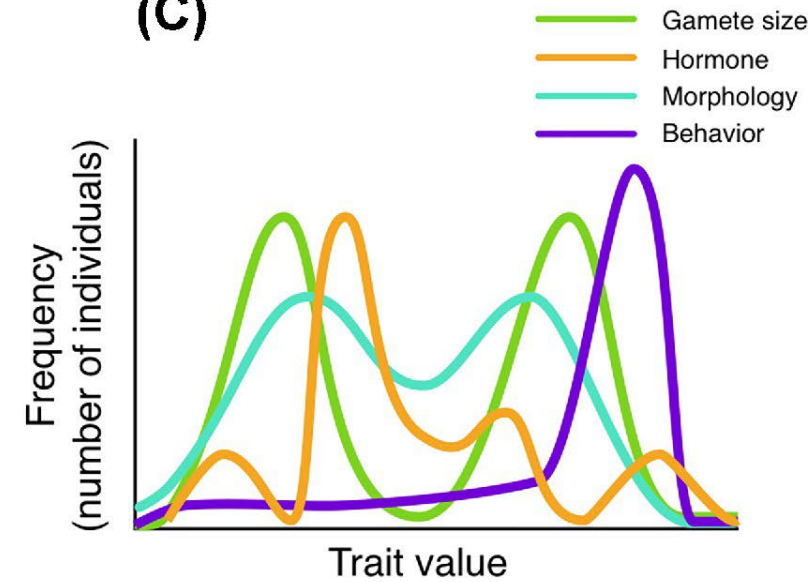
Binary model

(B)



Bimodal model

(C)



Multivariate model

Assumption: Sex = Gender

- **Sex:** broad classification of individuals based on observations of traits like gamete type (sperm vs ova), chromosomes (XX vs XY), morphology (genitalia), etc.
 - Often classified as 'male' or 'female'
- **Gender:** multifaceted and abstract self-interpretation of identity; internal personal experience that expresses itself in the context of an individual's specific culture, place, and time

Talk outline

- Why are we talking about this?
- Definition & diversity of sex
- Teaching approaches and resources

How do we support all learners' motivations & success through a course:

- **Instructional Practices**
- **Climate**
- **Content**

In our lectures:

- Distinguish sex (biological phenomenon) from gender (sociocultural phenomenon)
- Acknowledge variation within and between groups, beyond the binary
- Teach the many different components of sex: gametes, chromosomes, hormones, morphology

How can we teach more inclusively?

1. Present Diversity First
2. Provide Context
3. Use inclusive language
4. Show iterative process of science
5. Diversify role models
6. Cultivate culture of respect

JOURNAL ARTICLE

Six Principles for Embracing Gender and Sexual Diversity in Postsecondary Biology Classrooms

Ash T Zemenick, Shaun Turney, Alex J Webster, Sarah C Jones, Marjorie G Weber

BioScience, Volume 72, Issue 5, May 2022, Pages 481–492,

<https://doi.org/10.1093/biosci/biac013>

Published: 16 March 2022



Teach Diversity First: Let's test it!



- What are the impacts of Zemenick et al.'s framework (i.e., the “treatment”) on student **understanding of sex/gender and affect?**
- Spring 2023: First Year Organismal Biology
 - **Section 1:** Business as usual (n=274)
 - **Section 2:** Treatment Lecture (n=241)
 - Adapted from Project Biodiversify materials
 - 1.5 months later: collected survey responses from both classes



Dr Cissy Ballen
Auburn University






Research Questions

Section

 Treatment
 Traditional

-  **RQ1:** What is the impact of the treatment lecture on students' reports of inclusion or
 discomfort in the class ***compared*** to the traditional course?

-  **RQ2:** What is the impact of the treatment lecture on student experiences ***within*** the course?

-  **RQ3:** How do students exposed to the treatment lecture understand the concepts of
 sex & gender and the relationship between the two ***compared*** to the traditional course?

Demographics Highlights

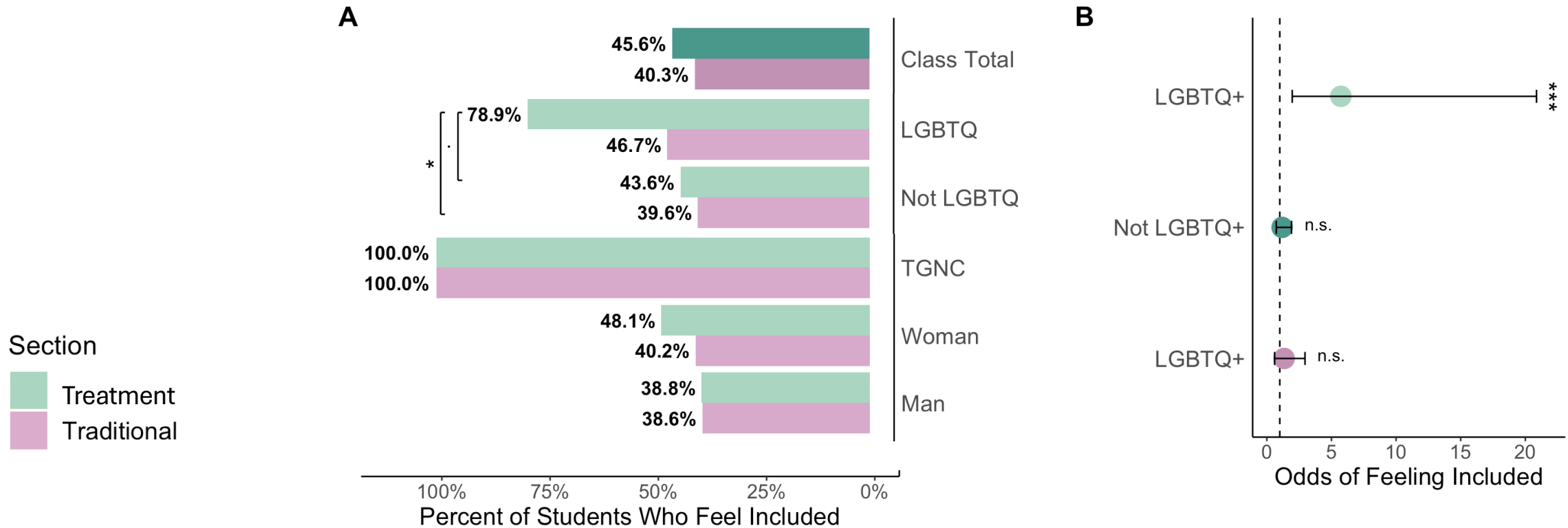
- Gender
 - Select all that apply + write-in
 - TGNC = Trans-gender + gender nonconforming
 - Results for TGNC will be reported descriptively,
 - Statistical comparisons: Man vs Woman+TGNC
- LGBTQIA+
 - **Y/N:** “Do you identify as a member of the LGBTQIA* community?”
*lesbian, gay, bisexual, transgender, queer/questioning, intersex, asexual/aromantic”

	Treatment	Traditional
Total	169	200
Man	29.0%	29.0%
Woman	61.5%	59%
TGNC	3.0%	1.5%
unreported gender	6.51%	10.5%
LGBTQIA+	11.24%	15.0%
White	86.4%	80.5%
First-year	77.51%	51.5%
First Generation	16.6%	14.0%
Bio Major	27.8%	24.5%
Non-Bio STEM Major	37.9%	45.5%

Research Questions

- **RQ1:** What is the impact of the treatment lecture on students' reports of inclusion or discomfort in the class ***compared*** to the 'traditional' course?

“Are there ways sex and gender have been taught or discussed that made you feel included in this class?” Y/N



“Are there ways sex and gender have been taught or discussed that made you feel uncomfortable in this class?” Y/N

- No!
 - 87% in the Treatment Section and 100% of the Traditional Section
 - n.s.

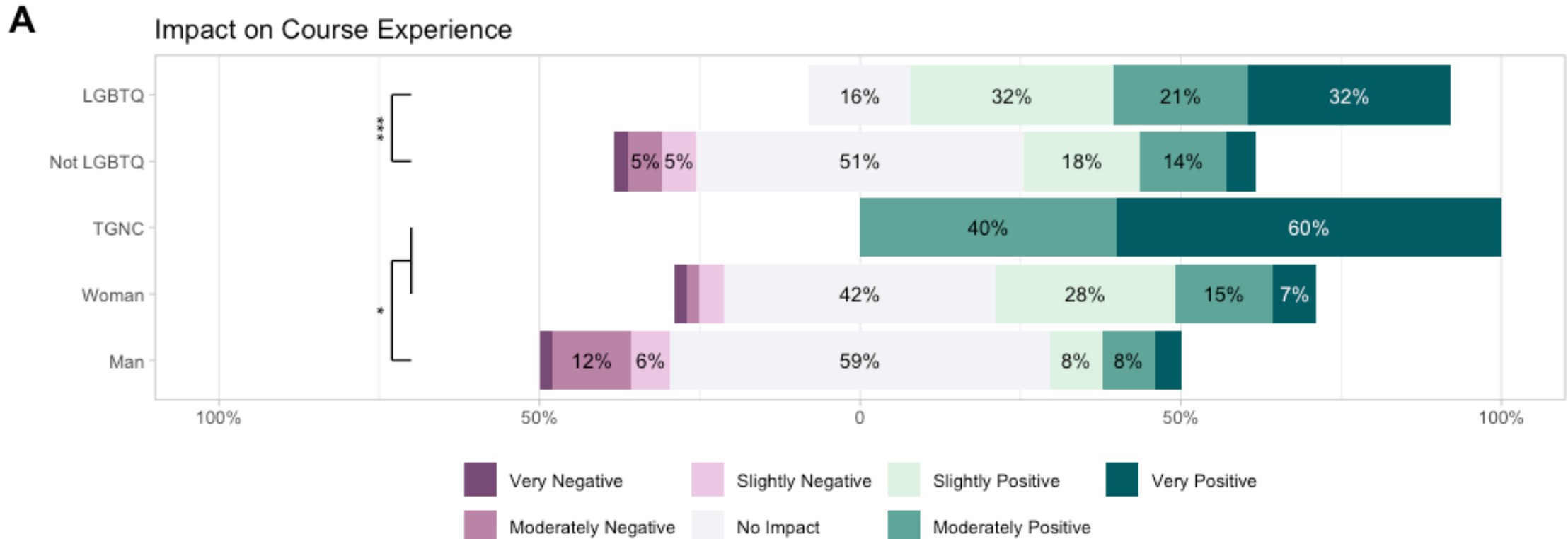
Research Questions

-  **RQ1:** What is the impact of the treatment lecture on students' feelings of inclusion or discomfort in the class ***compared*** to the 'traditional' course?
 -  • More LGBTQIA+ students felt included after the treatment lecture
 - No significant differences between student reports of discomfort

-  **RQ2:** What is the impact of the treatment lecture on student experiences ***within*** the course?

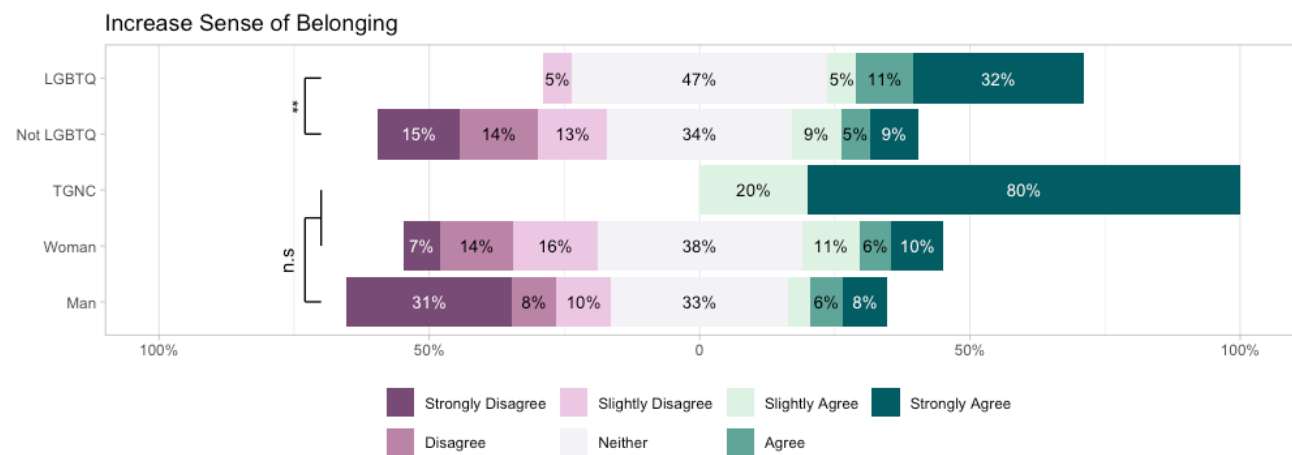
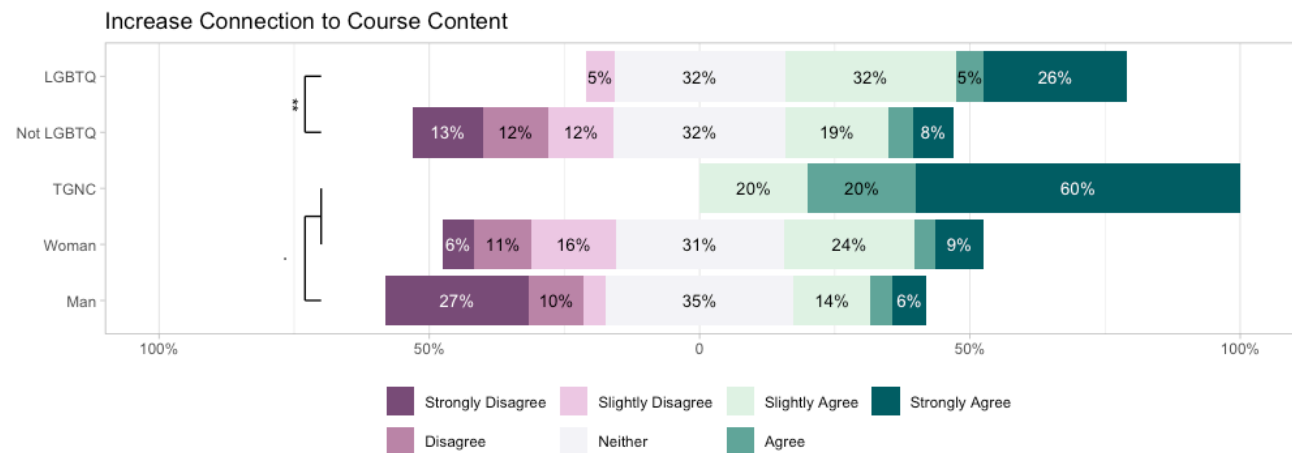
“The lecture on sexual diversity in the beginning of the course had ___ impact on my course experience” [1-7]

1 – Very Negative, 2 – Moderately Negative, 3 – Slightly Negative, 4 – No Impact, 5 – Slightly Positive, 6 – Moderately Positive, 7 – Very Positive.



“The lecture on sexual diversity in the beginning of the course made me feel more connected to the biology course content”

“The lecture on sexual diversity in the beginning of the course increased my sense of belonging in the class”



Research Questions

RQ1: What is the impact of the treatment lecture on students' feelings of inclusion or discomfort in the class ***compared*** to the 'traditional' course?

- LGBTQIA+ students were more likely to feel included after the lecture
- Students did not report feeling discomfort

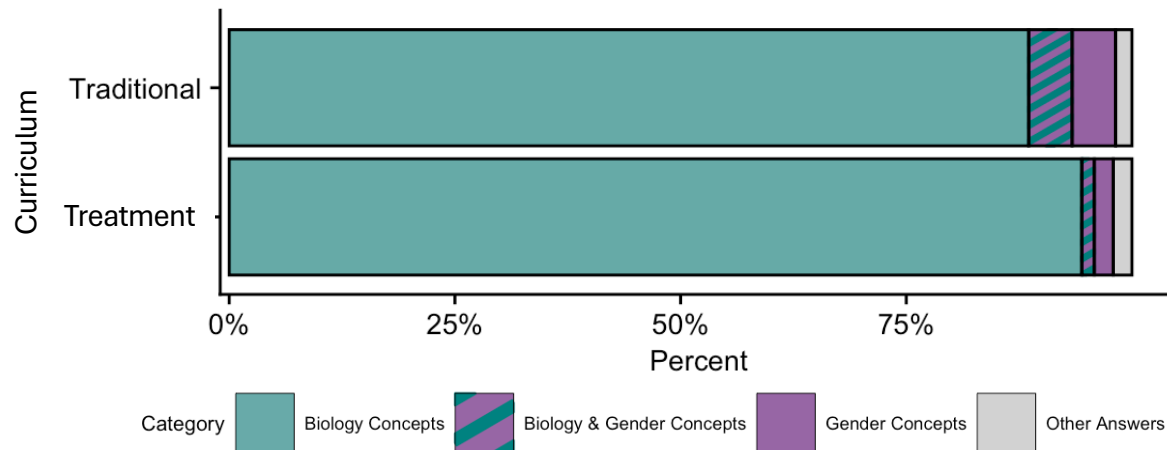
RQ2: What is the impact of the treatment lecture on student experiences ***within*** the course?

- LGBTQIA+ & TGNC students reported a more positive impact, increased connection to course content, and increased sense of belonging

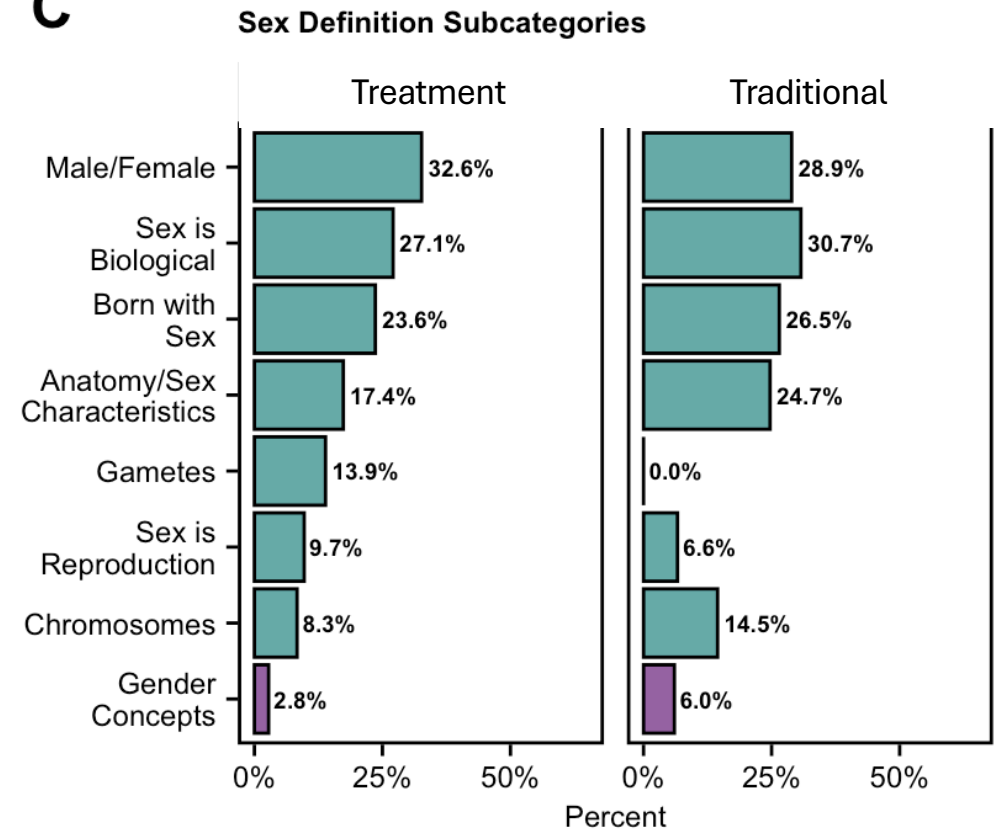
RQ3: How do students exposed to the treatment lecture understand the concepts of sex & gender and the relationship between the two ***compared*** to the 'traditional' course?

How do students define sex?

- Students define sex with biological concepts >93% of the time
- Definitions included
 - Using male/female labels
 - Sex is biological
 - That we are born with sex
 - Using anatomical features to define sex

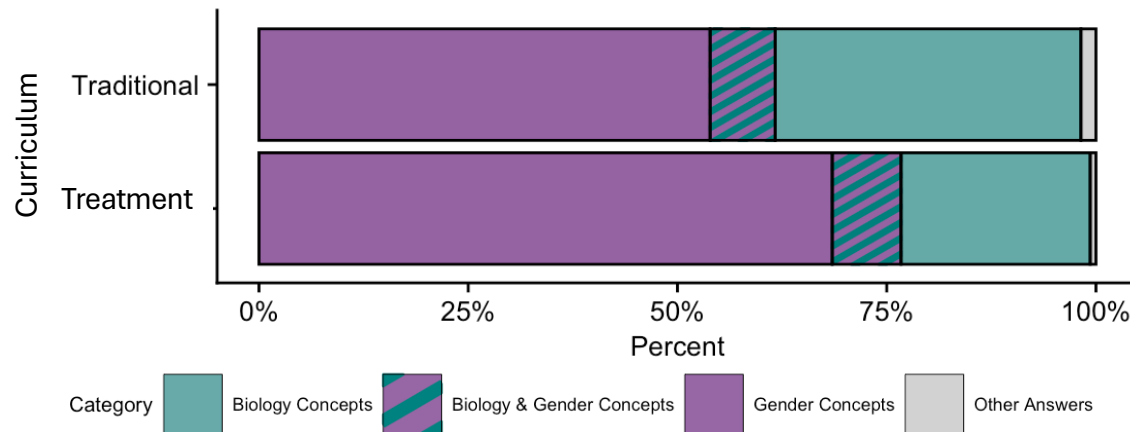


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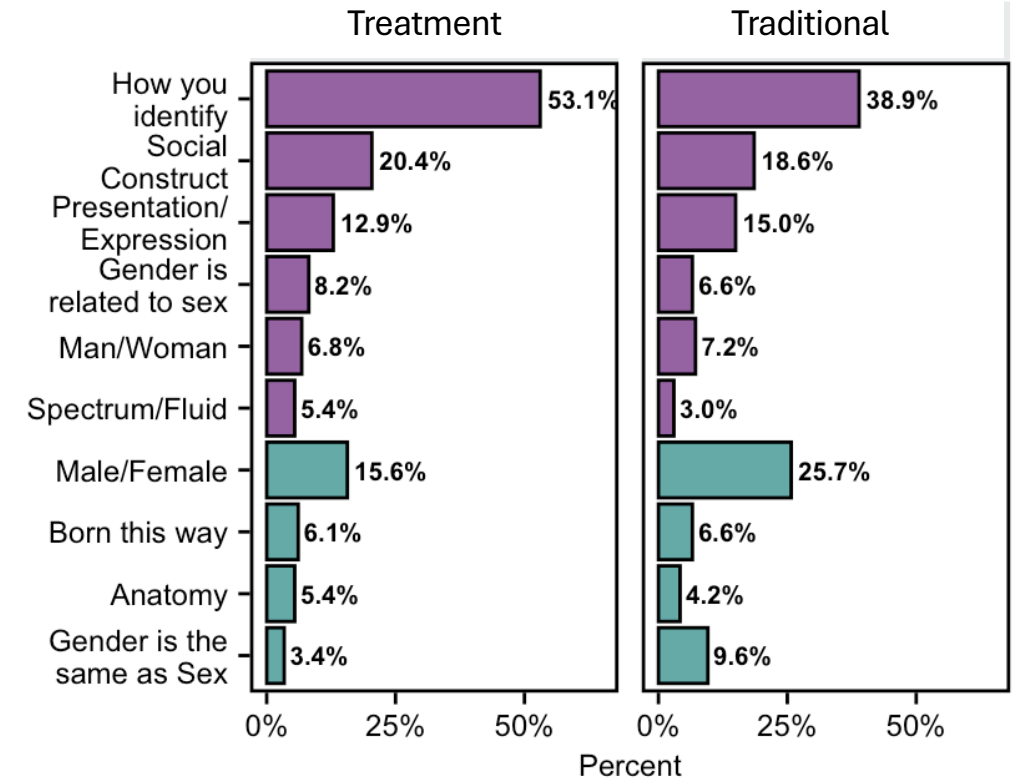
How do students define gender?

- Students struggled more to define gender
 - 76% Treatment vs 62% Traditional used gender concepts in their definitions
 - 30% vs 44% conflate sex with gender
- Gender concepts include
 - Identity, social construct, expression
- Biological concepts include:
 - Male/Female, anatomy, gender is the same as sex



D

Gender Definition Subcategories



Research Questions

RQ1: What is the impact of the treatment lecture on students' feelings of inclusion or discomfort in the class **compared** to the 'traditional' course?

- LGBTQIA+ students were more likely to feel included after the lecture
- Students did not report feeling discomfort

RQ2: What is the impact of the treatment lecture on student experiences **within** the course?

- LGBTQIA+ & TGNC students report a more positive impact, increased connection to course content, and increased sense of belonging

RQ3: How do students exposed to the treatment lecture understand the concepts of sex & gender and the relationship between the two **compared** to the 'traditional' course?

- Students conflate the concepts of sex and gender when defining gender
- Students who received the treatment lecture conflate sex and gender less

Take Aways:

- Teaching Zemenick et al.'s framework about sex and gender makes LGBTQIA+ students feel more included
- Non-LGBTQIA+ students reported neutral impacts of the treatment lecture
- Students in the treatment section were less likely to conflate sex and gender

Brief inclusion of the diversity of sex and gender can have a significant impact on LGBTQIA+ students

How do narratives in life science courses influence the experiences of trans-spectrum and intersex undergraduates?

- Sarah Eddy et al. interviewed **53 trans-spectrum and/or intersex life science majors** 4 time each (~ 4 hours of data from each student) about experiences in biology contexts.
- **Recruited Nationally:** 21 states and 39 universities across the U.S.
- **Deliberate Sampling:** recruited trans-spectrum &/or intersex students with a range of intersectional identities and backgrounds.



Dr Sarah L Eddy
Univ of Minnesota – Twin Cities

Results

- **8 narratives about sex & gender** in biology content identified:
 - **5** narratives trans-spectrum students had **negative** reactions to.
 - **3** narratives that trans-spectrum students had **positive** reactions to.
- **Impacts** of these narratives:
 - **7** categories of **harm** resulted from negative narratives.
 - **3** categories of **benefits** from positive narratives.

Negative narratives & their harms

1. Sex is binary.
2. Sex and gender are the same.
3. Gender is not relevant in biology contexts.
4. There is a natural essence to being man or woman that leads to certain appearances and behaviors; men and women are fundamentally different due to their biology (Gender Essentialism).
5. Man and woman gender identities, expressions, and embodiments are more natural and legitimate than any other gender identities (Cisnormativity).

Narratives manifested in two ways:

1. As assertions that these things are true
2. As silence on the biological variation beyond male/man or female/woman leading to presumption that narratives are true.

Negative narratives & their harms

Harms (themes)		Example Quotes
Belonging	Lack of connection to content. Have to emotionally distance themselves from class content.	<i>"I came up with a coping mechanism that anytime I'm in that class [when sex or gender come up], I'm just not there. I'm just there physically. But mentally, I switched off.... I just had to not be there mentally for my own mental health's sake."</i>
	Relationship harm. Reduced ability to build relationships with instructor or peers.	<i>"The moment that [sex & gender topics] come up in class, I look around and people are in agreement with it.... If the professor said [the color] is red it's red, they're not looking to challenge these ideas. It makes me extremely uncomfortable around my peers. I'm not close with my peers in my science classes."</i>
	Lack of safety. Uncertainty about how will be reacted to.	<i>"If [professors] don't initiate the conversation, can we really share who we are with them? ...Cis-het students have it so much easier because ... they don't have that barrier of having to ... come out to [their] Professor. Are they going to accept me? They don't have to do that."</i>

Negative narratives & their harms

Harms		Example Quotes
Career Preparation	Access to opportunities. Erasure limited student's access to resources & opportunities.	<i>"[Not seeing myself represented] gives me a hard time building personal relationship with [instructors] and then that prevents me from getting letter of recommendation so I can pursue future you know academic endeavors and I think that's a barrier for a lot of LGBTQ students."</i>
	Missed opportunity to educate. Exclusion of content on diverse gender identities does not prepare students to work with diverse people in their careers.	<i>"I think [the way biology is taught] affects [my peers] by reinforcing ... biases that they already had. I worry ... because it doesn't challenge some of the incorrect things that they've been taught ... Because less people are learning about it, especially people going into the medical profession. It's a bit worrying when our future doctors aren't being taught that we exist, and that it's normal for us to exist. And I worry that they'll try to force us into a binary."</i>

Our students believe in the power of biology instruction and instructors to make a difference

“Biology has a lot of exceptions, you know. They make a huge difference... I wish the professors would have come up with more diverse narratives.... I think it would be a wonderful learning experience.”



“I think students take teachers as role models In a biology class... they put a lot of value into wanting to know what the biology teacher knows since they're a respected person in science specifically, rather than humanities where things are up for debate. Science is concrete. It is how it is.”



“This is incredible... I think that it's very nice for me to see people in positions of power, especially people ... who are not gender diverse in any way. Both of the bio professors [in] this genetics class were cis-men, acknowledging stuff like this, it's very novel to me.”



Positive gender/sex narratives & their impacts

1. Sex and gender are not the same.
2. Sexes and genders beyond male/man & female/woman are legitimate.
3. Biological concepts of sex and gender are both contextual and socially constructed.

Narratives manifested in many ways:

1. Disclaimers
2. Short one-off examples
3. Extended integrated examples
4. Exclusively non-human examples
5. Use of human examples

Disclaimers & their impacts

Example	Impacts
<p><i>“[When] the professor did bring up ...sex or gender. They would always have stipulations: “Hey, this is a topic that is more expansive than what we can cover, but if you want to talk about that, the door is open for you.”</i></p>	<p>Identity & belonging affirmed: <i>“It makes me feel recognized. It lets me feel legitimized in my identity....”</i> <i>“[felt a] greater connection with instructor & classmates”</i></p> <p>Makes diversity concrete: Whenever topics of ... sex and gender are talked about, I always get ... a knot in my stomach because these are ... stressful topics for me. But that ...go[es] away when it's mentioned that not everyone is straight ... Pandora's box has been opened ... we won't be able to talk about this more without thinking about ... the diversity.</p>

Problems with disclaimers

Harmful narratives can remain dominant in the classroom

Inconsistency in message kept harmful narrative dominant:

“Usually what happen[s] is the professor is like, “Sex isn’t binary. There are intersex people” and I understand that. And then the whole rest of the conversation is just male and female.”

Perceived as avoidance so harmful narrative remains dominant:

“It’s not something that they’ve purposefully brought out in class.... They do a disclaimer, but they never got into the topic.”

Alternative narratives & their impacts

Human examples & their impacts:

Example:	Impacts:
<p>Binary sex is socially constructed: <i>"There's an entire unit in our intro biology class where <u>the professor discussed sex being a spectrum...</u> We were given a worksheet list[ing] made-up people, and ... some were intersex, some were cisgender, some were transgender, and it listed traits like their chromosome mappings, what their genitalia resembled.... <u>You were put into the role of an athletic supervisor trying to determine who was going to be allowed in this sports team.</u>"</i></p>	<p>Provides biological tools to challenge narratives about sex & gender in society: <i>"I very much knew ... that the differences between transgender individuals and cisgender are not... There were so little differences. And I knew this, but I didn't really have a deep understanding of why."</i></p> <p>Increased belonging: <i>"People use science, especially biology, to weaponize [cisnormativity].... And then teaching people that, "Hey, you can't use science to weaponize your hatred. Science doesn't agree with you," is really validating."</i></p>

How can instructors bring in these examples?

Entry points instructors used:

Hormones: Even though we talk about male and female hormones everyone has testosterone and estrogen.

Plants: As modular organisms, definitions of sex and gender in plants are more complicated and inherently challenge students' conceptions of sex as universally binary.

Polygenic inheritance and the consequence that most traits are spectrums: starts breaking down propensity for categorical thinking.

- *"I would not have been comfortable ... to have shown up one day in one of my classes and say, Hey, guys, today we're gonna talk about homosexuality and transgender issues.*
- *But I was able to mitigate ... that concern by saying... today we're talking about sexual behavior and hormones. ...Well, if anybody asks me, why are you teaching this? I'll simply say, Well, it's part of hormones and sexual behavior."*



Conclusions

- Instructors can influence the narratives that dominate their classrooms and the experiences of their trans-spectrum and intersex students.
- There are many paths for including more inclusive narratives in biology
 - disclaimers
 - one-time examples
 - restructuring of whole units
 - human example
 - non-human examples

Resources & Thanks

Dr. Karen Warkentin's resources for Biology + gender/sexuality studies (undergraduate & graduate focused):

<http://sites.bu.edu/warkentinlab/gen-sex/>

Project Biodiversify (undergraduate focused):

<https://projectbiodiversify.org/>

- **Zemenick et al. 2022**, "Six Principles" paper

Gender Inclusive Biology (K-12 focused):

<https://www.genderinclusivebiology.com>



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