

ESA 2018 WK44

Inclusive and Accurate Approaches for Teaching Sex and Gender in Biology

Alex Webster
she/her/hers
@alxweb

Ash Zemenick
they/them/theirs
@mtn_ash

Sarah Jones
she/her/hers
@jones943

why is diversity and
inclusivity important?



collective biological knowledge

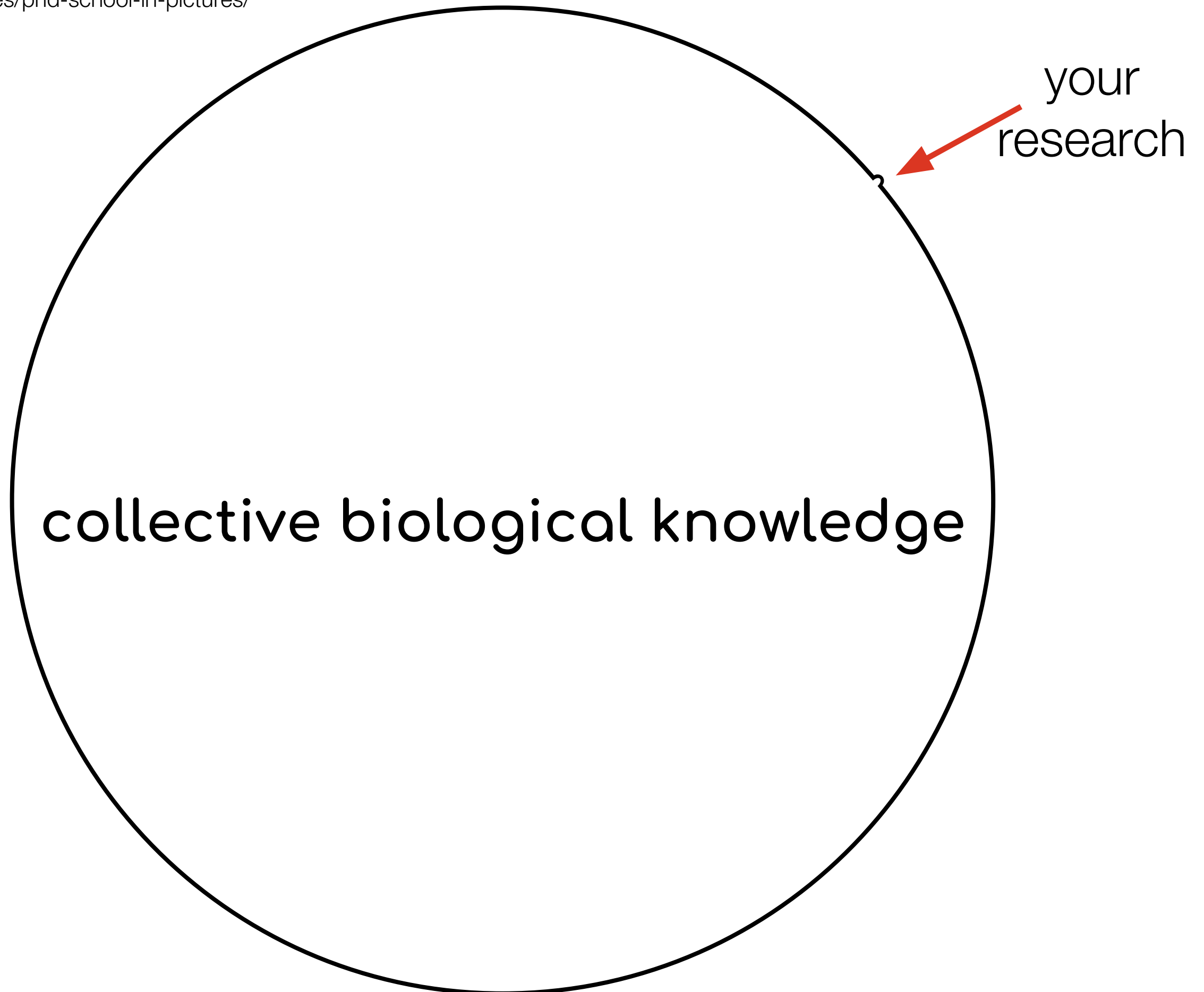
diversity

sexual reproduction

sex determination

sexual selection

resources



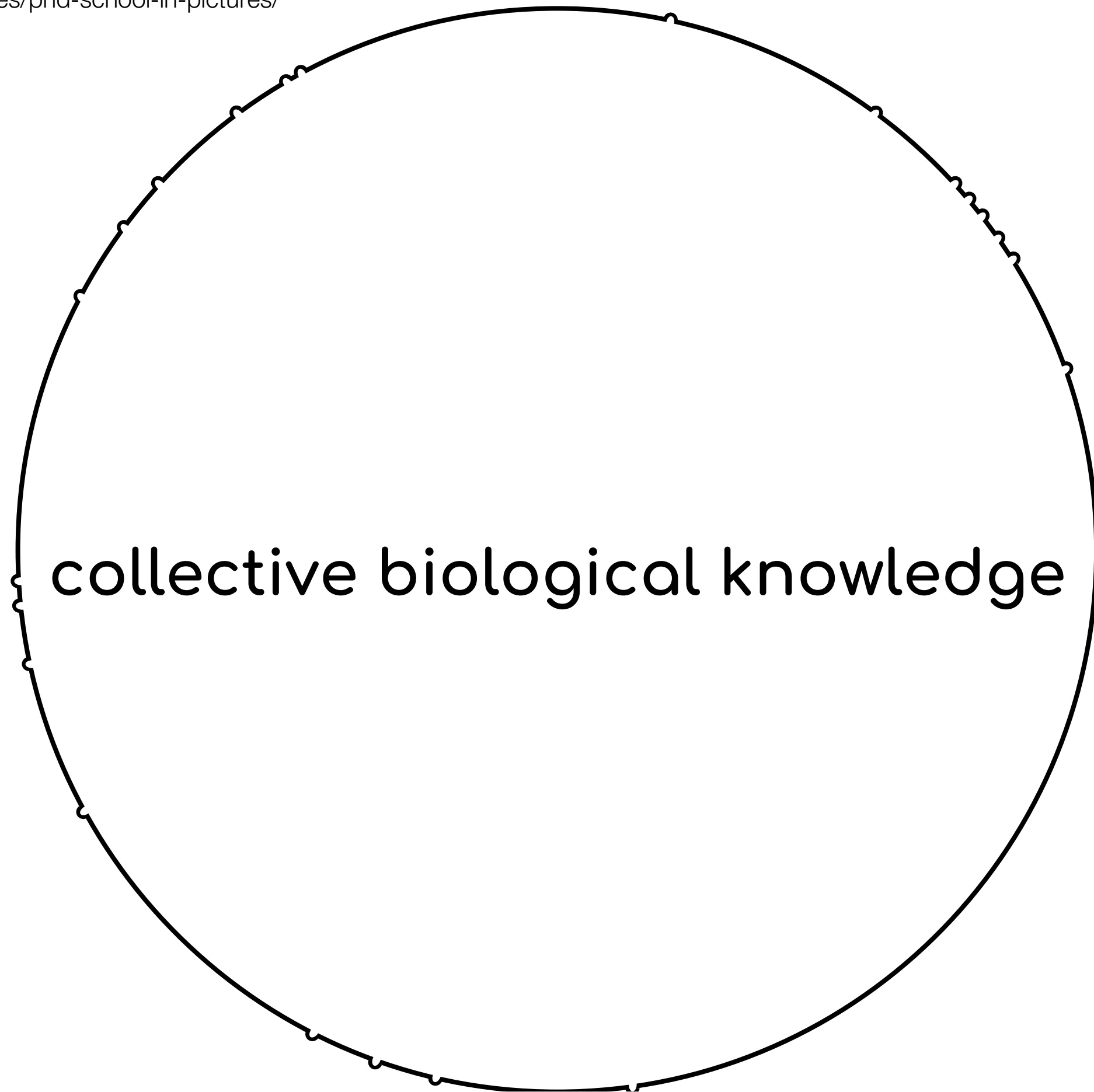
diversity

sexual reproduction

sex determination

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resources



diversity

sexual reproduction

sex determination

sexual selection

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diversity

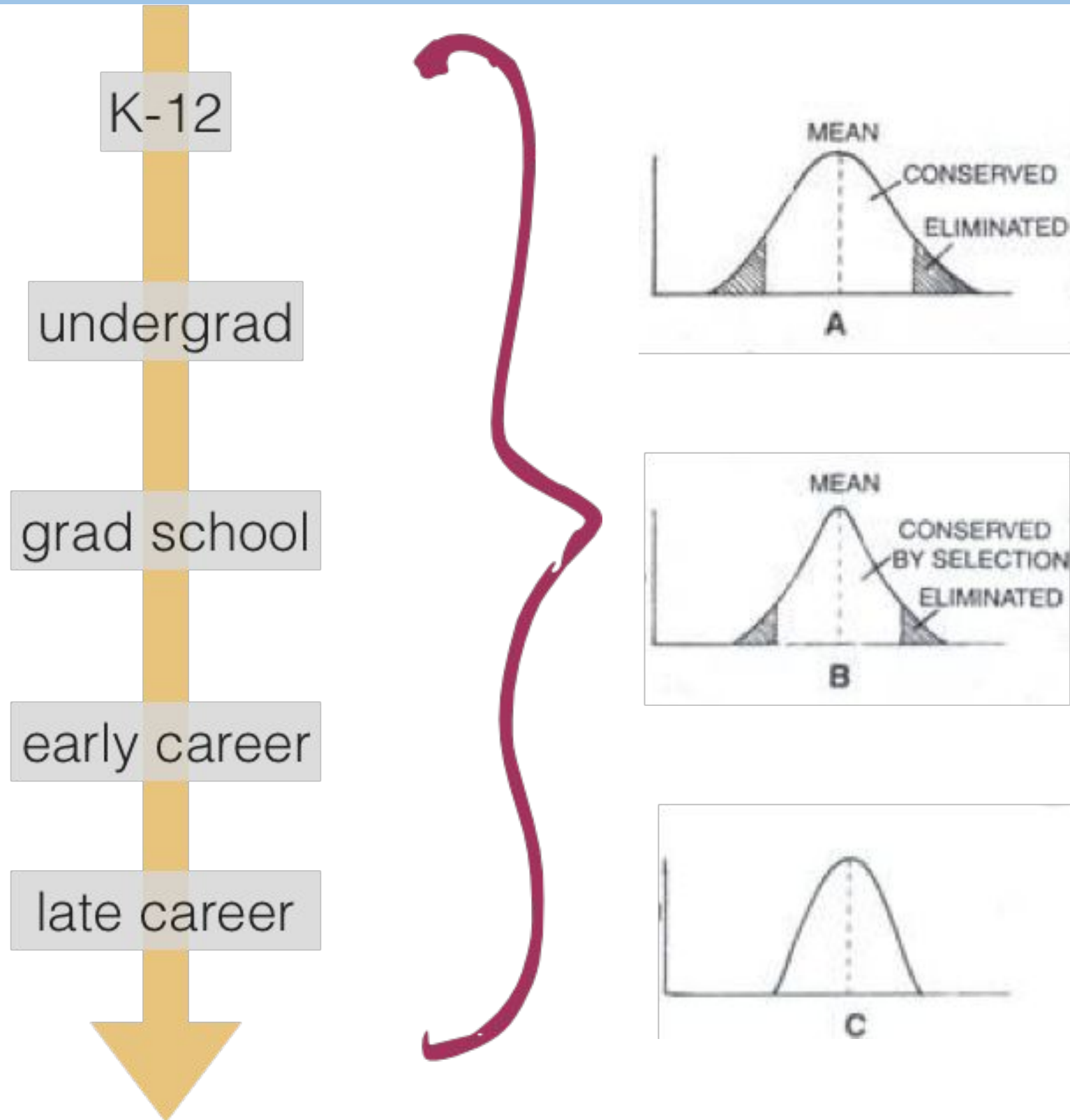
sexual reproduction

sex determination

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resources

why make biology inclusive?



diversity

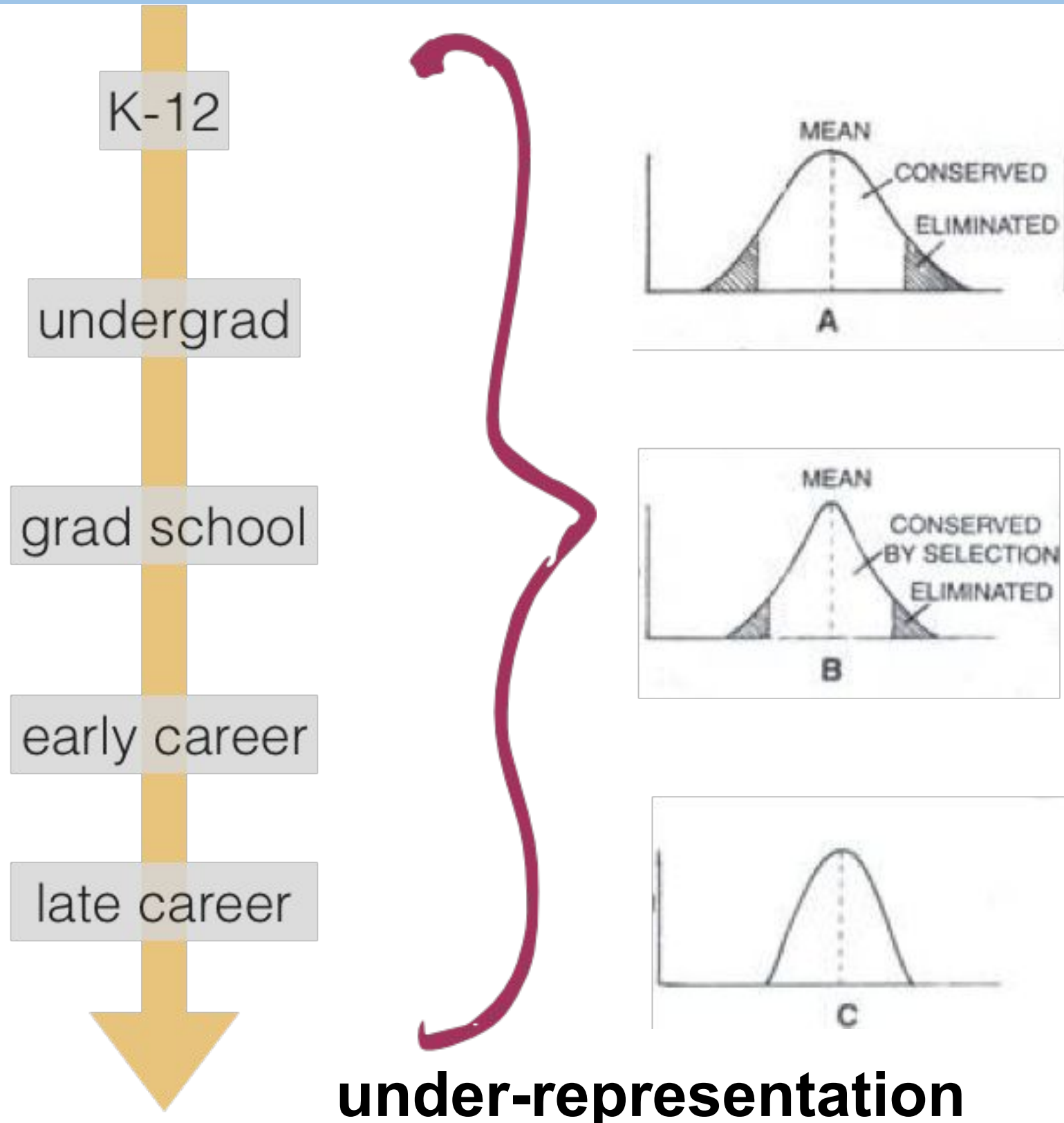
sexual reproduction

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why make biology inclusive?



diversity

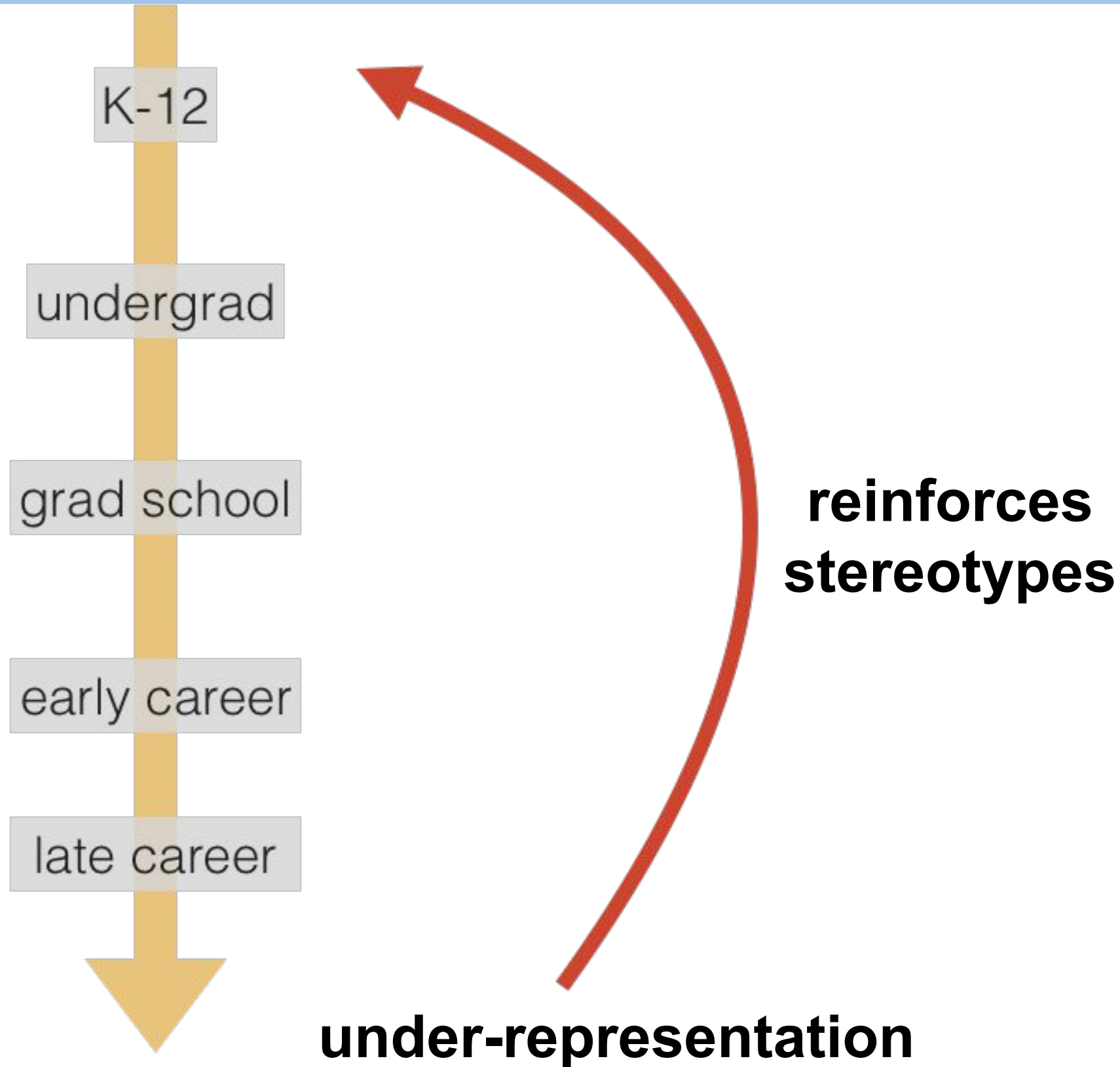
sexual reproduction

sex determination

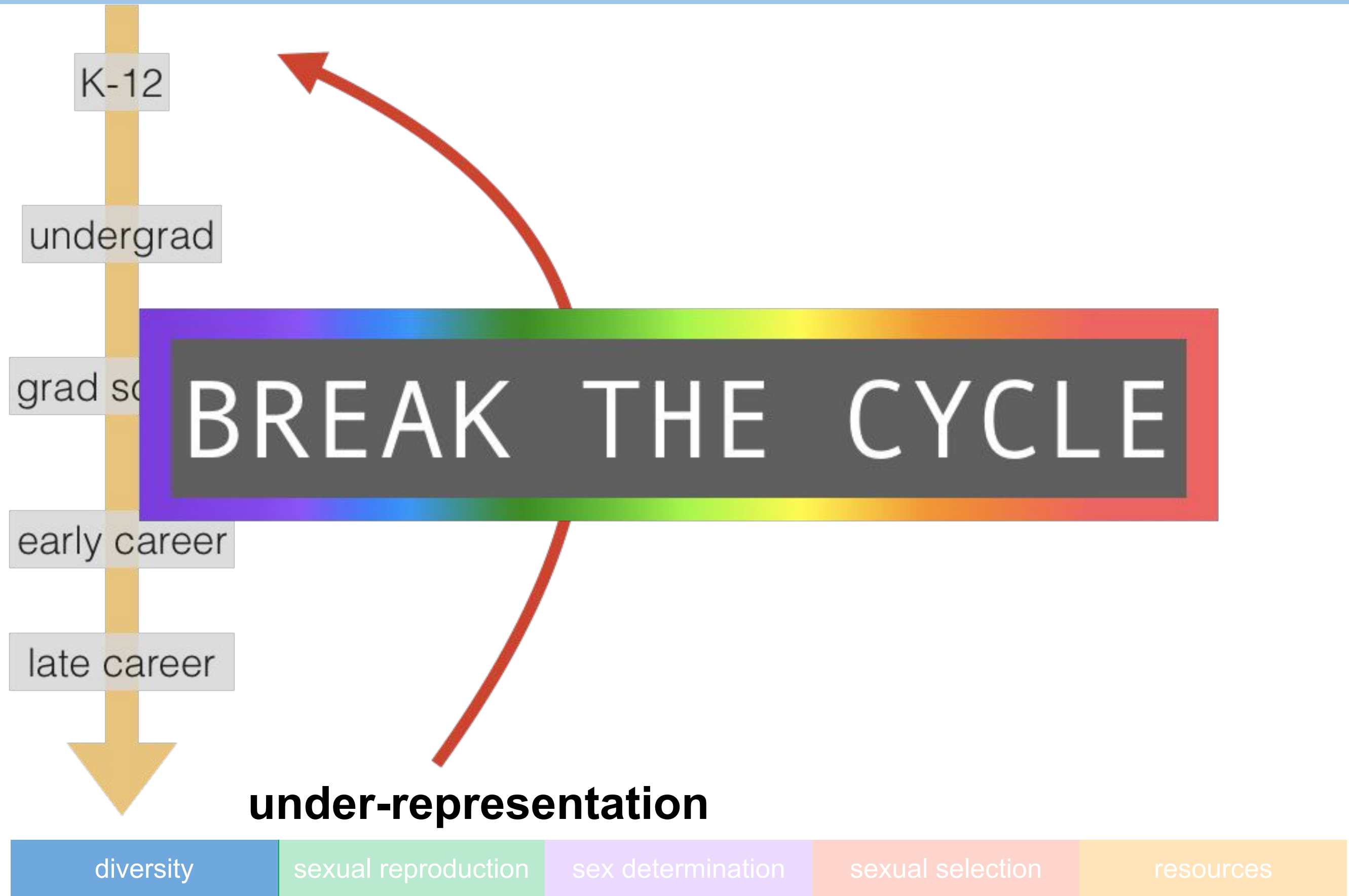
sexual selection

resources

why make biology inclusive?



why make biology inclusive?



identity:

diversity

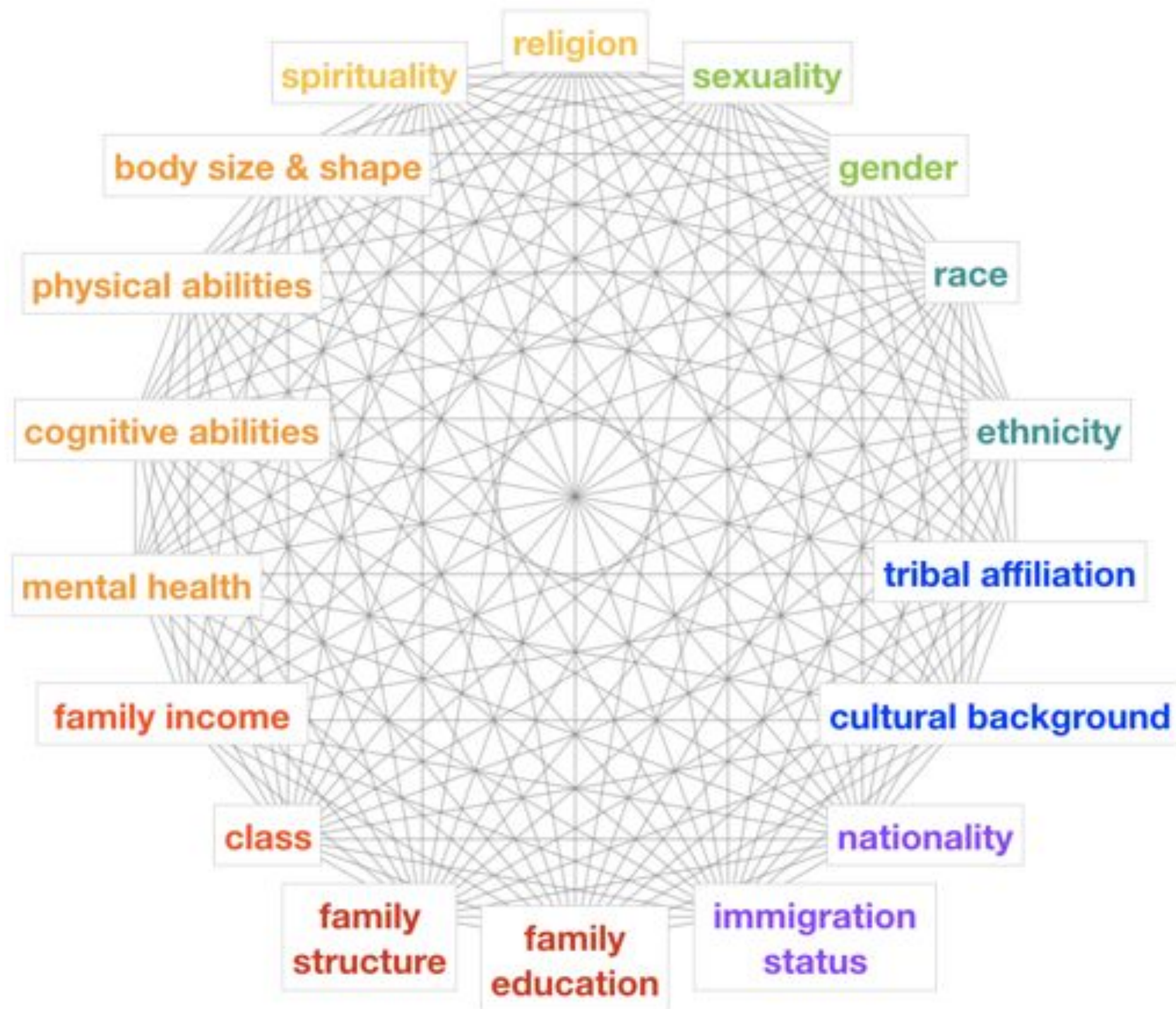
sexual reproduction

sex determination

sexual selection

resources

identity: an N-dimensional hypervolume



diversity

sexual reproduction

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why make biology inclusive?

forgive yourself

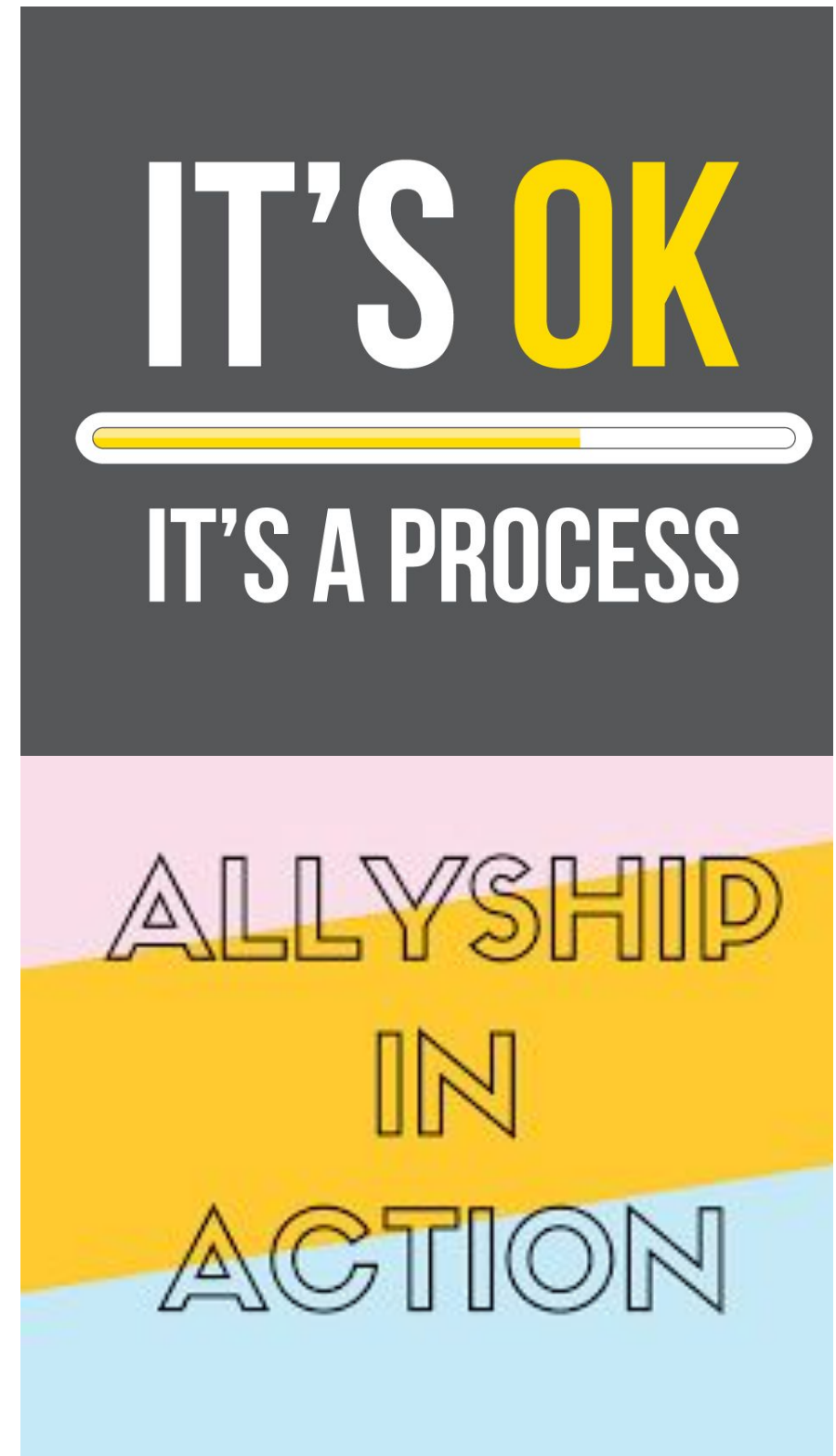
- we've all blundered
- we're all here to improve

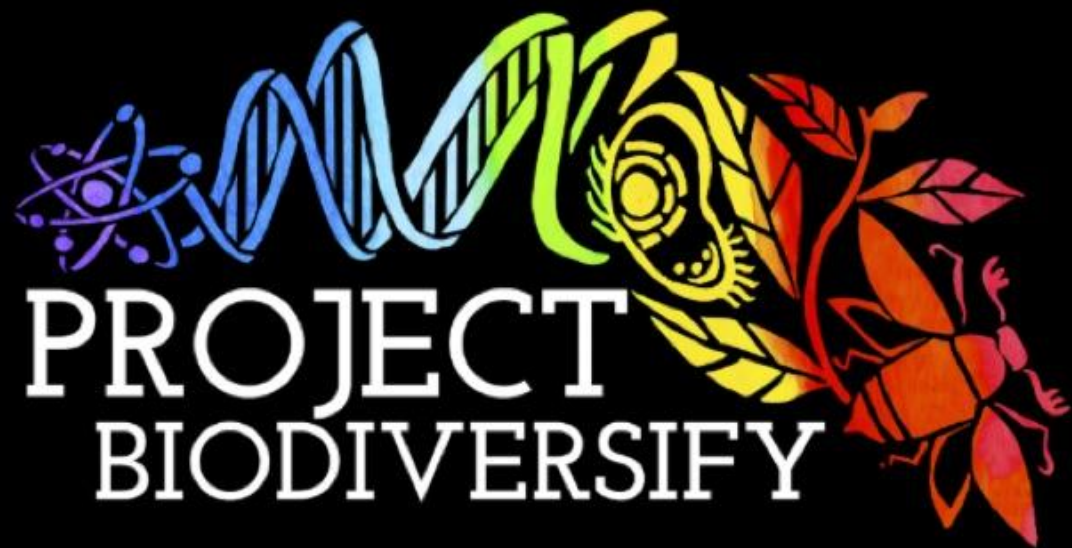


why make biology inclusive?

forgive yourself

- we've all blundered
- we're all here to improve
- start small and build
- biology & inclusivity = dynamic
- do your best





PROJECT BIODIVERSIFY

Tools for promoting **diversity** & **inclusivity**
in biology classrooms



Dr. Marjorie Weber

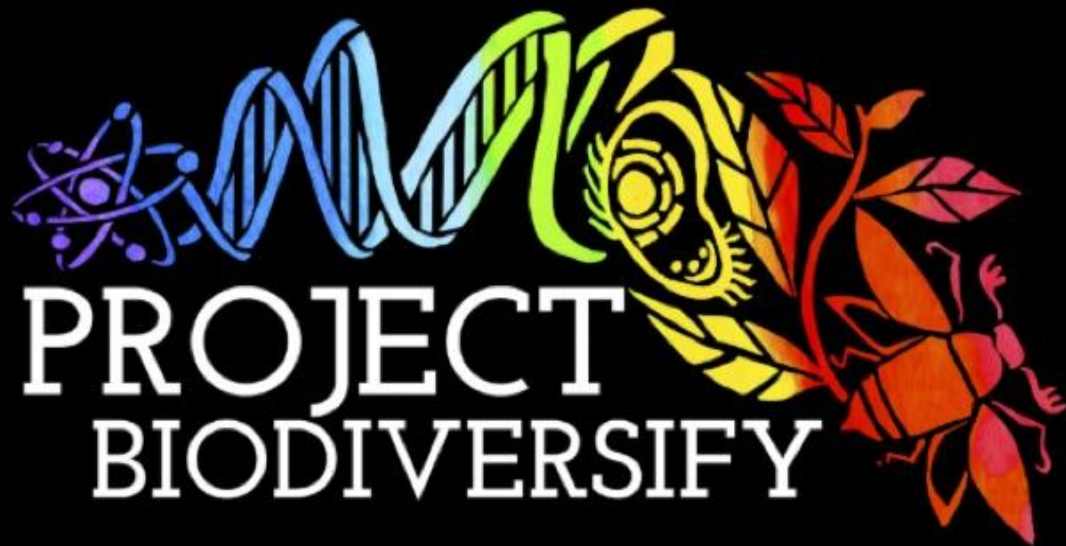
[diversity](#)

[sexual reproduction](#)

[sex determination](#)

[sexual selection](#)

[resources](#)



Tools for promoting **diversity** & **inclusivity**
in biology classrooms

Home

Project Biodiversify is a repository of teaching materials and methods aimed at enhancing human diversity and inclusivity in biology courses.

People – including students and biologists – exhibit a diverse set of **backgrounds and identities**. However, most biology students are not exposed to a diversity of role models in the field of biology, and many students are taught about biology in a way that (often unintentionally) does not feel inclusive to them or their communities.

Project Biodiversify is here to help! We are an online space that promotes the humanization, diversification, and inclusivity of biology classrooms.

Are you a biologist?

[become a role model](#)

Are you an educator?

[access teaching tools](#)

Are you a student?

[explore role models](#)

[diversity](#)[sexual reproduction](#)[sex determination](#)[sexual selection](#)[resources](#)



Tools for promoting **diversity** & **inclusivity**
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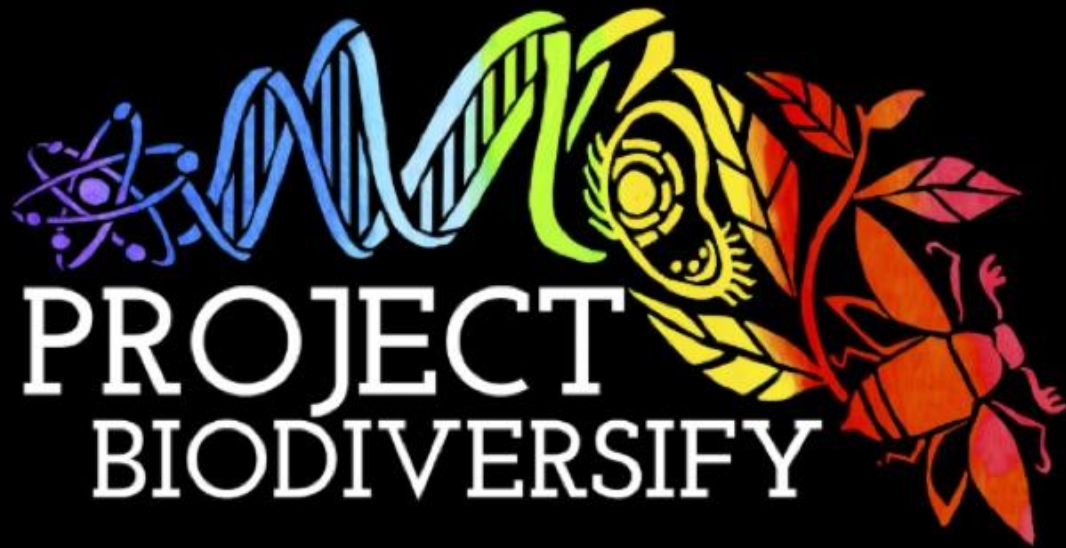
Are you an educator?

[access teaching tools](#)

Are you a student?

[explore role models](#)

[diversity](#)[sexual reproduction](#)[sex determination](#)[sexual selection](#)[resources](#)



Tools for promoting **diversity** & **inclusivity**
in biology classrooms

Here, we aim to show how we can be more **inclusive**, while also being more biologically **accurate** in how we teach biology.

Overview of our materials

In this section of our site, we include suggestions on how to:

- Integrate examples from primary literature done by biologists from diverse backgrounds (materials generated by Project Biodiversify)
- Suggestions on how to make the definitions you teach to be both up to date and maintain an inclusive classroom environment
- Resources to revitalize curricula for topics that are out of date and non-inclusive (e.g. topics related to sex and sexual systems)

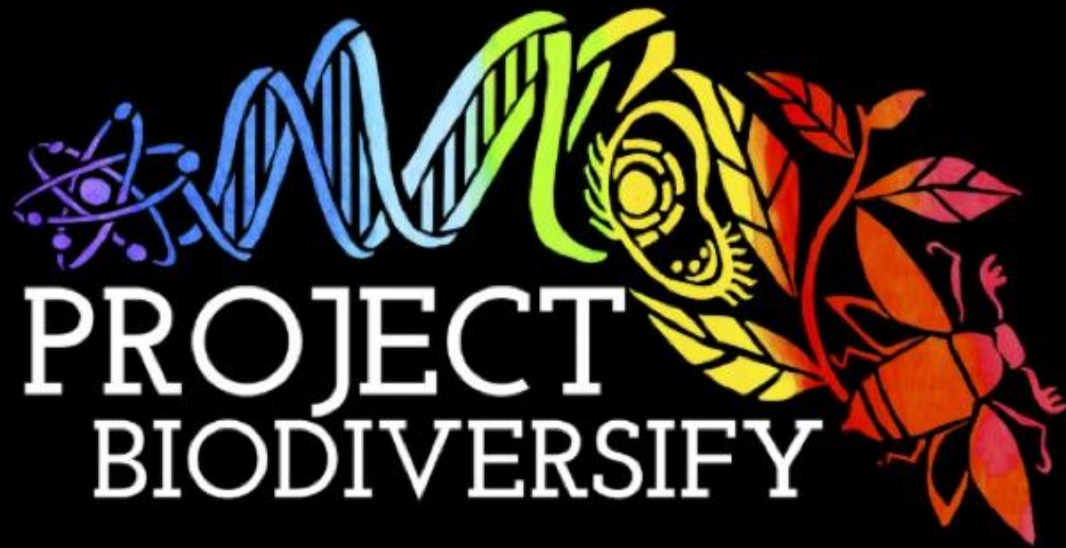
Benefits of an inclusive classroom

[coming soon]

Keeping up with the frontiers of biological research

[coming soon]

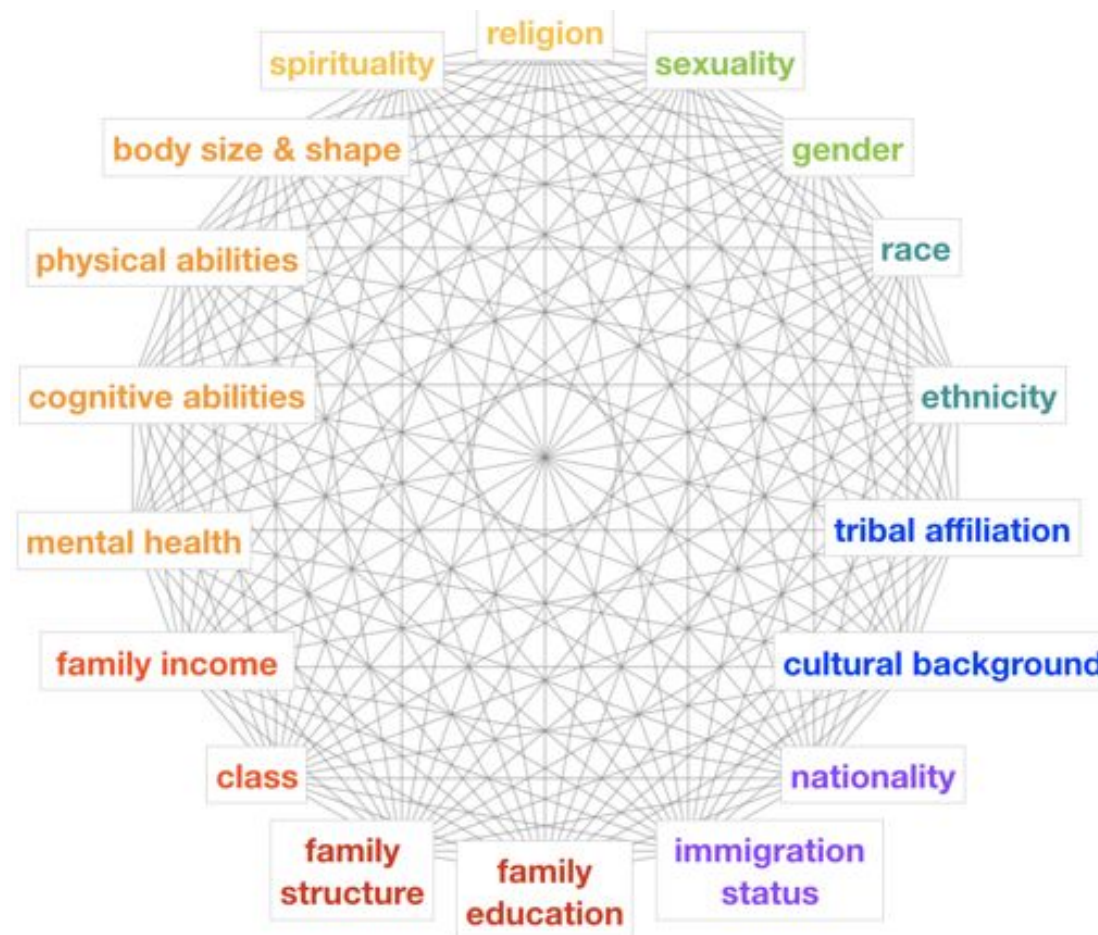
[diversity](#)[sexual reproduction](#)[sex determination](#)[sexual selection](#)[resources](#)



PROJECT BIODIVERSIFY

Tools for promoting **diversity** & **inclusivity**
in biology classrooms

We contain multitudes



[diversity](#)

[sexual reproduction](#)

[sex determination](#)

[sexual selection](#)

[resources](#)

Women & LGBTQIA+ inclusive

diversity

sexual reproduction

sex determination

sexual selection

resources

Women & LGBTQIA+ inclusive

**L
G
B
T
Q
I
A
+**

diversity

sexual reproduction

sex determination

sexual selection

resources

Women & LGBTQIA+ inclusive

Lesbian

Gay

Bisexual

Transgender

Queer

Intersex

Asexual

+ don't fit into those boxes or haven't yet found their voice

Women & LGBTQIA+ inclusive

Good for biological innovation

diversity

sexual reproduction

sex determination

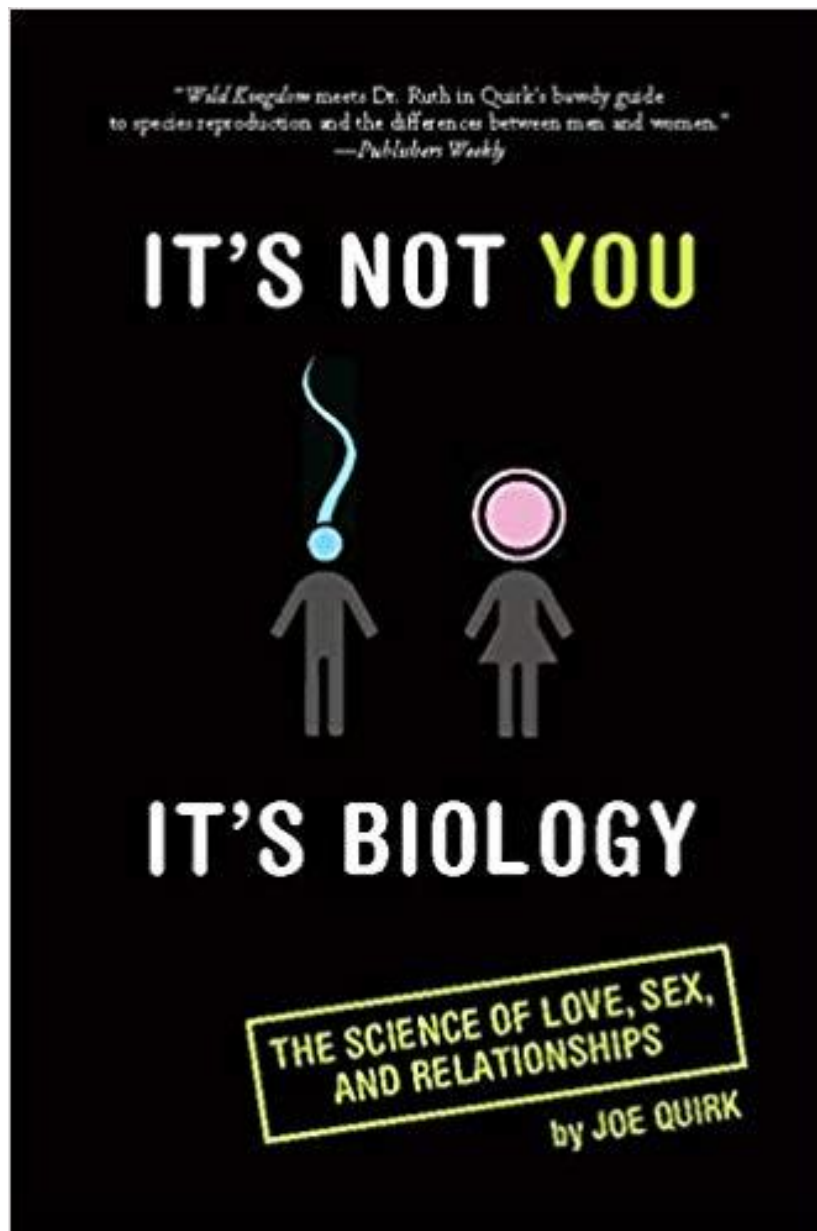
sexual selection

resources

Women & LGBTQIA+ inclusive

Good for biological innovation

Good for equity of women & the LGBTQIA+ community



ODISHA
SUN TIMES

Cops arrest newlywed youth for 'unnatural sex' with trans in Odisha

By Odisha Sun Times Bureau - May 12, 2018 0

diversity

sexual reproduction

sex determination

sexual selection

resources

Women & LGBTQIA+ inclusive

Good for biological innovation

Good for equity of women & the LGBTQIA+ community

Reach a large audience

•majors

→ future researchers

→ future healthcare providers

Gender Issues

How transphobia and ignorance of doctors drove a Kerala trans man to suicide



DOWNTOWN, SOUTH LOOP & RIVER NORTH Health & Wellness

Forced Into Genital Surgery As Babies, Intersex Adults Fight Back



diversity

sexual reproduction

sex determination

sexual selection

resources

Women & LGBTQIA+ inclusive

Good for biological innovation

Good for equity of women & the LGBTQIA+ community

Reach a large audience

- **majors**

- future researchers
- future healthcare providers

- **non-majors**

- community members
 - trust science
 - future funding

Women & LGBTQIA+ inclusive

**limited view
of sex in biology**

diversity

sexual reproduction

sex determination

sexual selection

resources

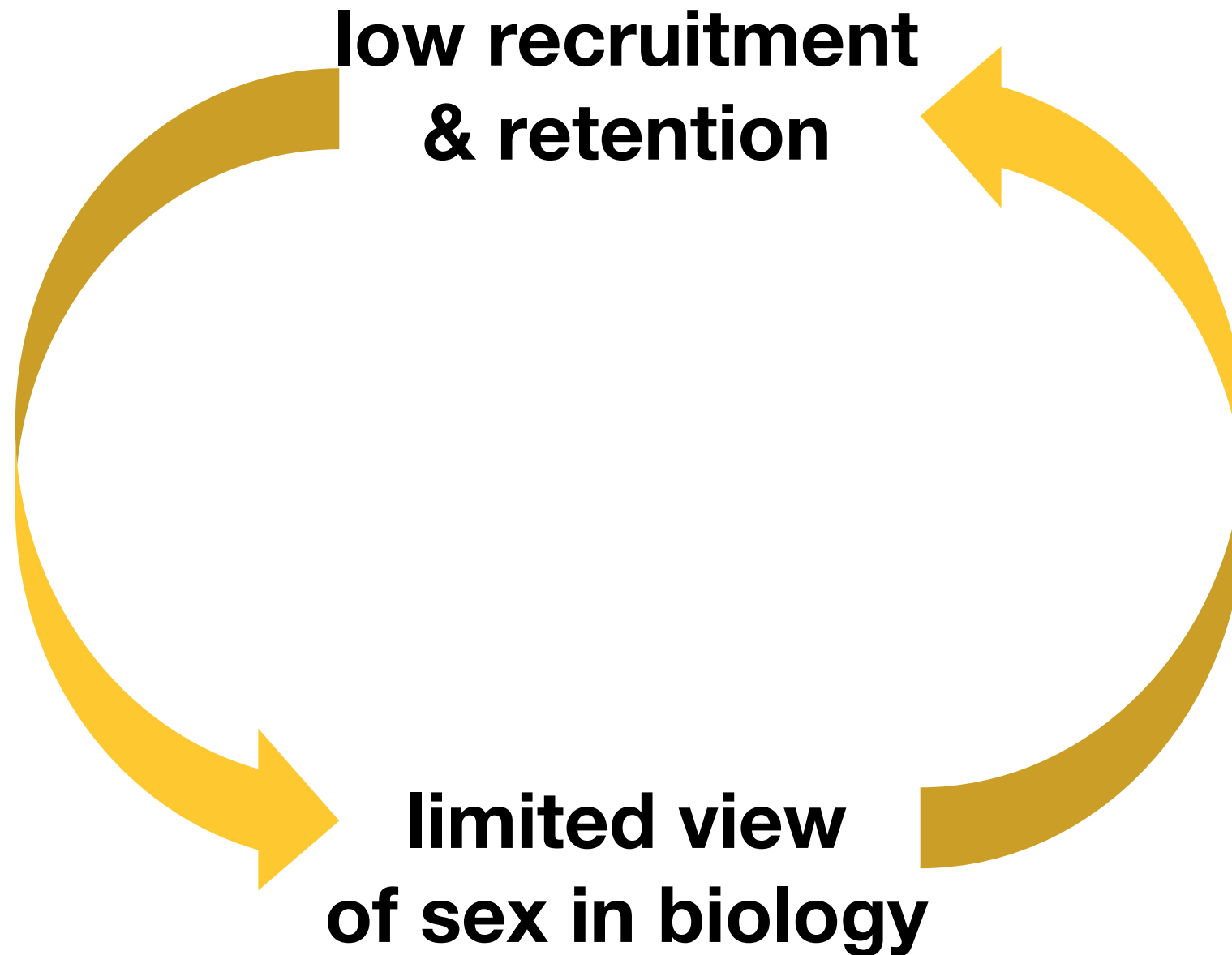
Women & LGBTQIA+ inclusive

**low recruitment
& retention**

**limited view
of sex in biology**



Women & LGBTQIA+ inclusive



diversity

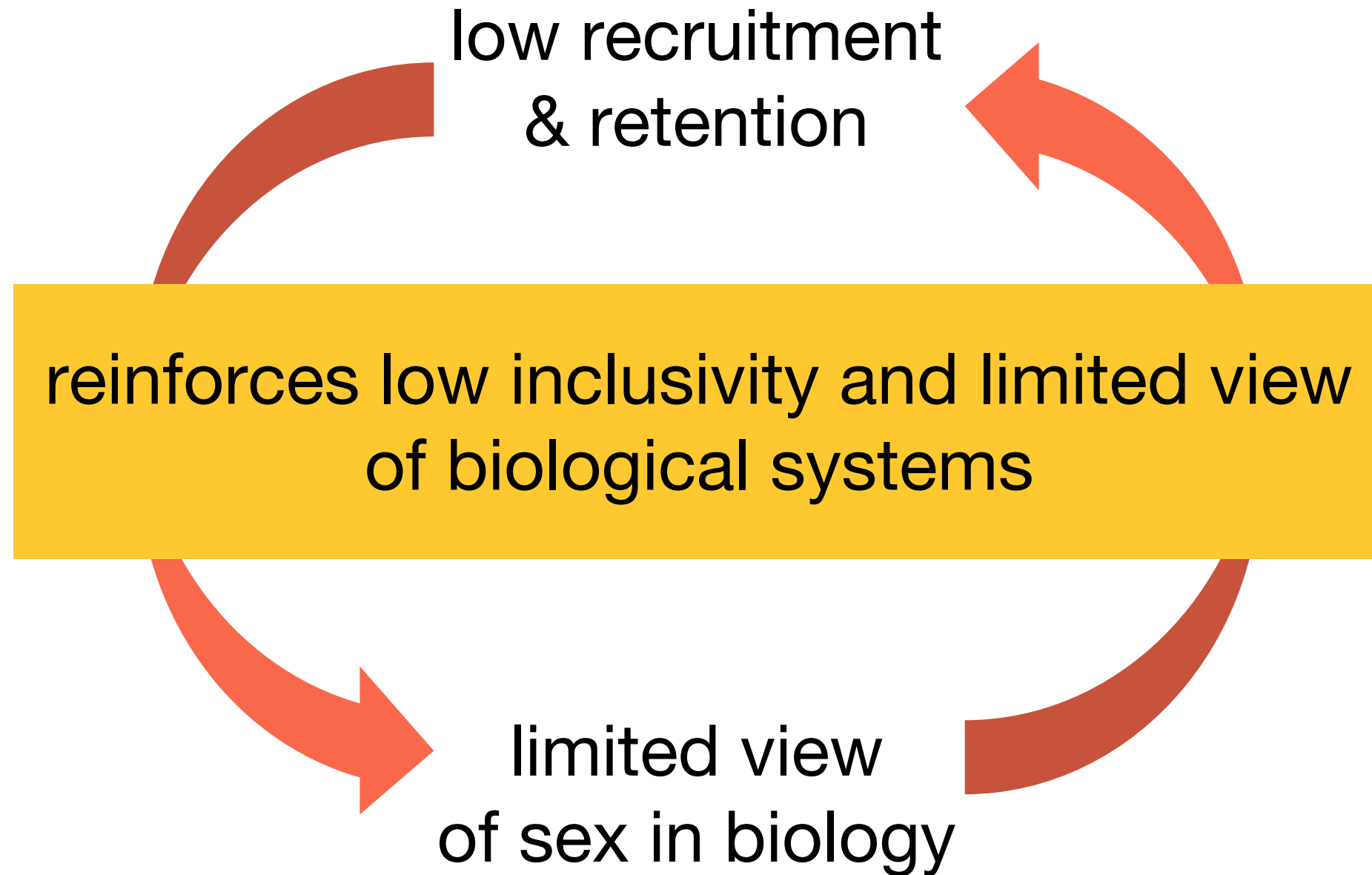
sexual reproduction

sex determination

sexual selection

resources

Women & LGBTQIA+ inclusive



diversity

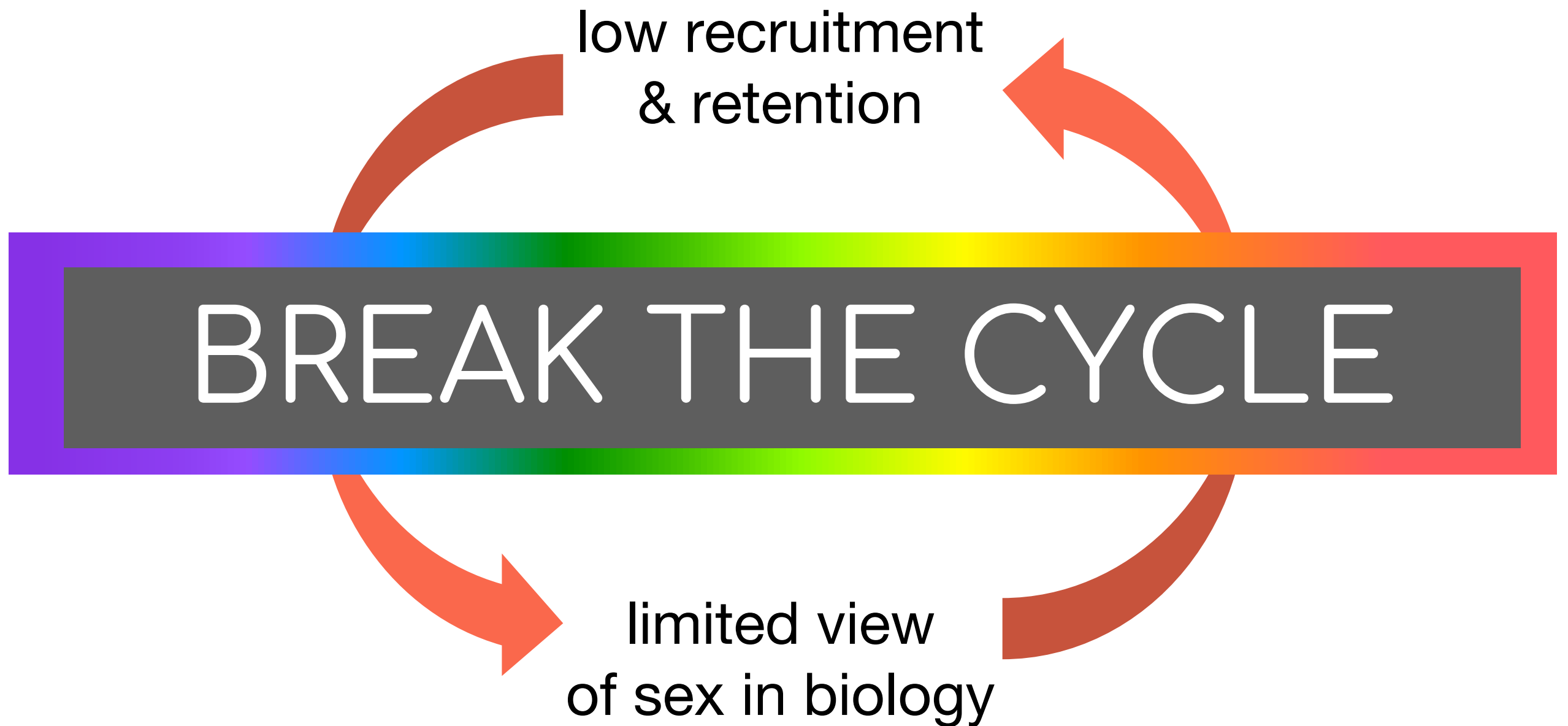
sexual reproduction

sex determination

sexual selection

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Women & LGBTQIA+ inclusive



diversity

sexual reproduction

sex determination

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Women & LGBTQIA+ inclusive



diversity

sexual reproduction

sex determination

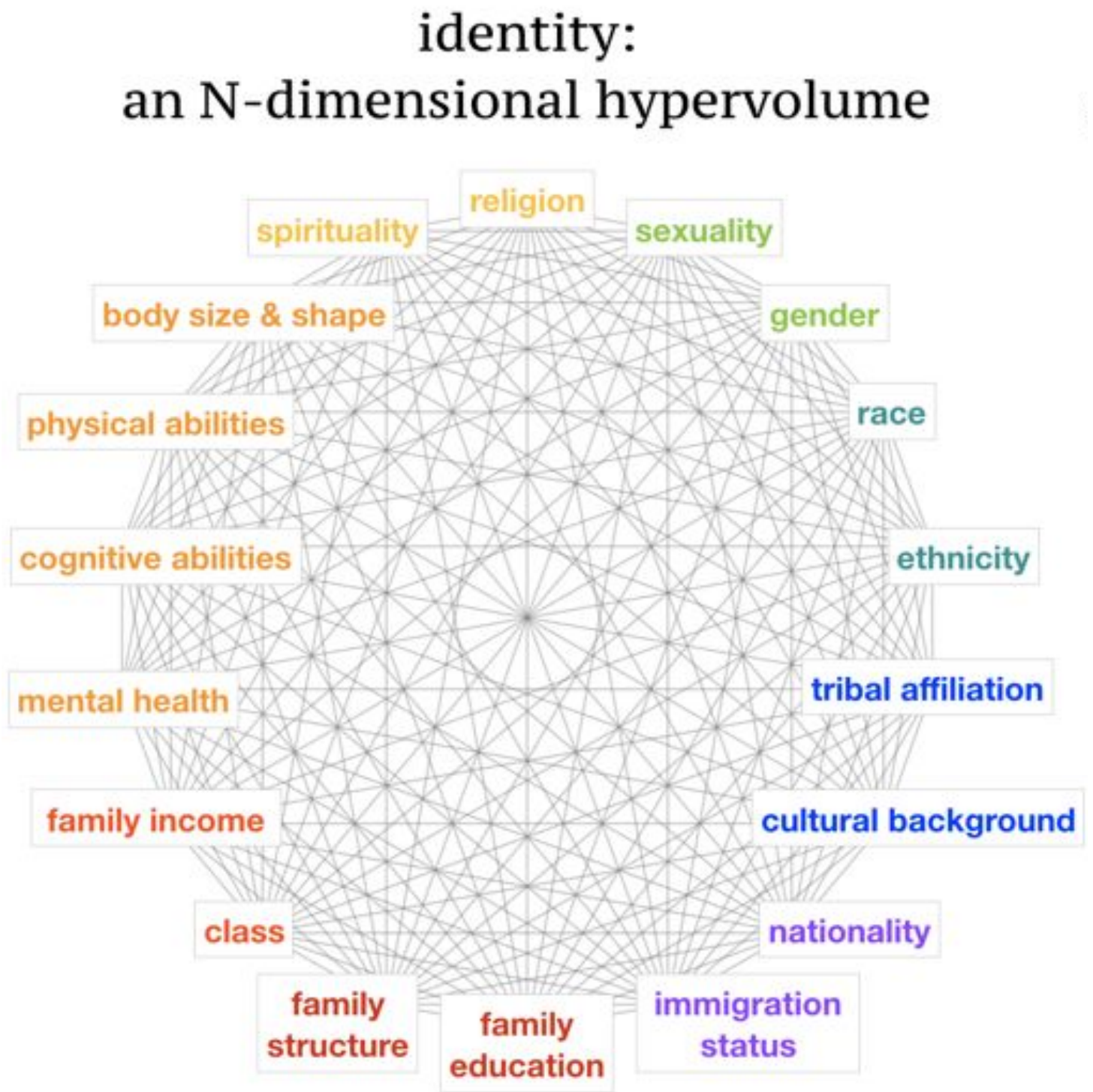
sexual selection

resources

workshop goals &
takeaways

workshop goals

Testing ground
to improve teaching of sex
and gender-related topics

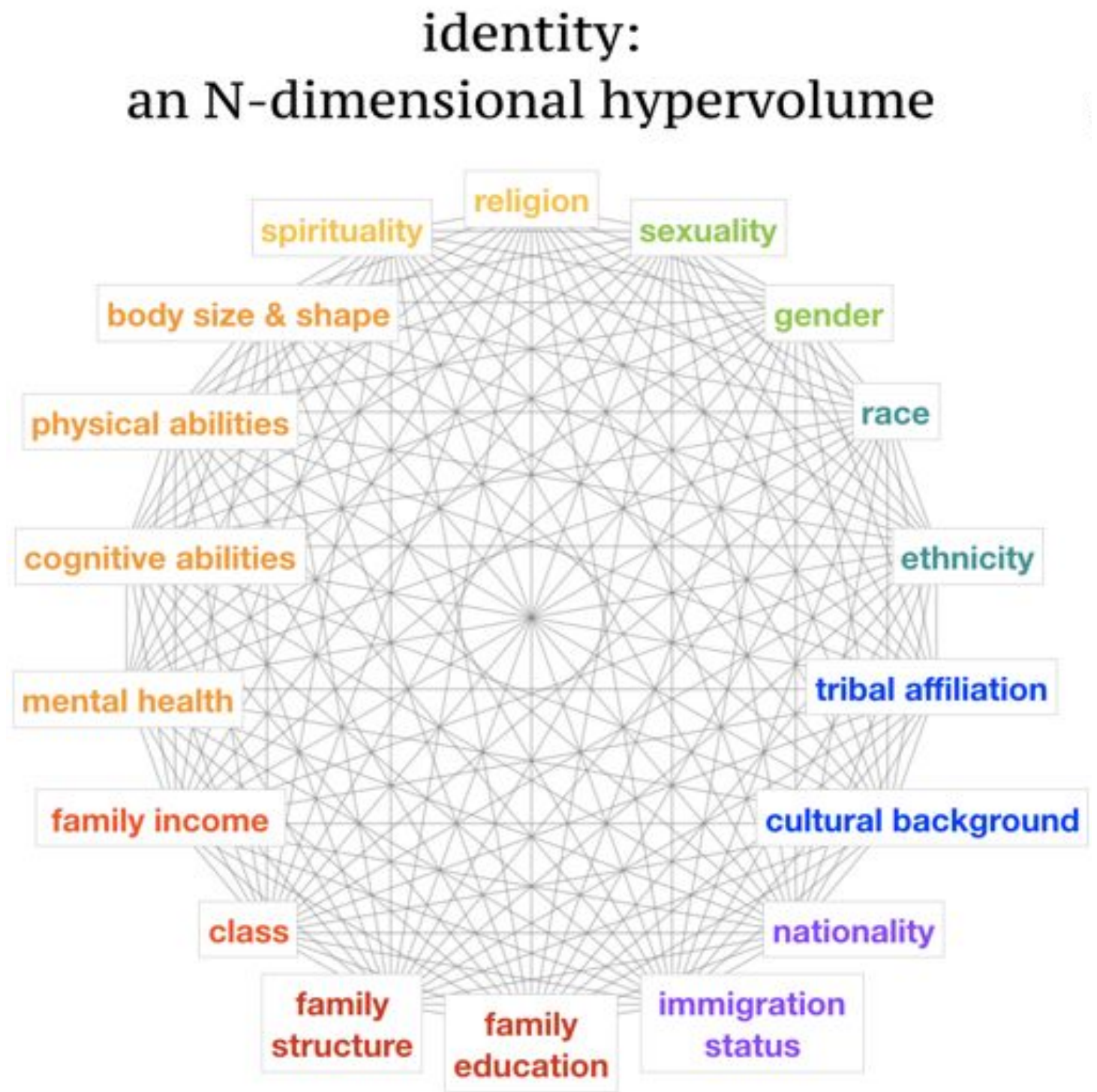


workshop goals

Testing ground
to improve teaching of sex
and gender-related topics

Examples:

- Sexual reproduction
- Sex determination
- Sexual selection



workshop goals

Testing ground
to improve teaching of sex
and gender-related topics

Examples:

- Sexual reproduction
- Sex determination
- Sexual selection



Journal
Singapore Journal of Education >
Volume 15, 1995 - Issue 2

Enter keywords, authors, DOI e

Original Articles

A Review of Some Sources of Students' Misconceptions in Biology

Kola Soyibo

Pages 1-11 | Published online: 02 Apr 2008

Download citation <https://doi.org/10.1080/02188799508548576>

diversity

sexual reproduction

sex determination

sexual selection

resources

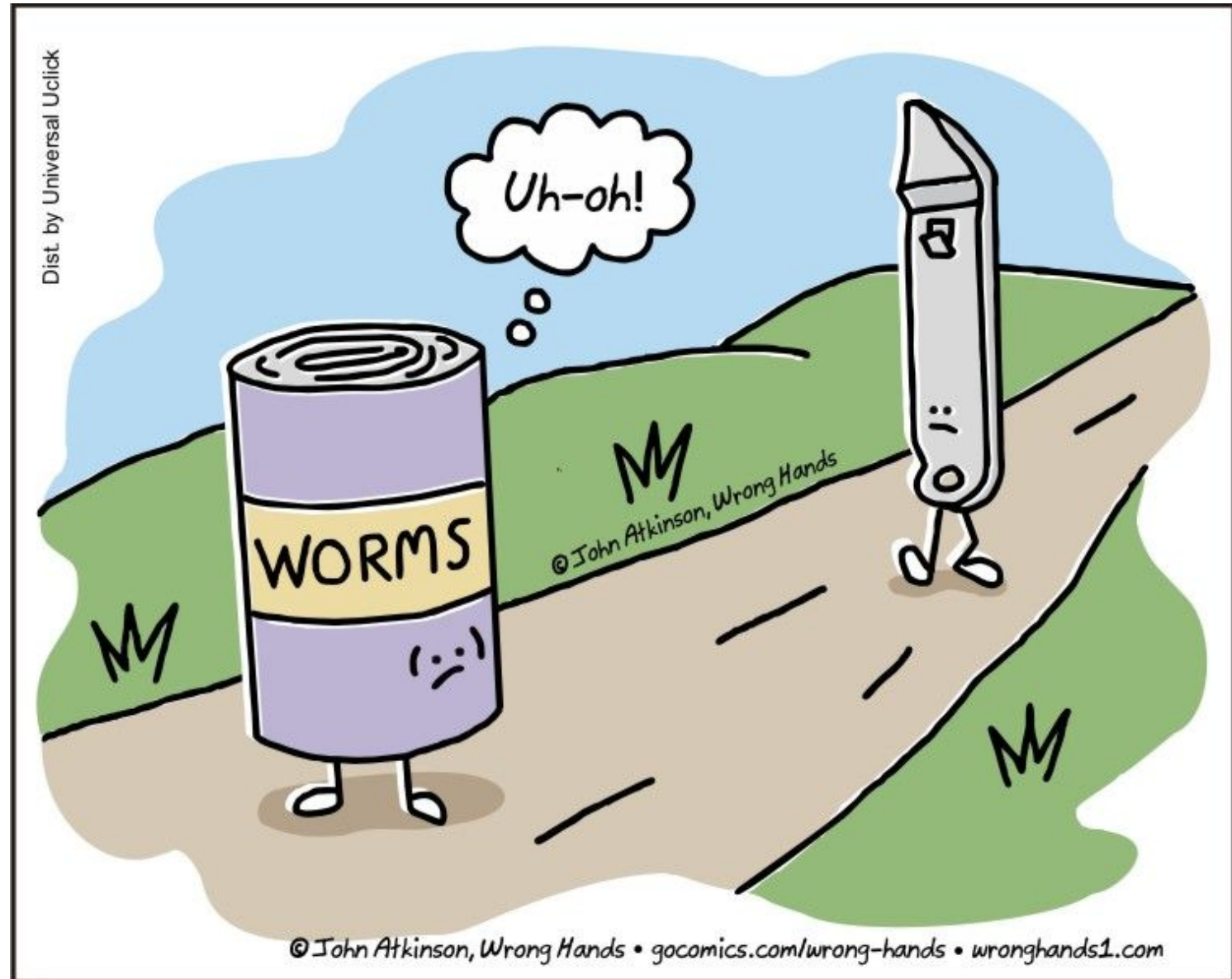
workshop goals

Testing ground

to improve teaching of sex and gender-related topics

Examples:

- Sexual reproduction
- Sex determination
- Sexual selection



takeaways

In fact, it is practically impossible to avoid these common issues:

- **Oversimplification**
 - false binaries/black & white thinking
- **Overgeneralization**
 - focusing on patterns and erasing diversity
 - human- and mammal-centric
 - outside average or the general biological rule → “**weird/other**”



takeaways

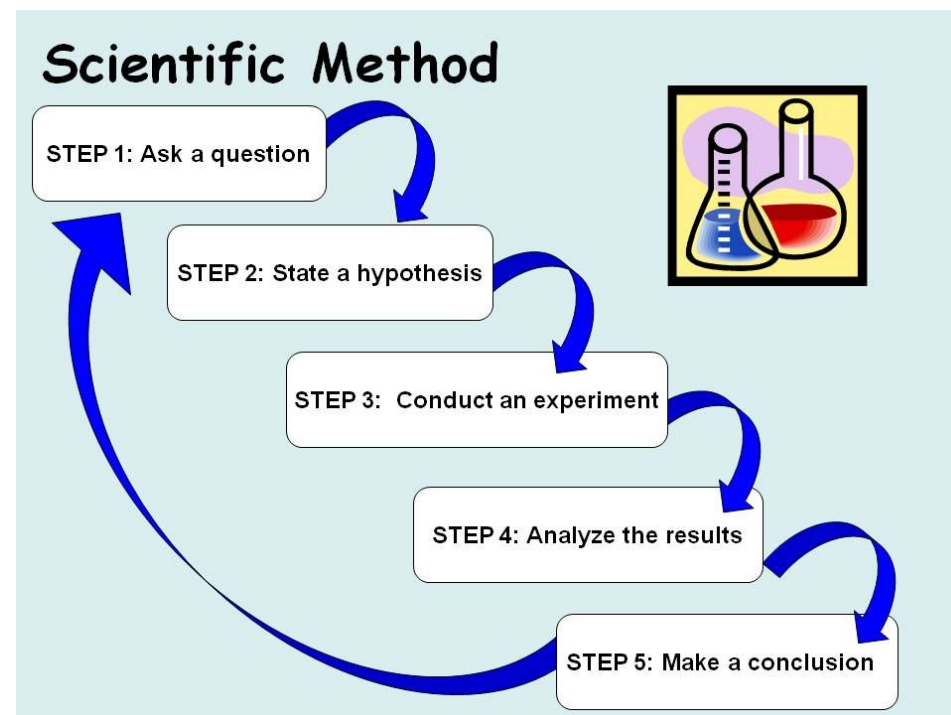
How can we minimize this?

1. Present or explore diversity first

takeaways

How can we minimize this?

1. Present or explore diversity first
2. Don't hide the iterative process. Model it!



takeaways

How can we minimize this?

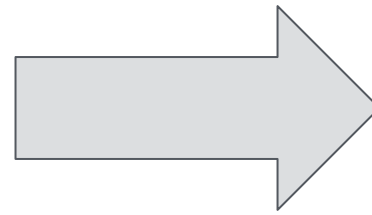
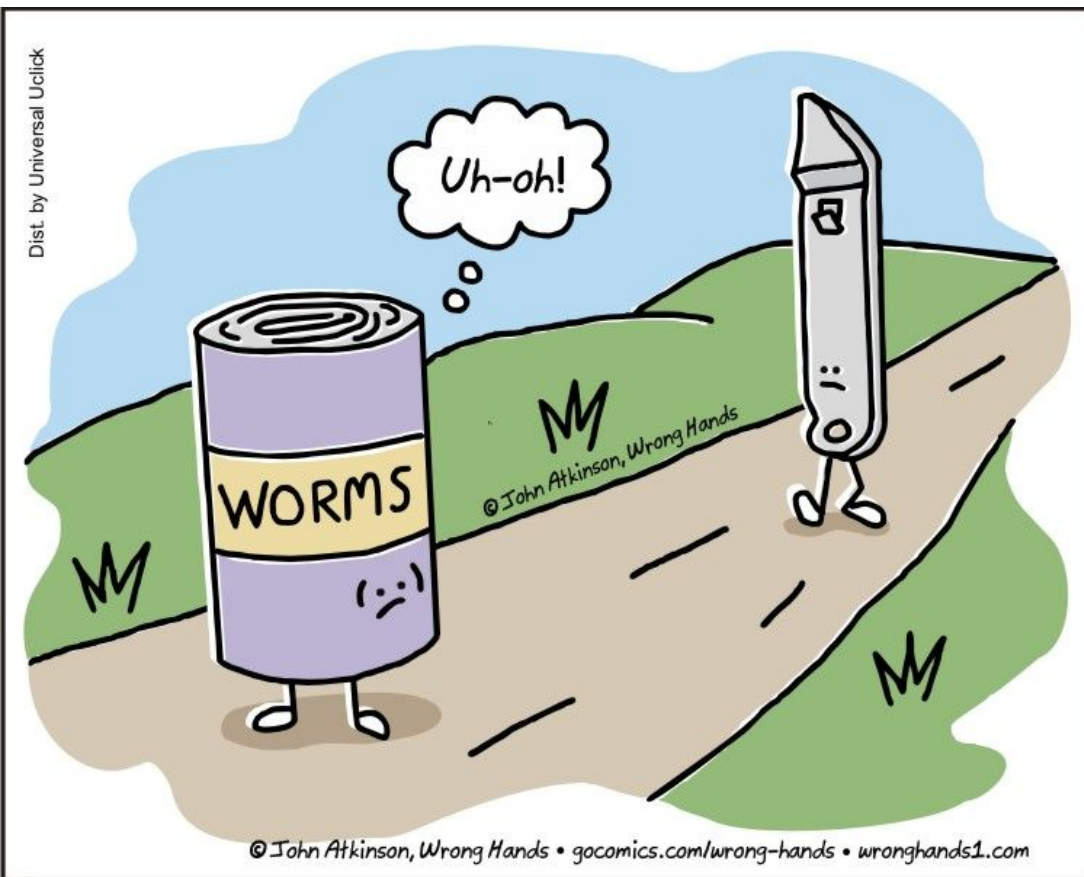
1. Present or explore diversity first
2. Don't hide the iterative process. Model it!
3. Update your definitions/language

takeaways

How can we minimize this?

1. Present or explore diversity first
2. Don't hide the iterative process. Model it!
3. Update your definitions/language
4. Contextualize: biological, historical/social

inclusive, accurate, effective



diversity

sexual reproduction

sex determination

sexual selection

resources

inclusive, accurate, effective

Teaching the Biology of Gender, Sex, and Sexuality Leads to a Marked Increase in Acceptance of the Theory of Evolution by Natural Selection

Nathan H. Lents*

Marginalization of Socioscientific Material in Science–Technology–Society Science Curricula: Some Implications for Gender Inclusivity and Curriculum Reform

Gwyneth Hughes

diversity

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Marginalization of Socioscientific Material in Science–Technology–Society Science Curricula: Some Implications for Gender Inclusivity and Curriculum Reform

Misconceptions as a trigger for enhancing student learning in higher education



Document Type

Book

Citations

Verkade, H; Mulhern, TD; Lodge, J; Elliott, K; Cropper, S; Rubinstein, B; Horton, A;

diversity

sexual reproduction

sex determination

sexual selection

activity

inclusive, accurate, effective



[Science & Education](#)

January 2013, Volume 22, [Issue 1](#), pp 119–142 | [Cite as](#)

The Strategies of Modeling in Biology Education

Authors

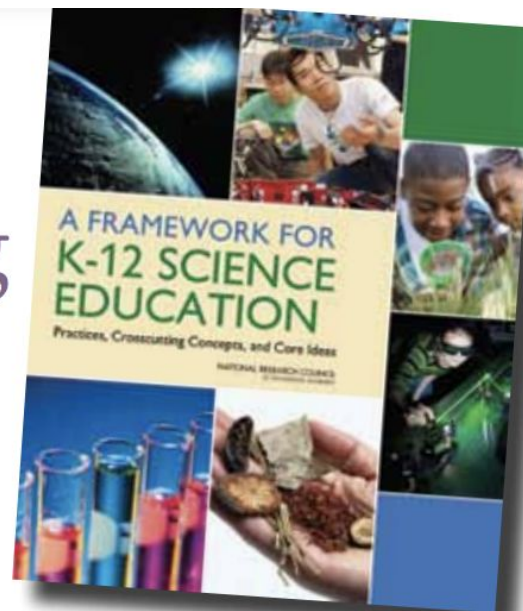
[Authors and affiliations](#)

Julia Svoboda , Cynthia Passmore

Engaging Students in
Scientific Practices:
What does constructing
and revising models
look like in the science
classroom?

*Understanding A Framework for K–12
Science Education*

By Joseph Krajcik and Joi Merritt



diversity

sexual reproduction

sex determination

sexual selection

activity

inclusive, accurate, effective



[Science & Education](#)

September 2014, Volume 23, [Issue 9](#), pp 1879–1909 | [Cite as](#)

Changes Observed in Views of Nature of Science During a Historically Based Unit

Authors

[Authors and affiliations](#)

David Wýss Rudge , David Paul Cassidy, Janice Marie Fulford, Eric Michael Howe

Using the history of science to promote students' problem-solving ability

Huann-Shyang Lin, Jui-Ying Hung & Su-Chu Hung

Pages 453-464 | Published online: 26 Nov 2010

diversity

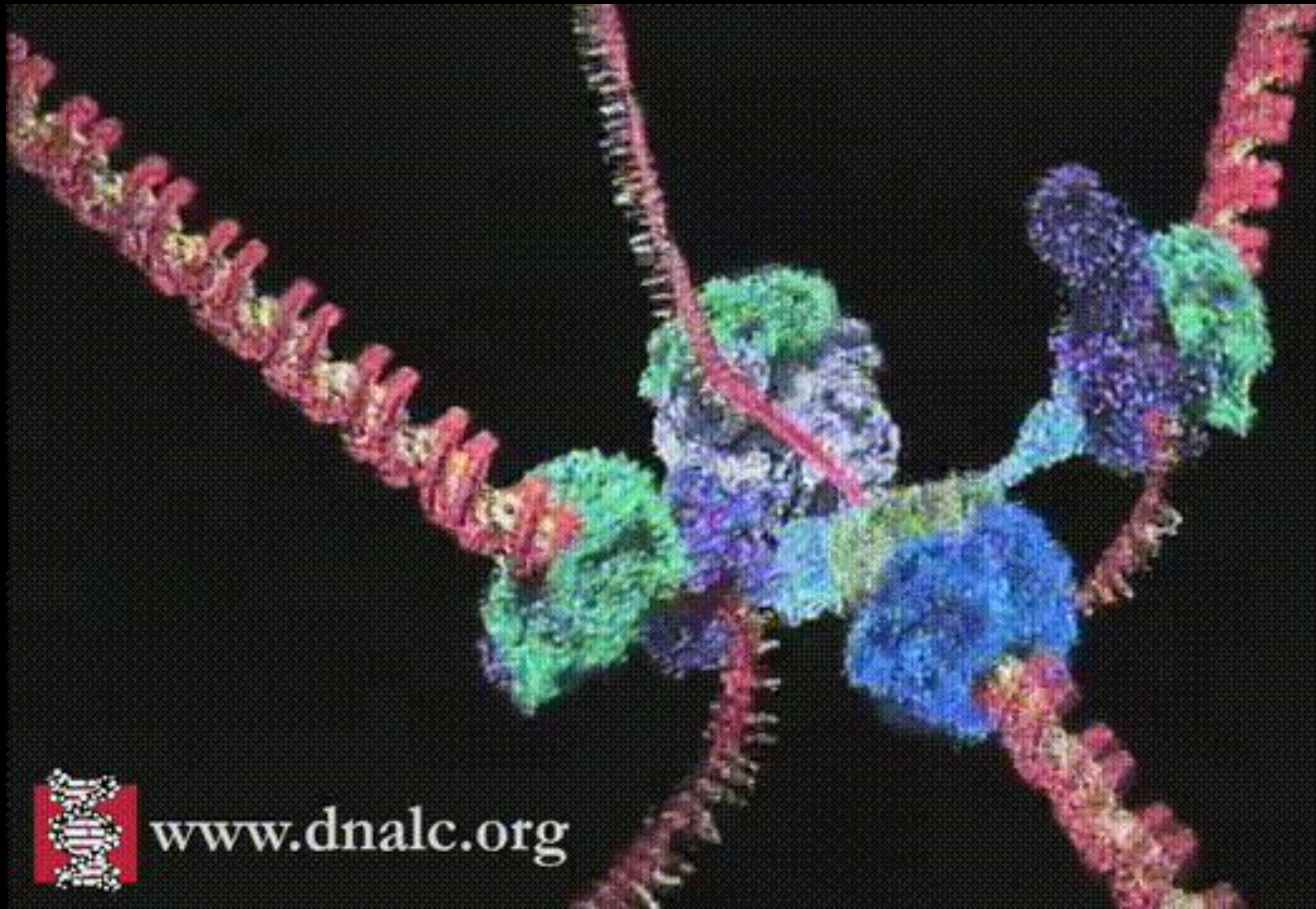
sexual reproduction

sex determination

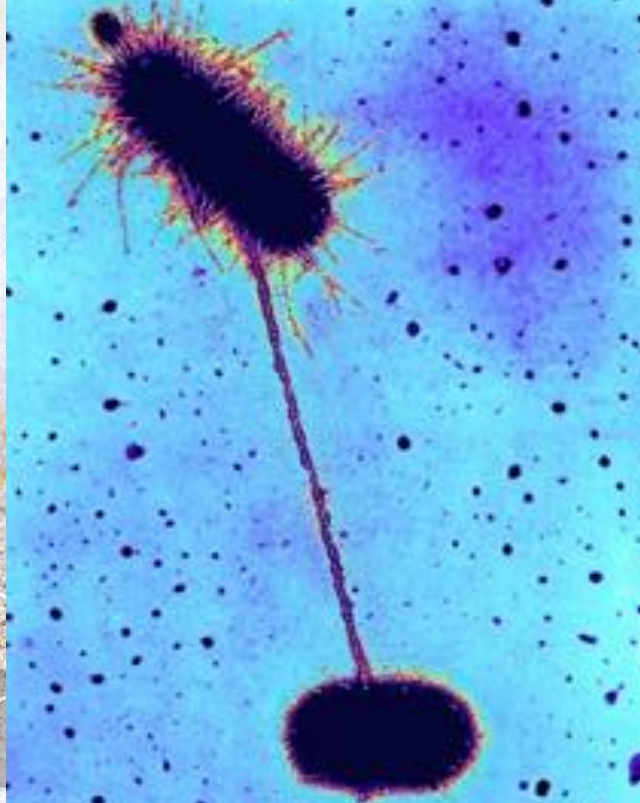
sexual selection

resources

sexual reproduction



www.dnalc.org



diversity

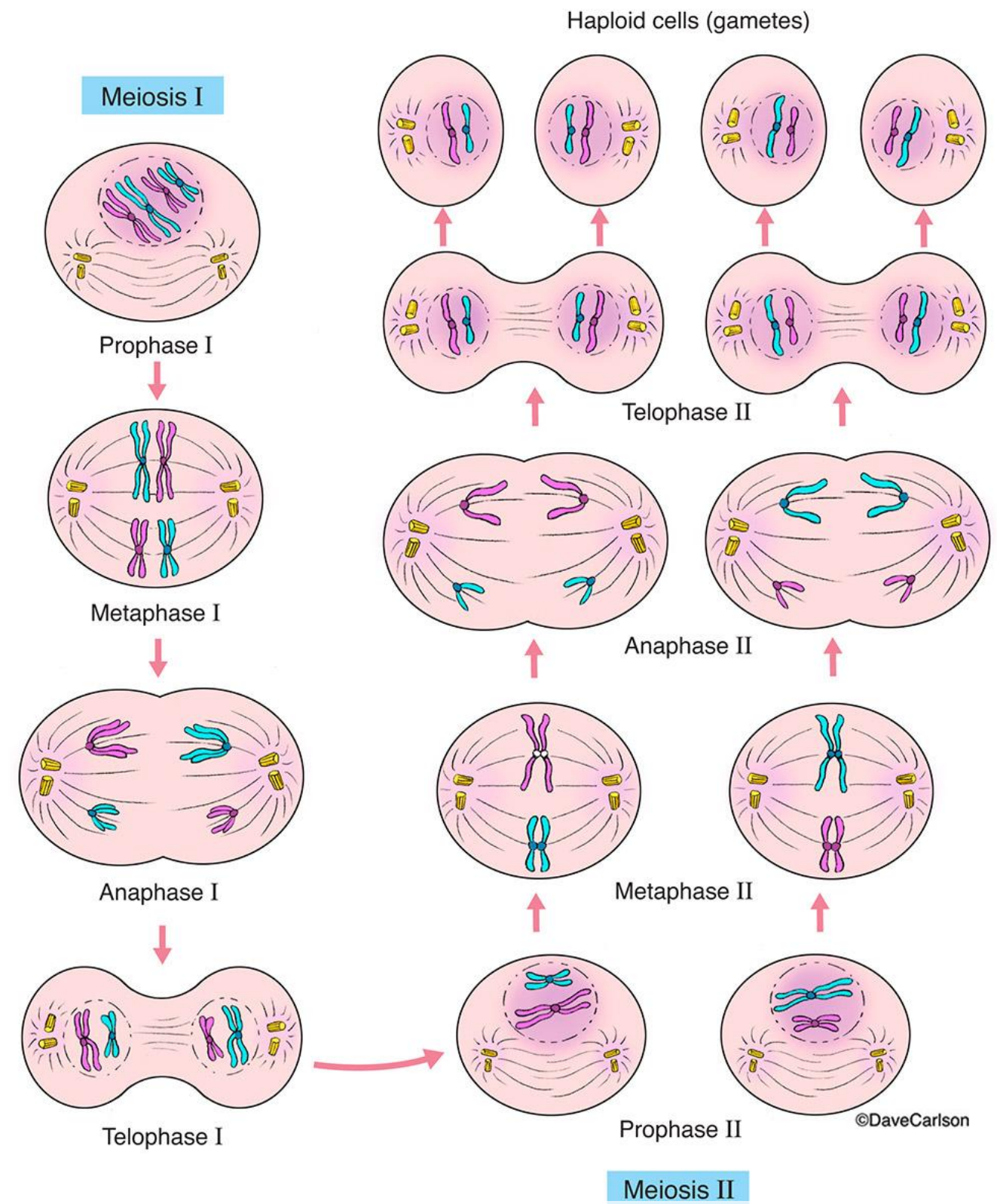
sexual reproduction

sex determination

sexual selection

resources

how it is taught



diversity

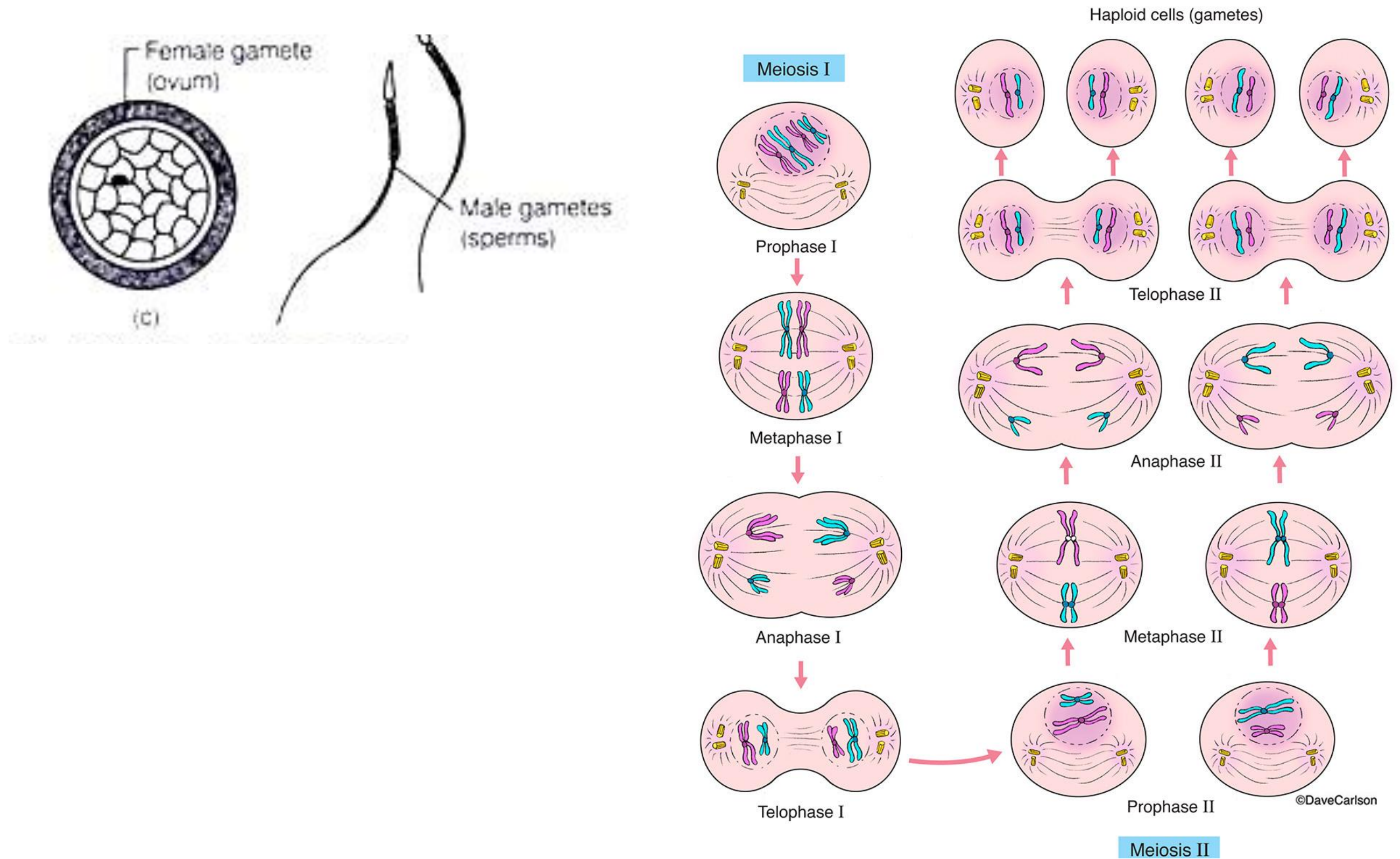
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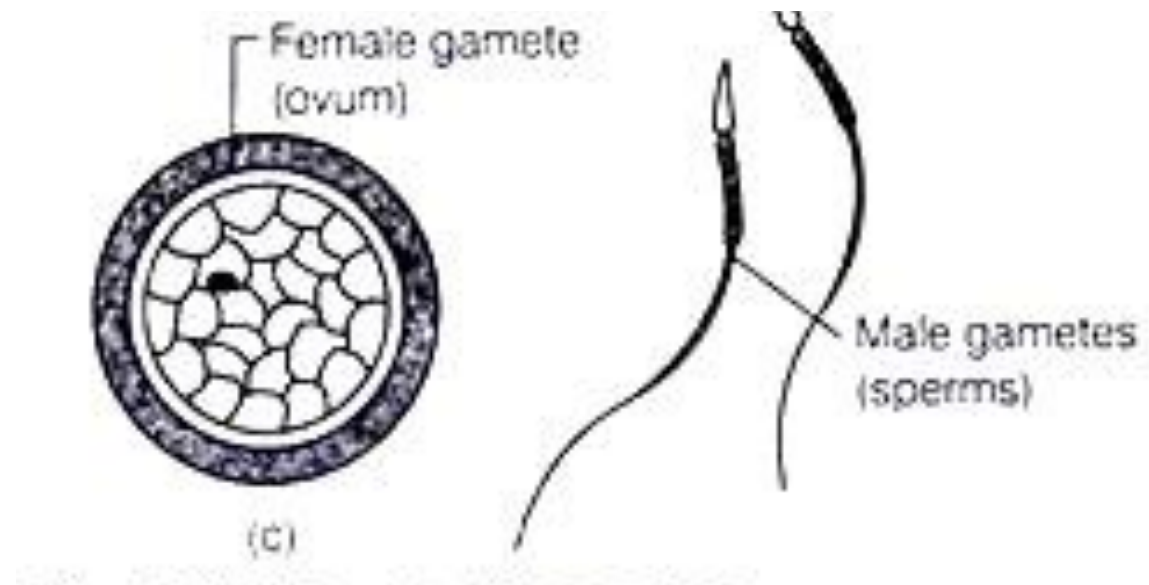
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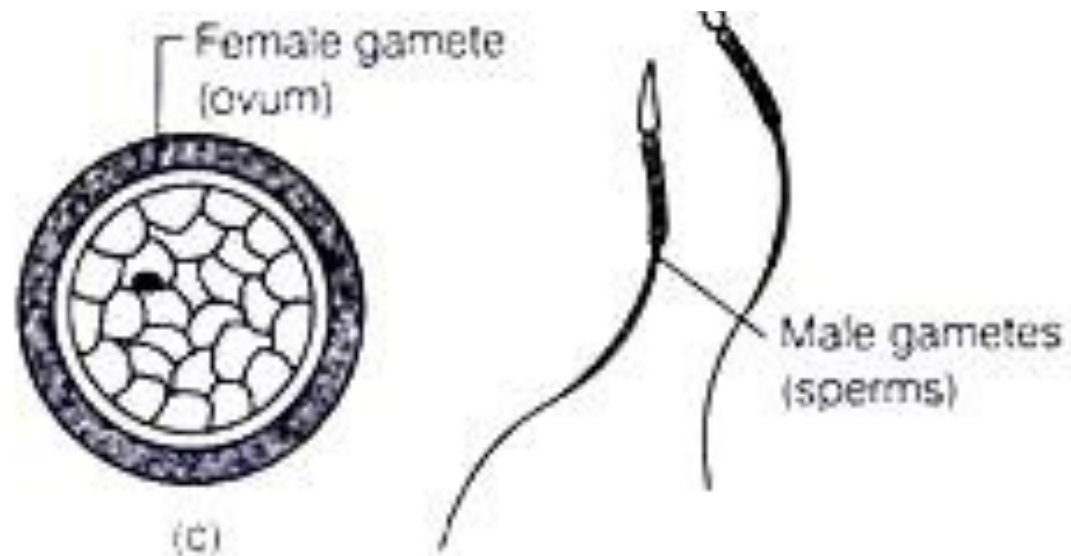


anisogamy

when gametes exhibit size dimorphism

only gametes of different sizes can fuse

how it is taught



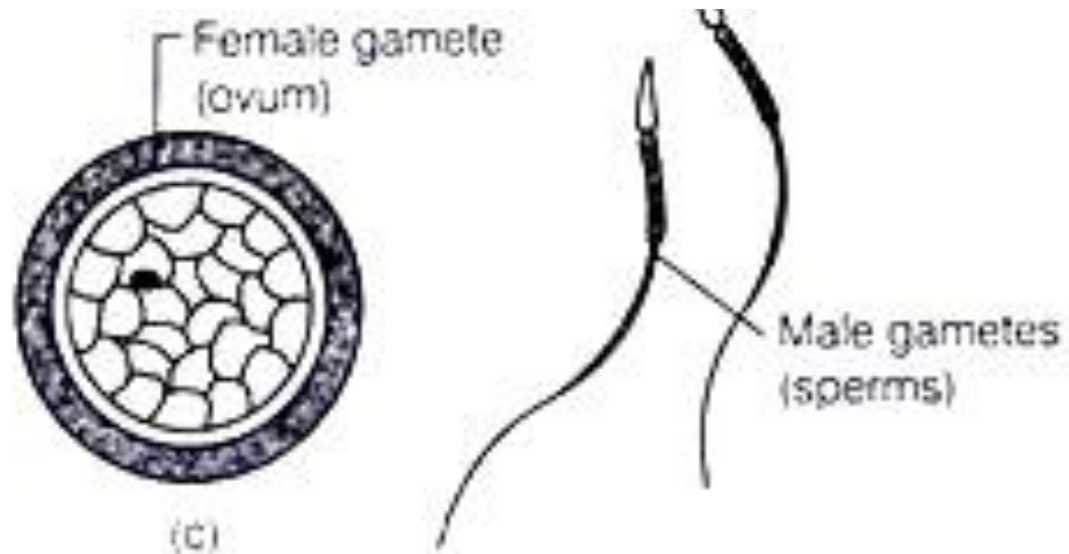
anisogamy

when gametes exhibit size dimorphism

only gametes of different sizes can fuse

female gamete male gamete

how it is taught



anisogamy

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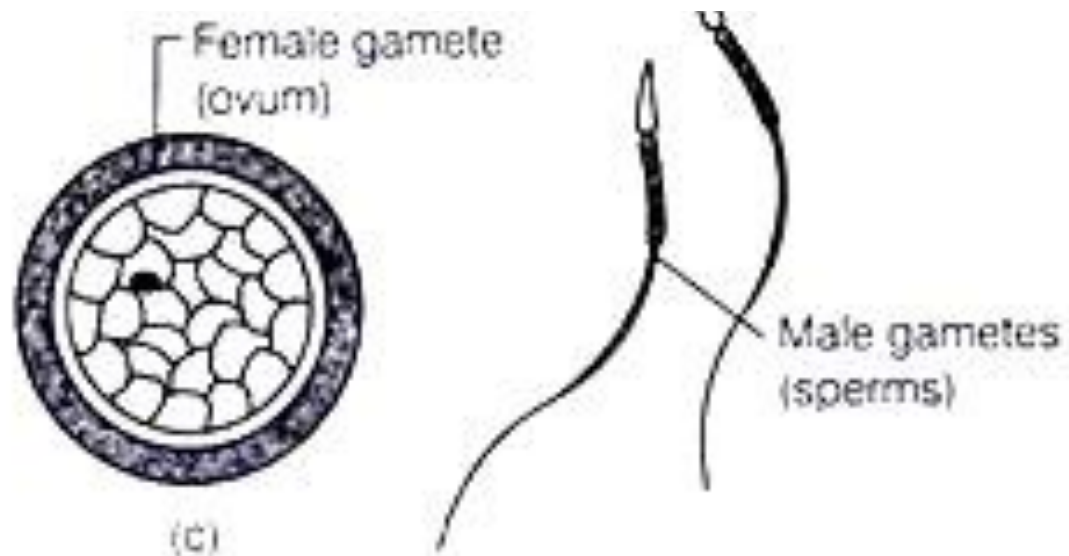
female gamete

larger gamete
egg

male gamete

small gamete
sperm

how it is taught



anisogamy

when gametes exhibit size dimorphism

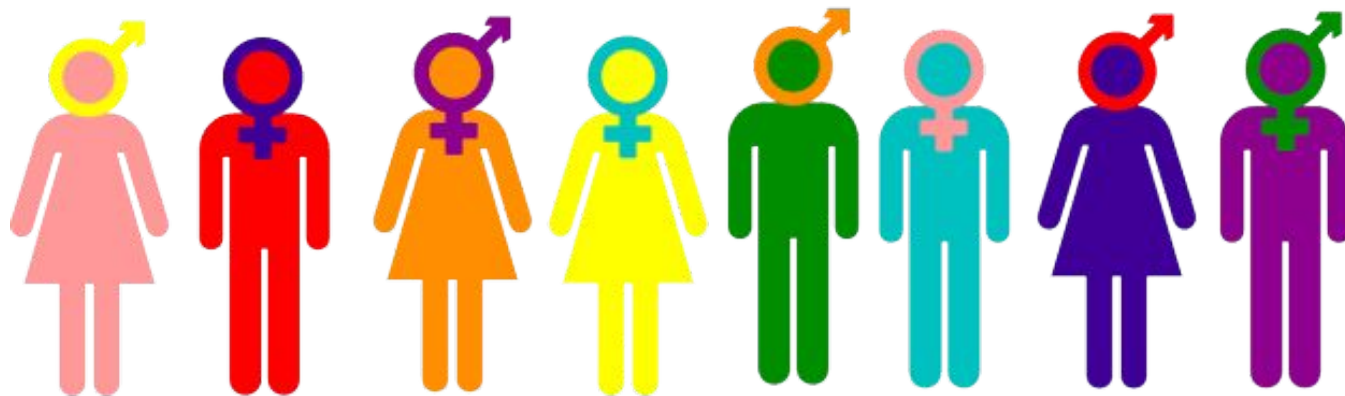
only gametes of different sizes can fuse

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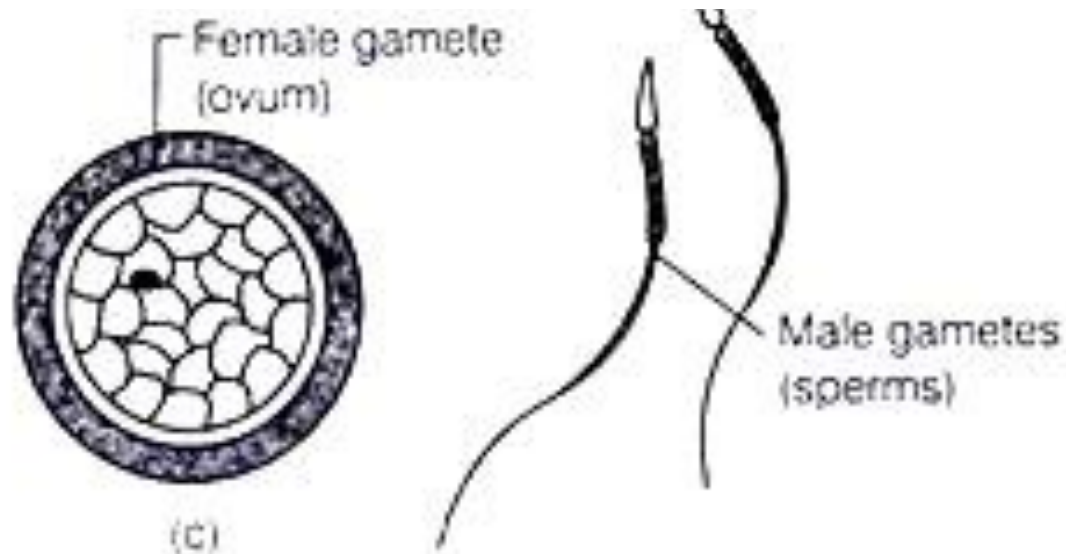
sex \neq gender

how it is taught

anisogamy

when gametes exhibit size dimorphism

only gametes of different sizes can fuse



female gamete

larger gamete
egg

male gamete

small gamete
sperm

hermaphrodite

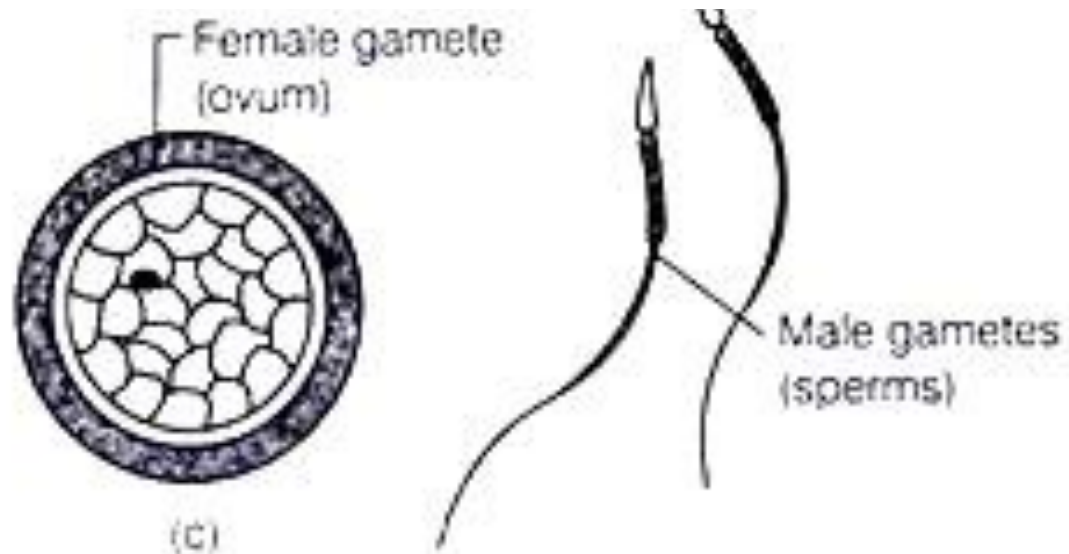
produce eggs & sperm

how it is taught

anisogamy

when gametes exhibit size dimorphism

only gametes of different sizes can fuse



female gamete

larger gamete
egg

male gamete

small gamete
sperm

hermaphrodite
produce eggs & sperm



diversity

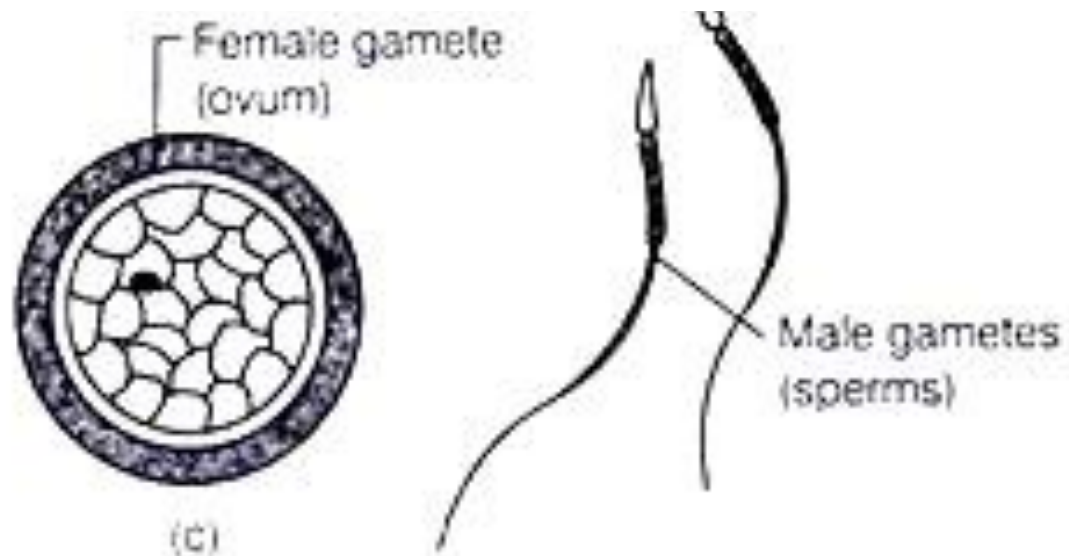
sexual reproduction

sex determination

sexual selection

resources

how it is taught



anisogamy

when gametes exhibit size dimorphism

only gametes of different sizes can fuse

female gamete

larger gamete
egg

male gamete

small gamete
sperm



hermaphrodite

≠

intersex

diversity

sexual reproduction

sex determination

sexual selection

resources

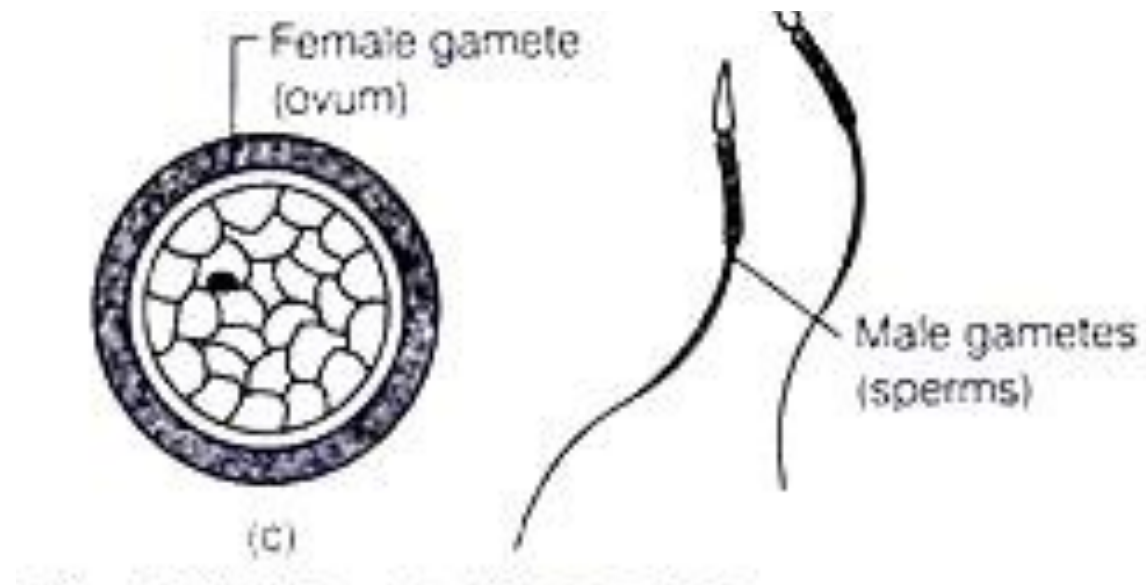
improve by:

	accuracy	inclusivity
define sex	sex \neq gender sex \neq the act male = small gamete female = large gamete	people who are <ul style="list-style-type: none">• sexual minorities• gender non-conforming• transgender

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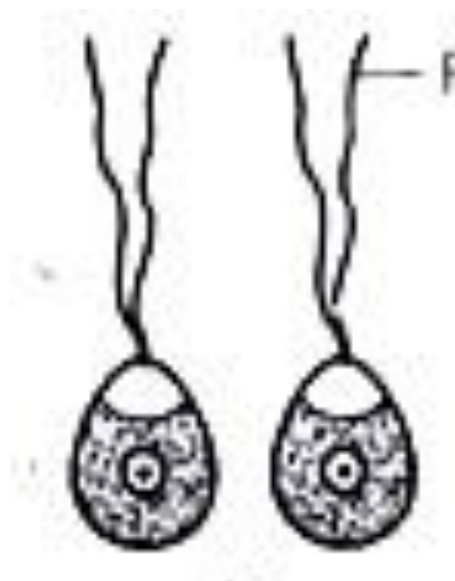
how it is taught



anisogamy

when gametes exhibit size dimorphism

only gametes of different sizes can fuse



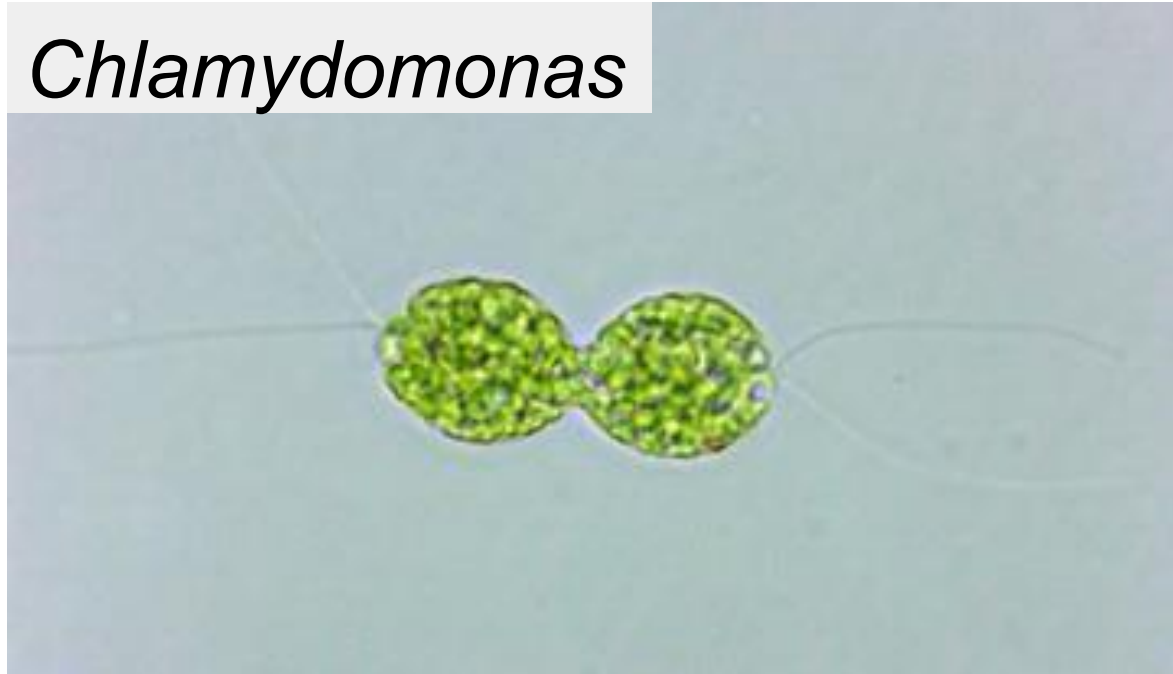
isogamy

all gametes are the same size

*all gametes reproduce
or gametes of different mating types reproduce*

how it is taught

Chlamydomonas



isogamy is **common**,
especially in algae & ciliates

Schizophyllum commune



fungi can have **2-1,000s** of
mating types!

diversity

sexual reproduction

sex determination

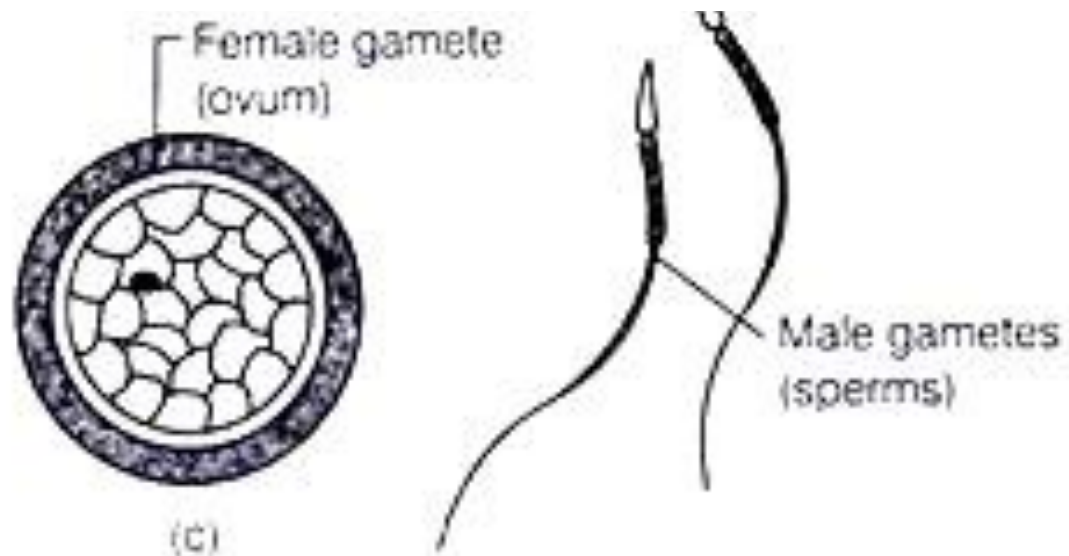
sexual selection

resources

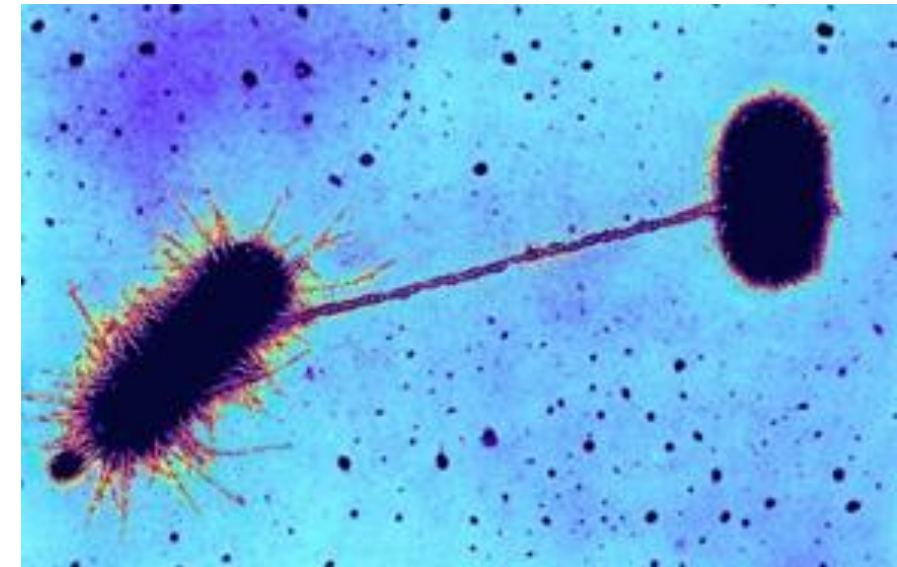
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include isogamous species	lots of species! sex doesn't require sexes	

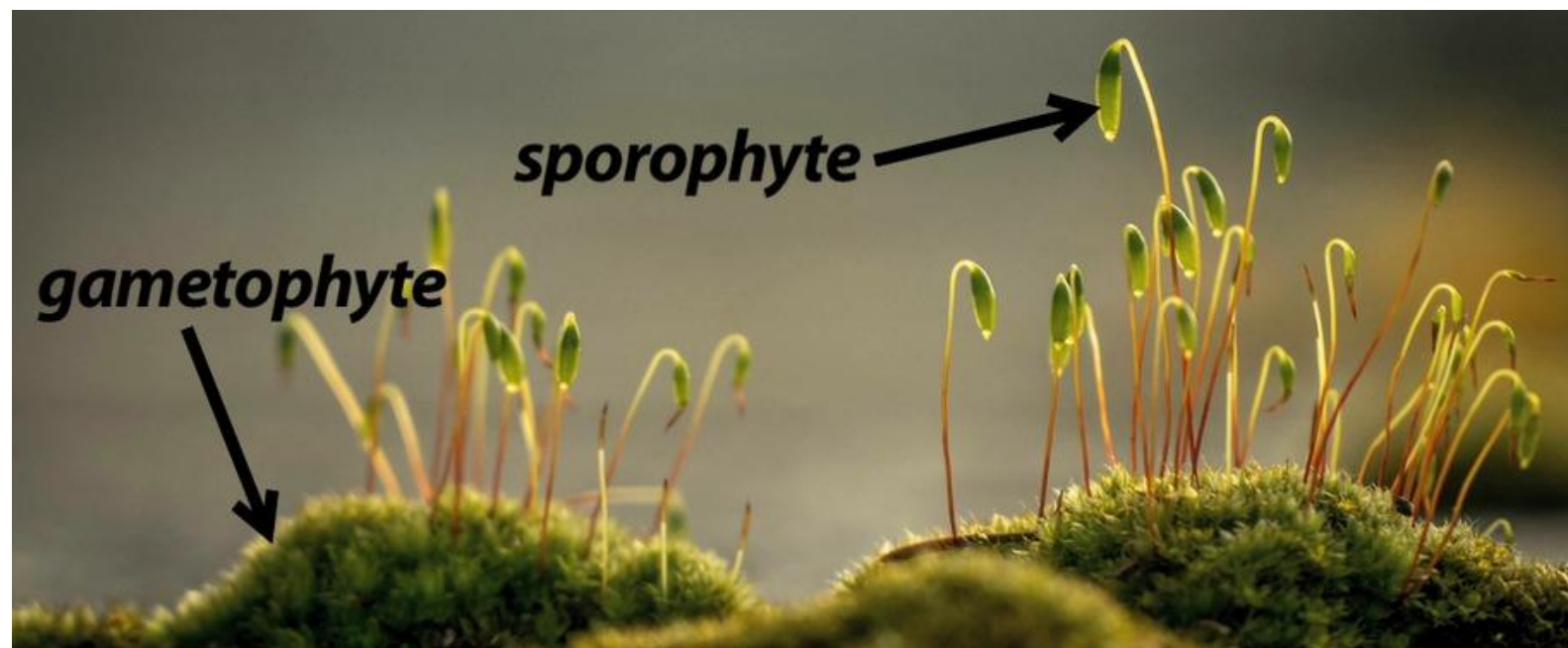
how it is taught



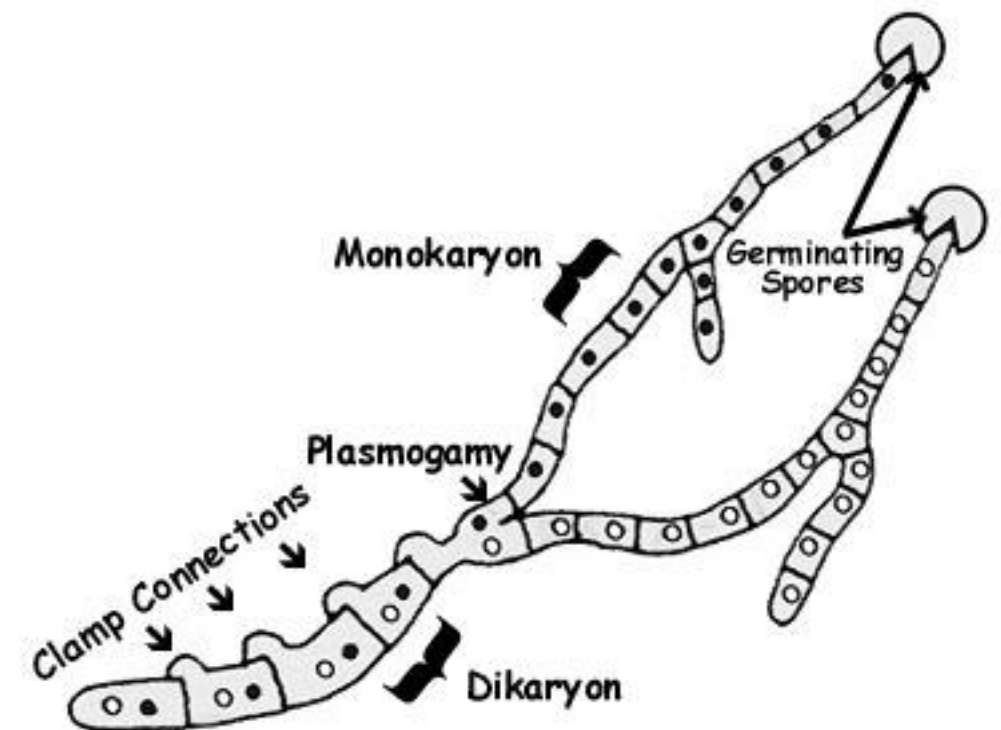
fertilization



conjugation



gametes germinate and later fuse



improve by:

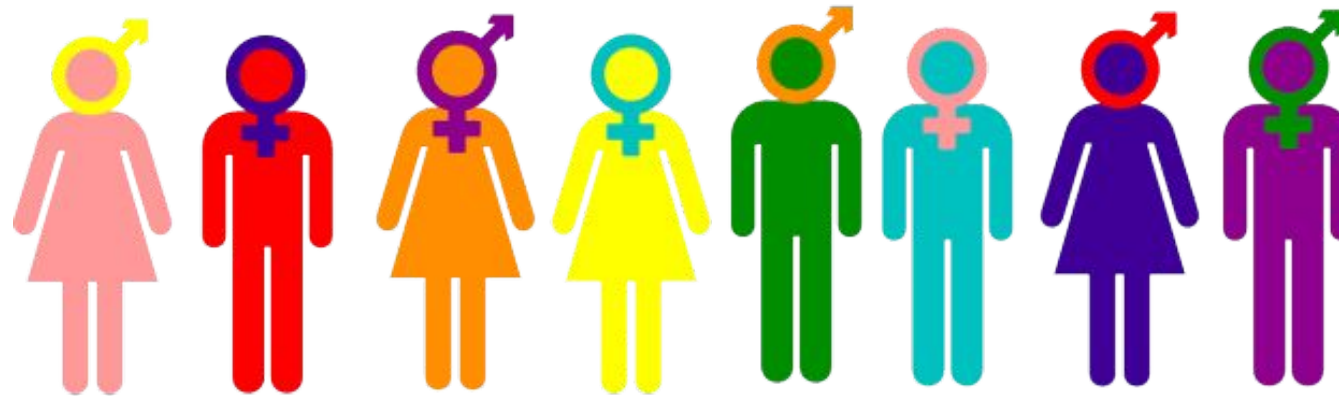
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don't limit to fertilization	conjugation germination \rightarrow reproduction	

improve by:

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include isogamous species	lots of species! sex doesn't require sexes	<ul style="list-style-type: none"> reinforce the notion that sex is not the only organizing factor of life on earth
don't limit to fertilization	conjugation germination \rightarrow reproduction	

improve language

“gender”



diversity

sexual reproduction

sex determination

sexual selection

resources

improve language

**“maternal and paternal
chromosome”**



diversity

sexual reproduction

sex determination

sexual selection

resources

improve language

“maternal and paternal chromosome”



“your mother/father/parent”



diversity

sexual reproduction

sex determination

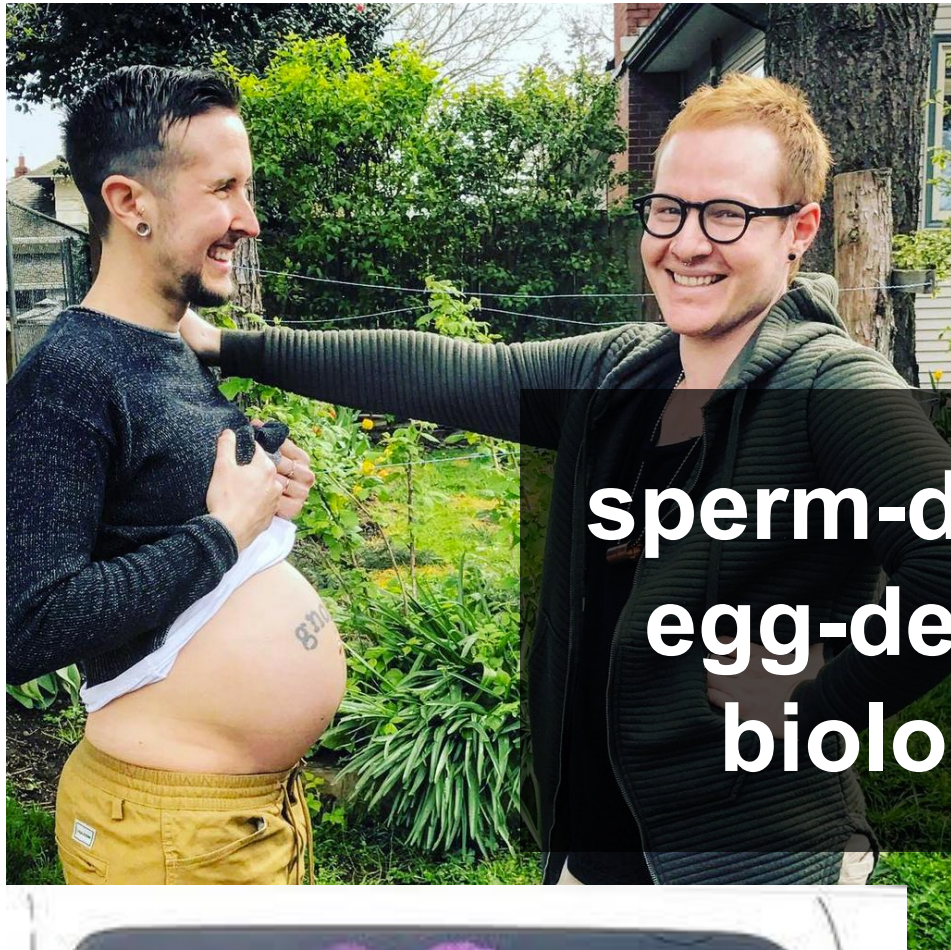
sexual selection

resources

improve language

“maternal and paternal
chromosome”

“your mother/father/parent”



sperm-derived chromosome
egg-derived chromosome
biological parents 1&2



diversity

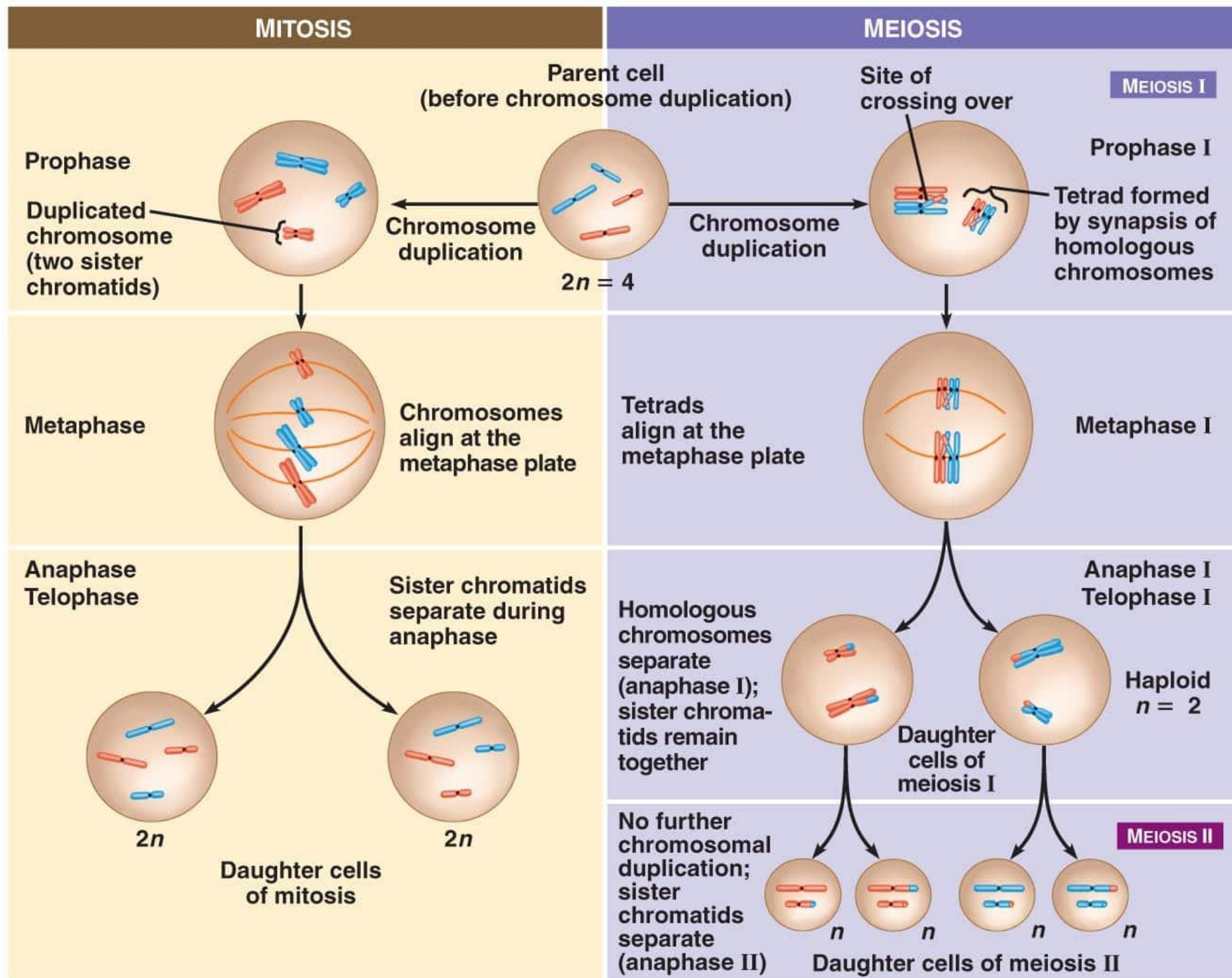
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sexual selection

resources

a different framework



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diversity

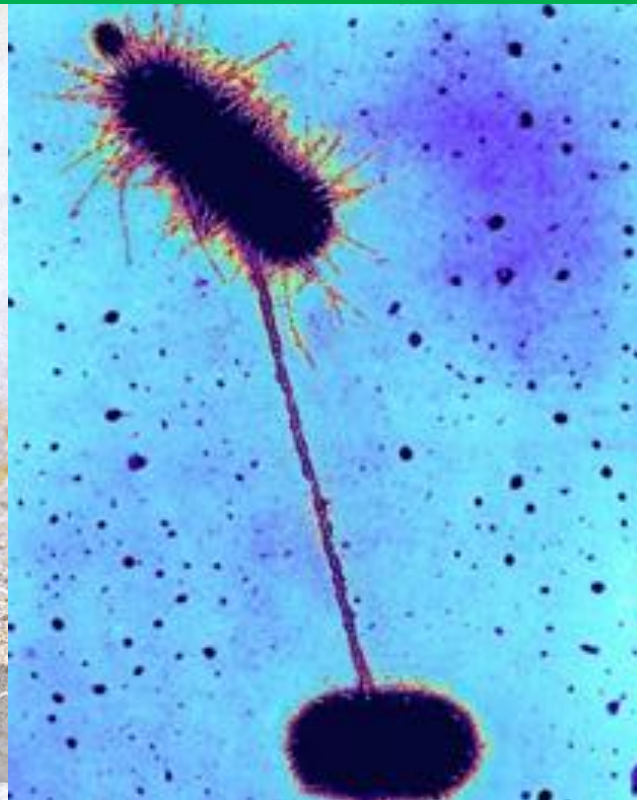
sexual reproduction

sex determination

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resources

a different framework



diversity

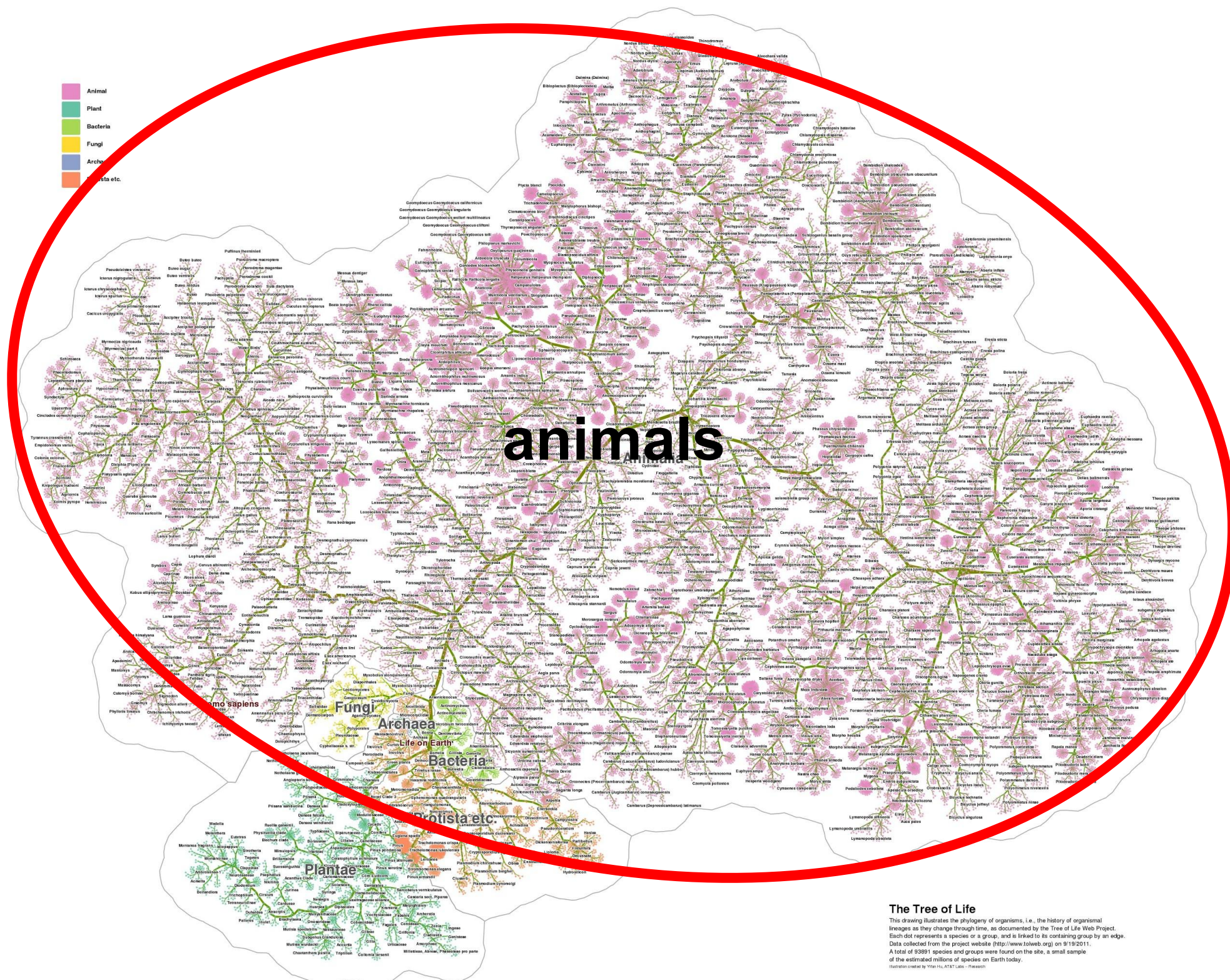
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diversity

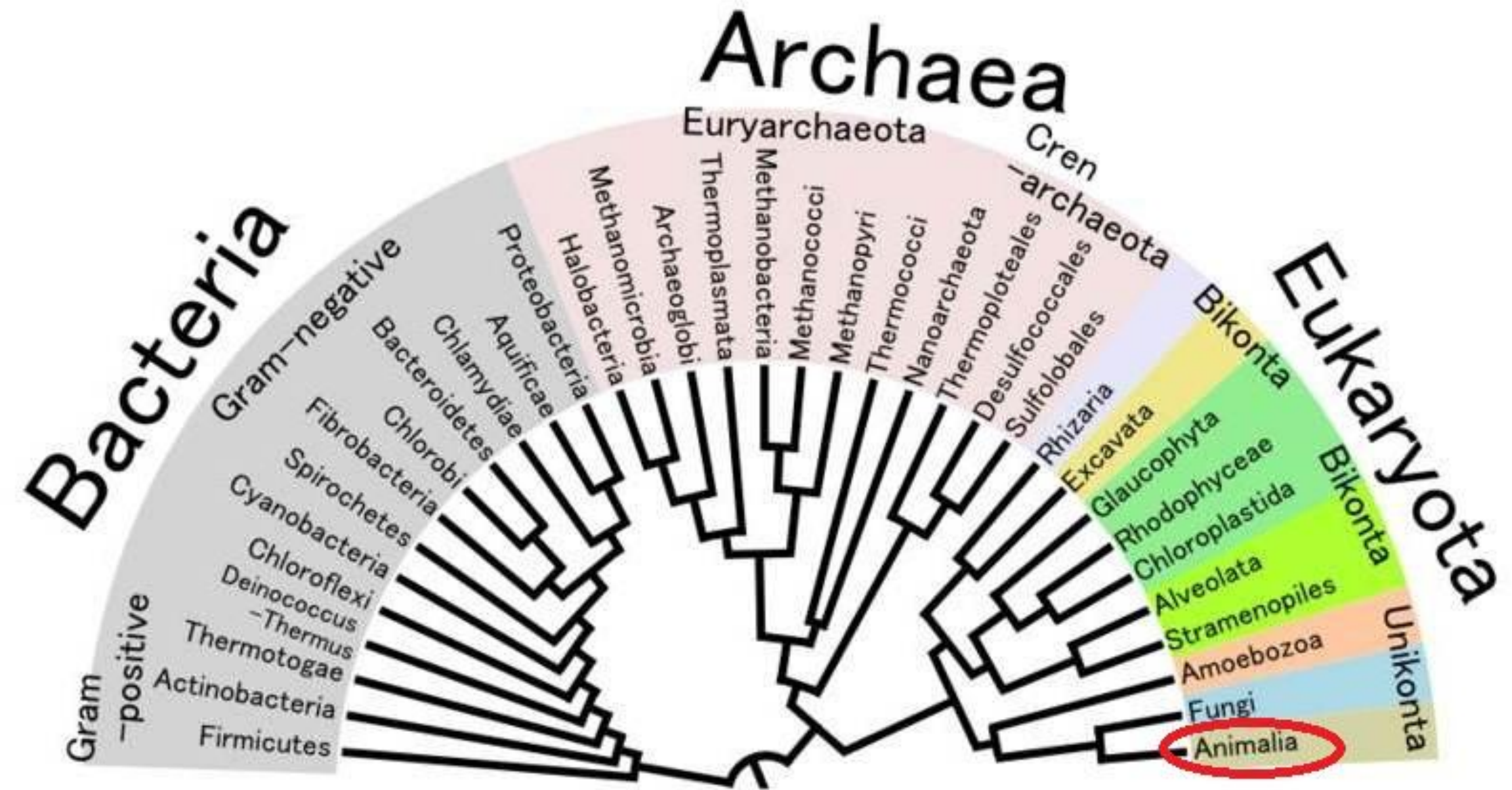
sexual reproduction

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diversity

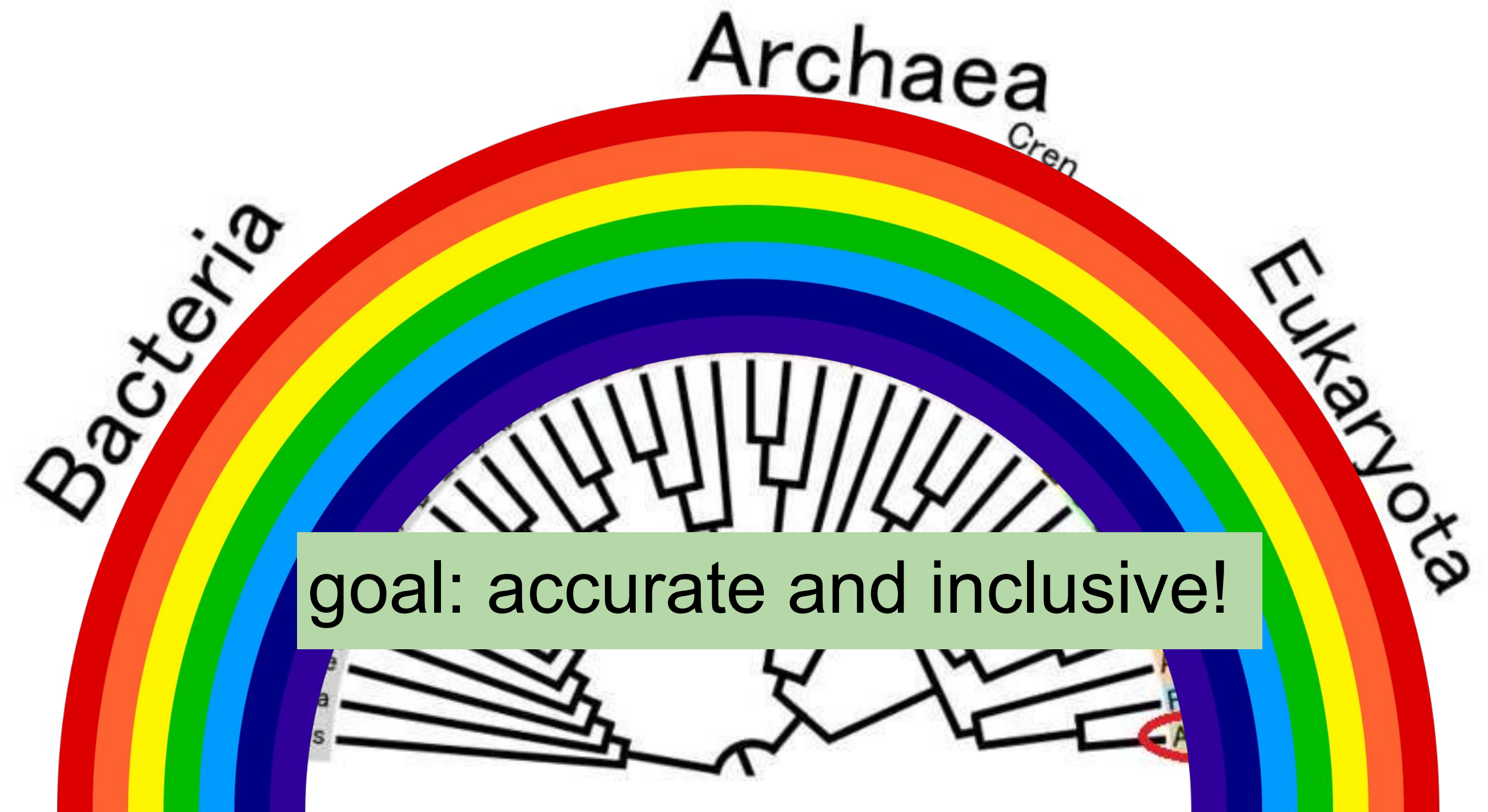
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a different framework



diversity

sexual reproduction

sex determination

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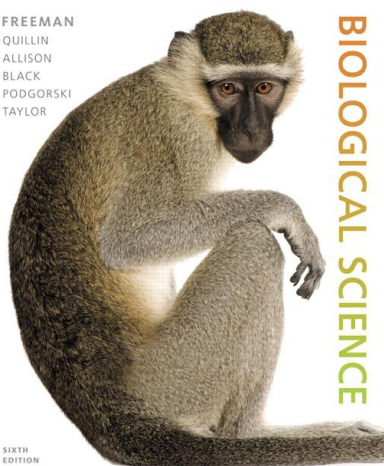
resources

example

The Role of Independent Assortment

...Suppose that the chromosomes you inherited from your mother contain alleles associated with normal hemoglobin and abnormal channel protein that causes cystic fibrosis. In contrast, suppose the chromosomes you inherited from your father include the alleles for the abnormal hemoglobin that causes sickle cell disease and a normal channel protein that does not cause cystic fibrosis.

FREEMAN
QUILLIN
ALLISON
BLACK
PODGORSKI
TAYLOR



BIOLOGICAL SCIENCE

SIXTH
EDITION

diversity

sexual reproduction

sex determination

sexual selection

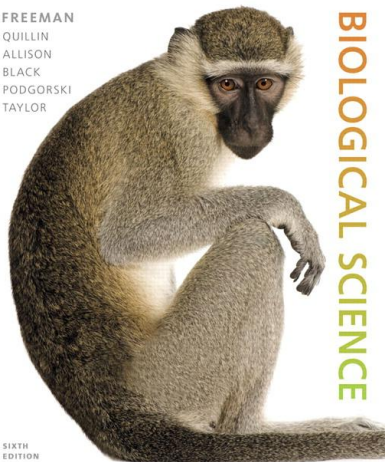
resources

example

The Role of Independent Assortment

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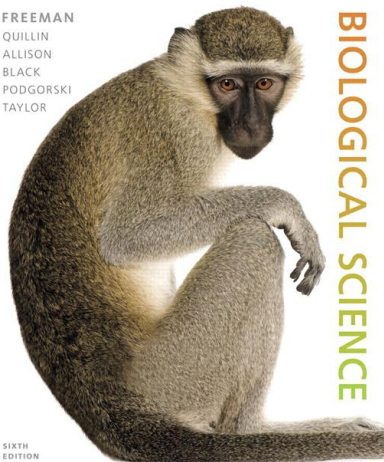
example

The Role of Independent Assortment

one biological parent
egg-producing parent

Suppose that the chromosomes you inherited from ~~your mother~~ contain alleles associated with **normal** hemoglobin and **abnormal** channel protein that causes cystic fibrosis. In contrast, suppose the chromosomes you inherited ~~from your father~~ include the alleles for the **abnormal** hemoglobin that causes sickle cell disease and a **normal** channel protein that does not cause cystic fibrosis.

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BIOLOGICAL SCIENCE

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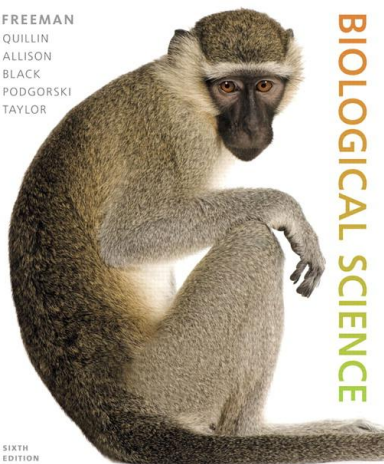
resources

example

The Role of Independent Assortment

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FREEMAN
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BIOLOGICAL SCIENCE

SIXTH
EDITION

diversity

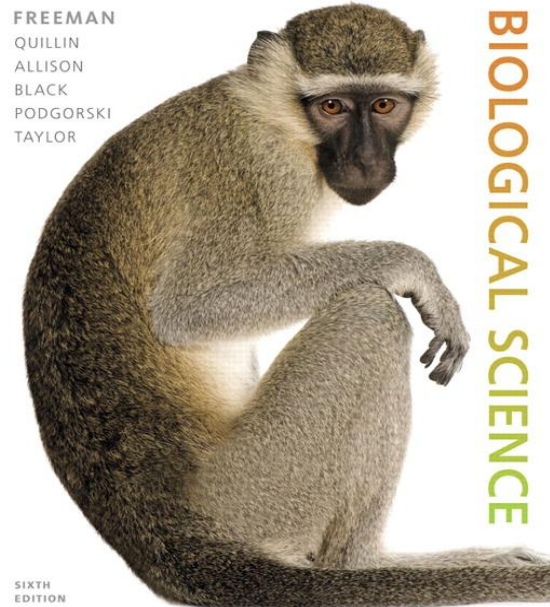
sexual reproduction

sex determination

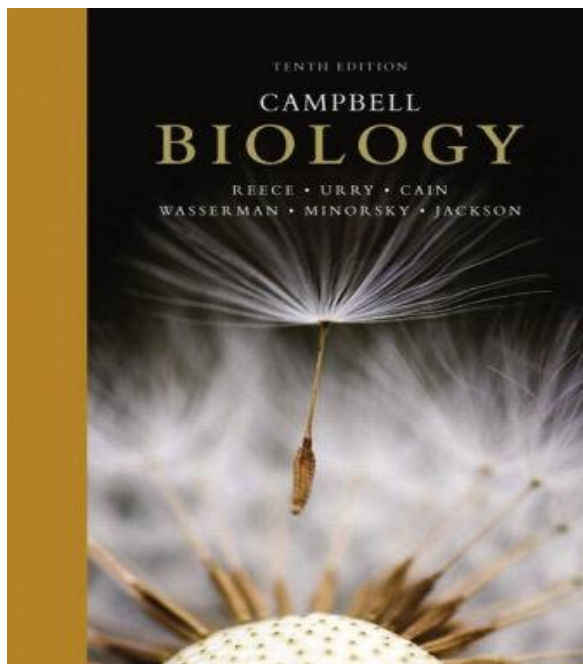
sexual selection

resources

your turn



or



The Paradox of Sex

Note that in the sexual population, it takes two individuals - one male and one female - to produce four offspring. Two out of every four children that each female produces are males, who cannot themselves give birth to children...

diversity

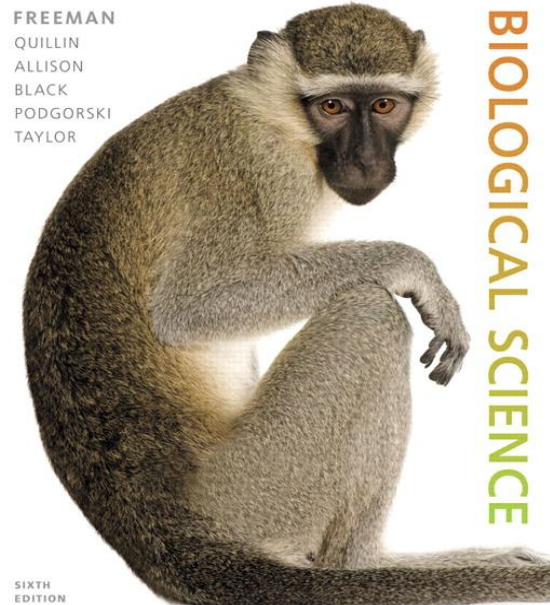
sexual reproduction

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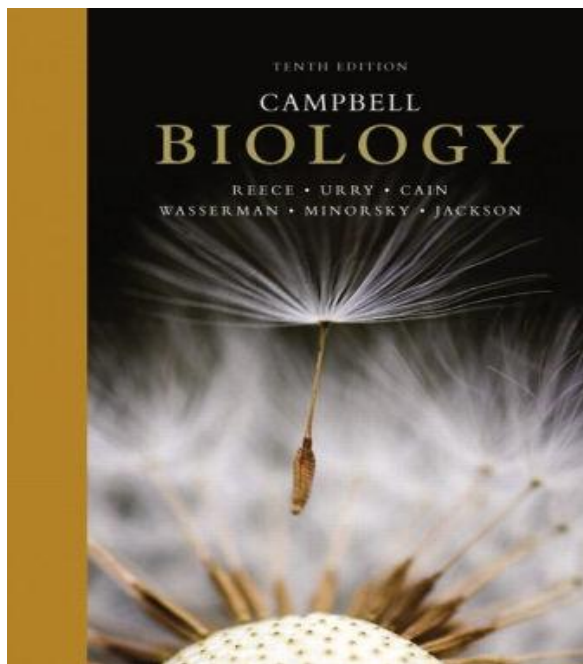
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diversity

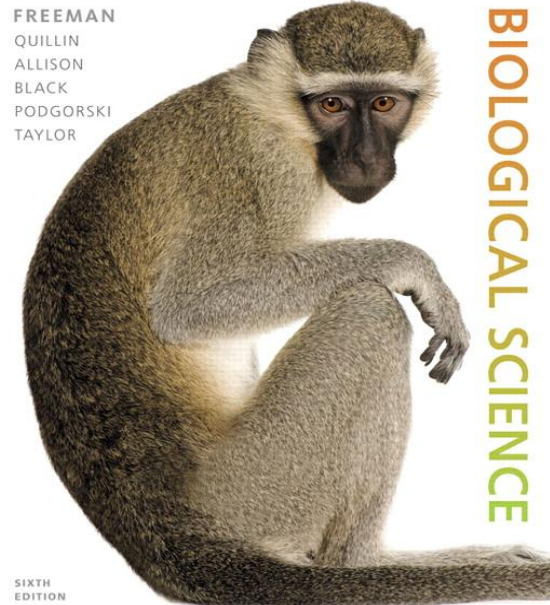
sexual reproduction

sex determination

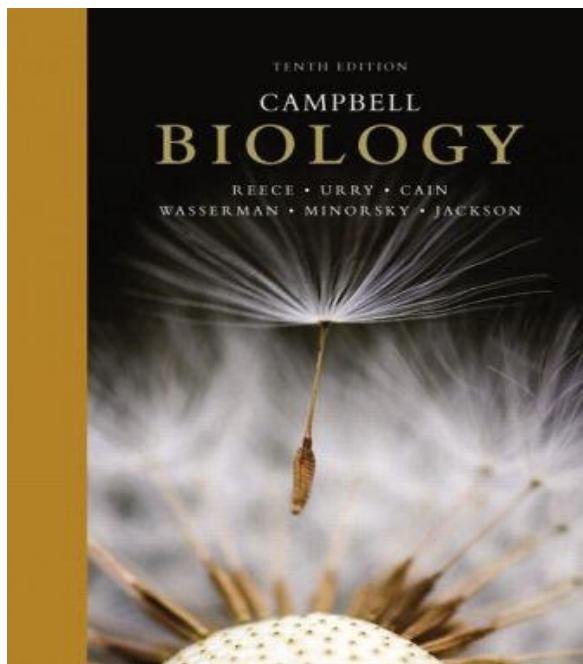
sexual selection

resources

your turn



or



The Paradox of **Sex**

One egg producer and one sperm producer
Note that in the sexual population, it takes two individuals - ~~one male and one female~~ - to produce four **offspring**. Two out of every four **children** that each **female** produces are **males**, who cannot themselves **give birth** to **children**
egg producer to **sperm producer**

diversity

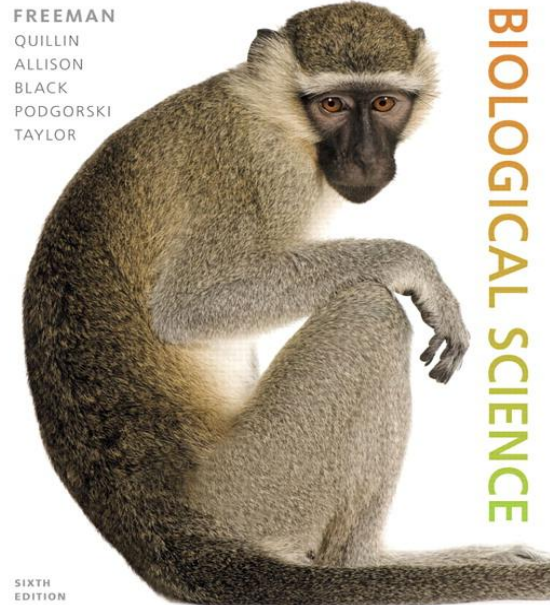
sexual reproduction

sex determination

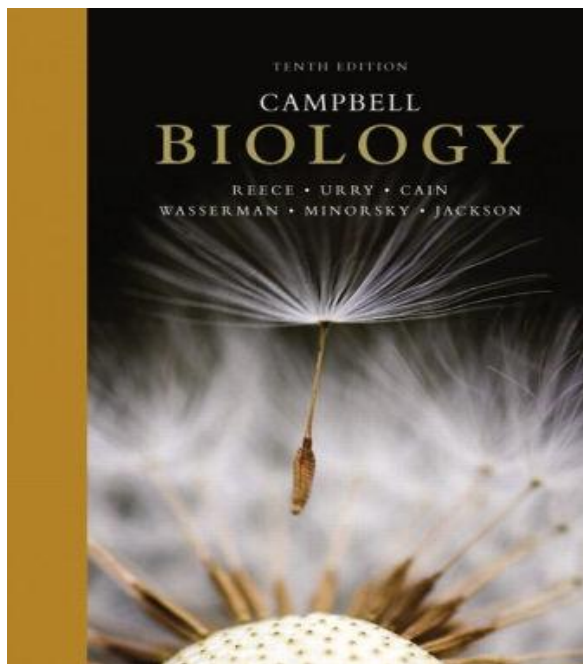
sexual selection

resources

your turn



or



The Paradox of ~~Sex~~ Anisogamy

Note that in the sexual population, it takes two individuals - ~~one male and one female~~ - to produce four **offspring**. Two out of every four **children** that each **female** produces are **males**, who cannot themselves **give birth** to **children**...

diversity

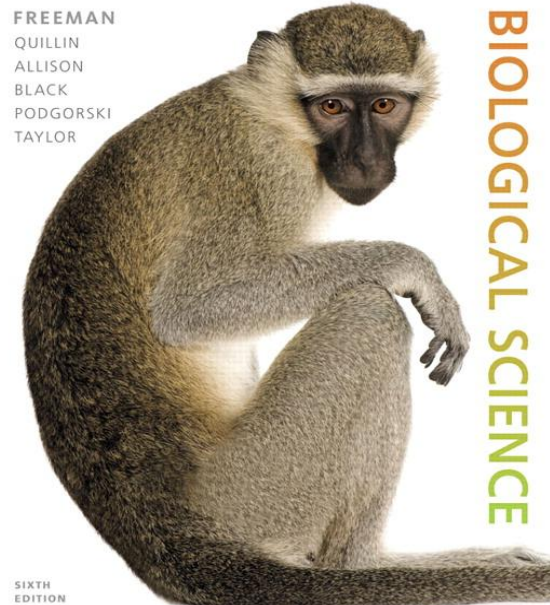
sexual reproduction

sex determination

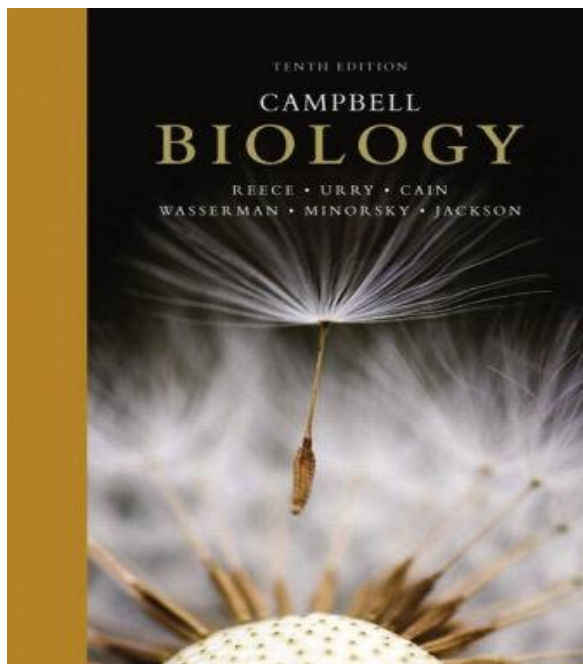
sexual selection

resources

your turn



or



The Paradox of ~~Sex~~

Note that in the sexual population, it takes two individuals - ~~one male and one female~~ - to produce four **offspring**. Two out of every four ~~children~~ that each ~~female~~ produces are **males**, who **offspring** themselves **give birth** to ~~children~~...

offspring

diversity

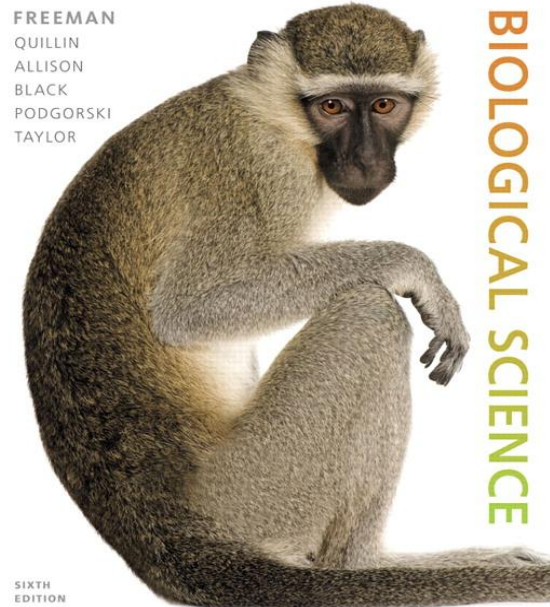
sexual reproduction

sex determination

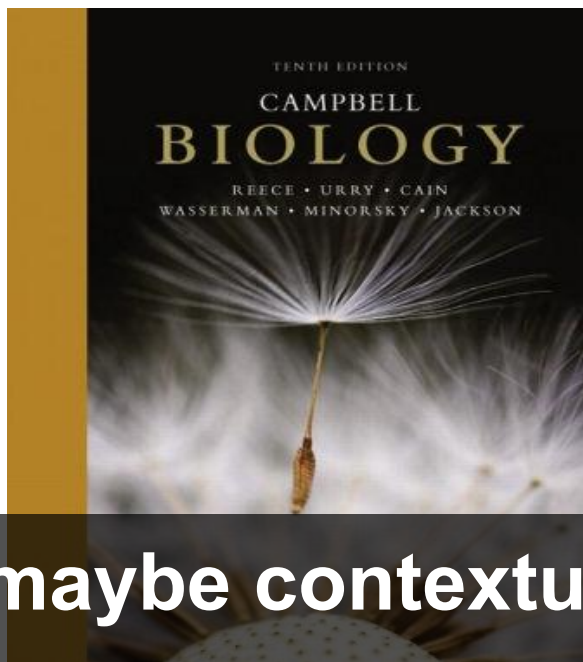
sexual selection

resources

your turn



or



The Paradox of ~~Sex~~

Note that in the sexual population, it takes two individuals - ~~one male and one female~~ - to produce four **offspring**. Two out of every four ~~children~~ that each ~~female~~ produces are **males**, who **offspring** themselves **give birth** to ~~children~~...

offspring

maybe contextualize that this doesn't include hermaphroditic species

diversity

sexual reproduction

sex determination

sexual selection

resources

definition checklist

- ☐ **Does it apply equally well to humans and fungi?**
If not, edit or clarify.
- ☐ **Does it privilege one species' system of sexual reproduction, sex determination, or sex-role-related behavior, over others?**
If yes, edit.
- ☐ **Is it aware of how the term is used in human society and explicitly distinguish itself or comment on its use in that context?**
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definition checklist

projectbiodiversify.org/definitions/

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definition checklist

definition updates working doc!

projectbiodiversify.org/definitions/

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sex determination & dimorphism

how it is taught

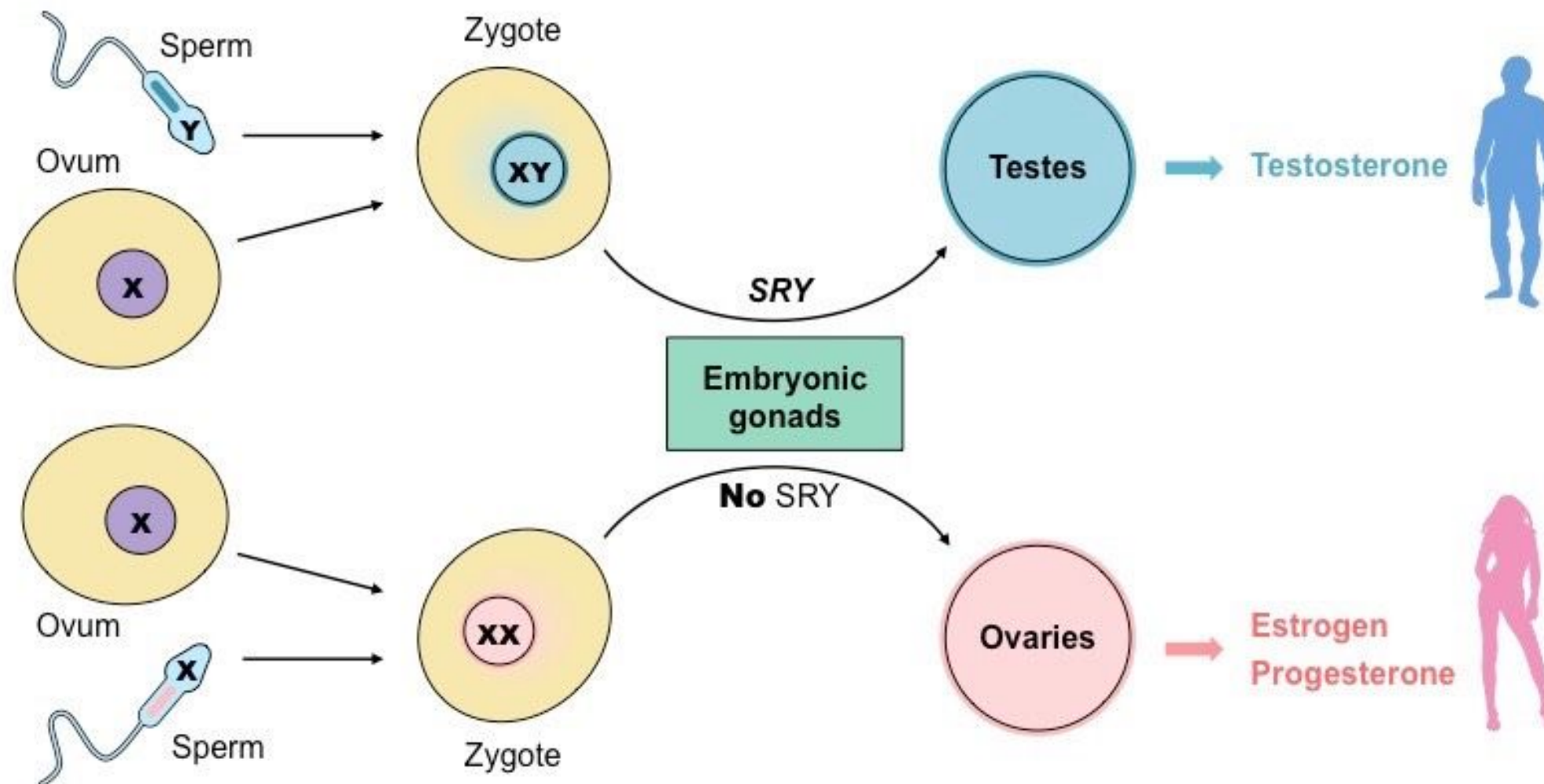
What is sex determination?

The biological system that determines the development of characteristics associated with dimorphic sexes.

Primary sex determination: determines gamete size

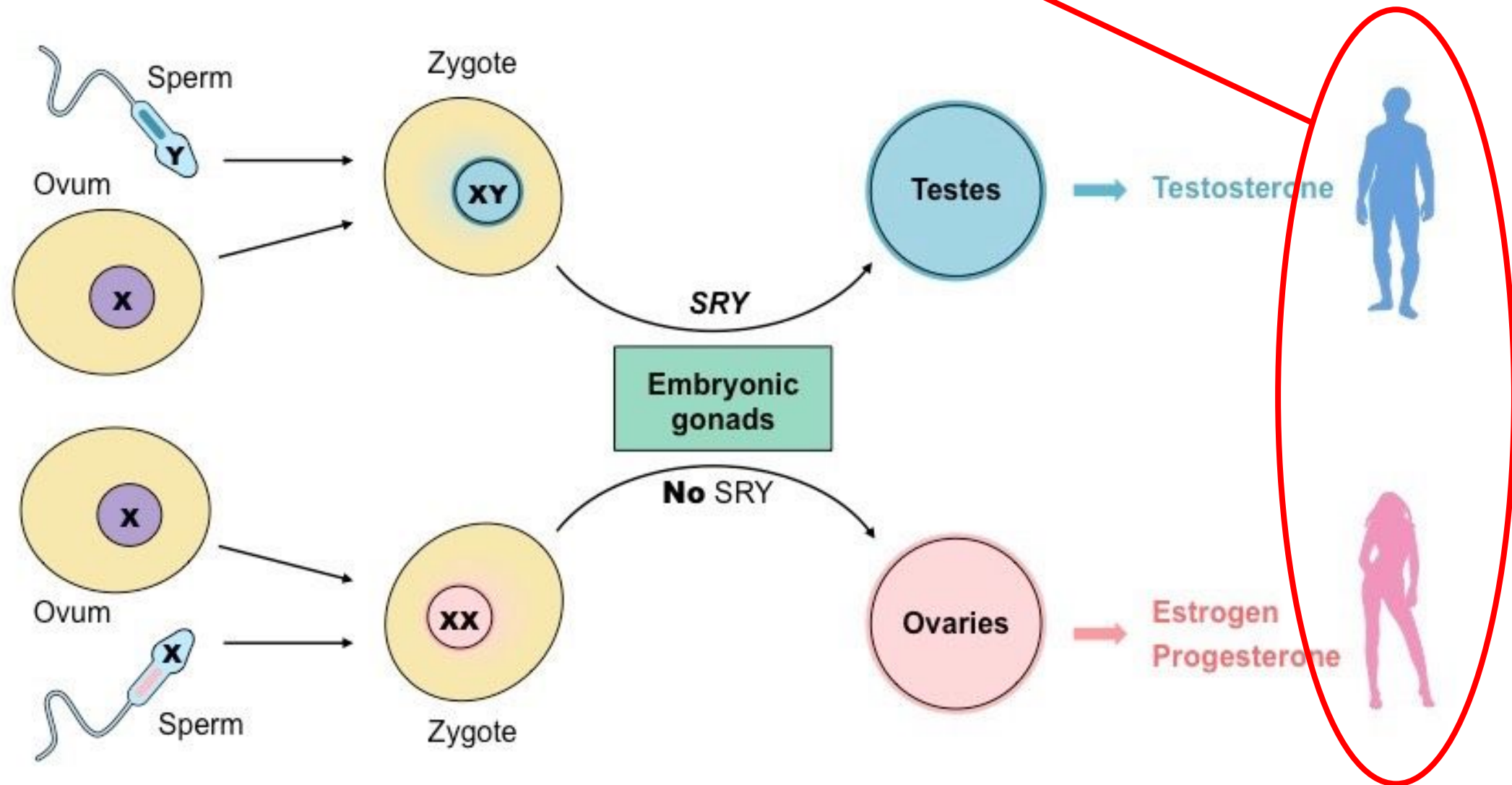
Secondary sex determination: determines other sex-related phenotypes

how it is taught

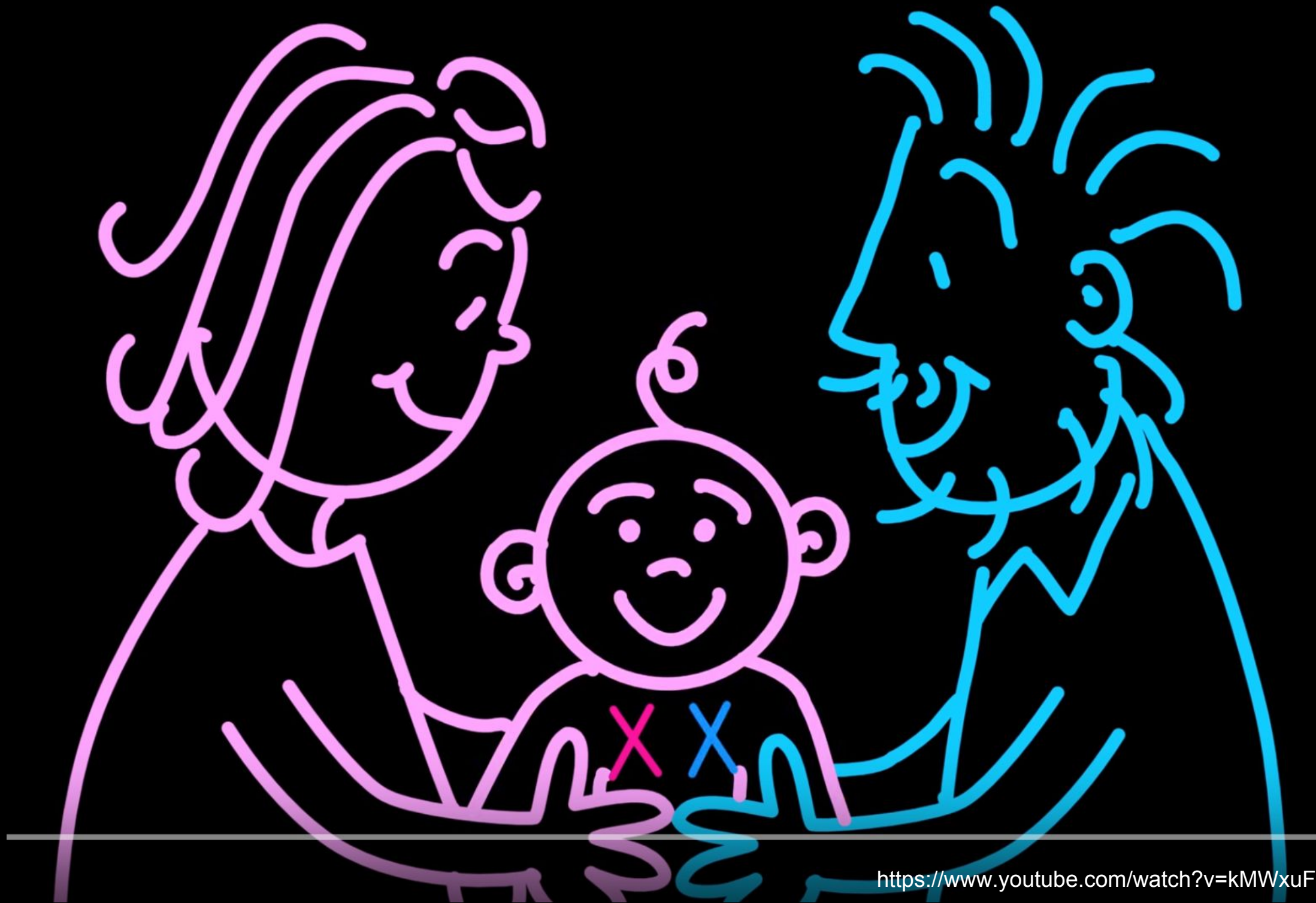


inaccuracies

1. Sex = Gender



inaccuracy: sex = gender



<https://www.youtube.com/watch?v=kMWxuF9YW38&vl=en>

diversity

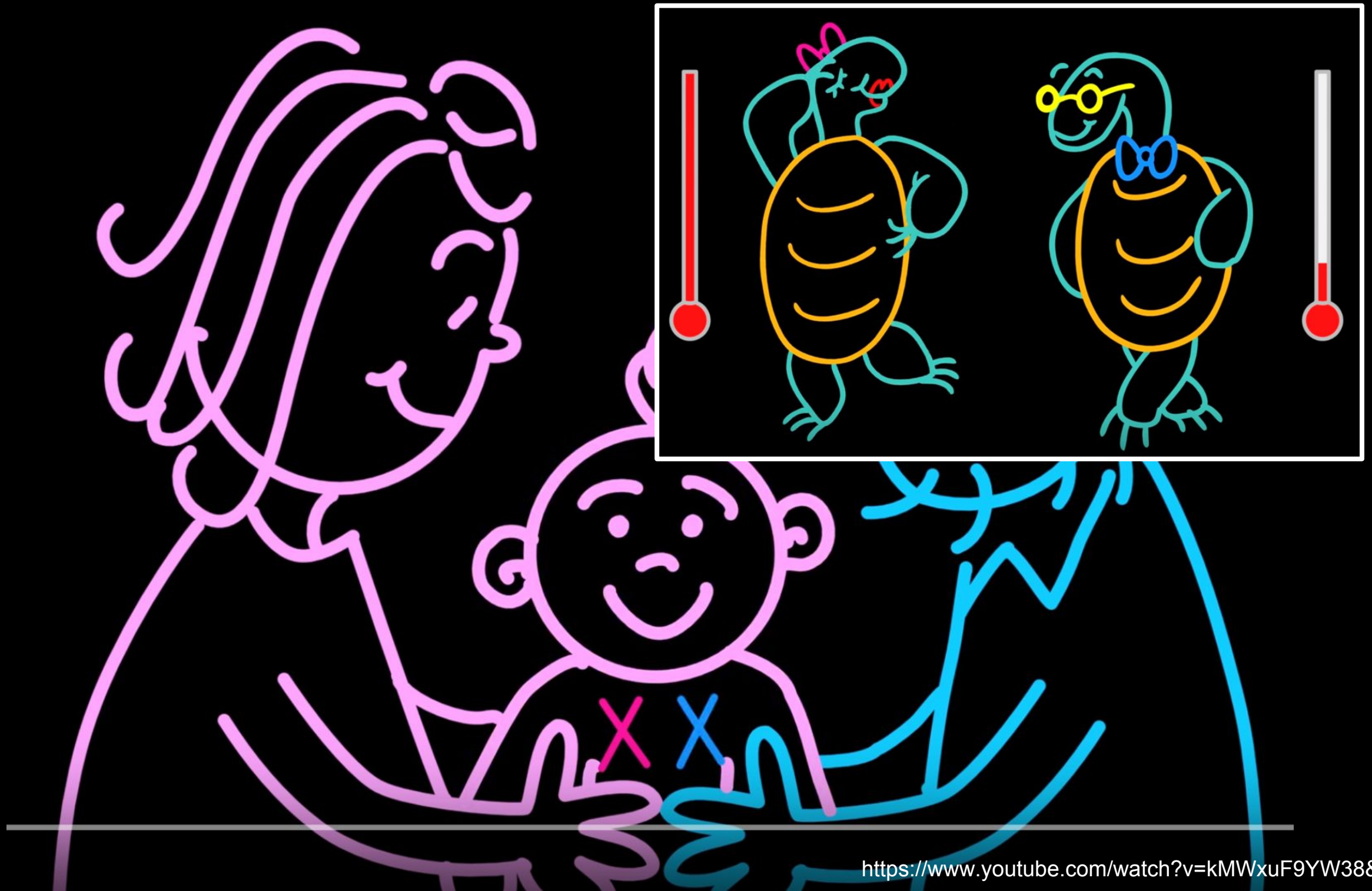
sexual reproduction

sex determination

sexual selection

resources

inaccuracy: sex = gender



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diversity

sexual reproduction

sex determination

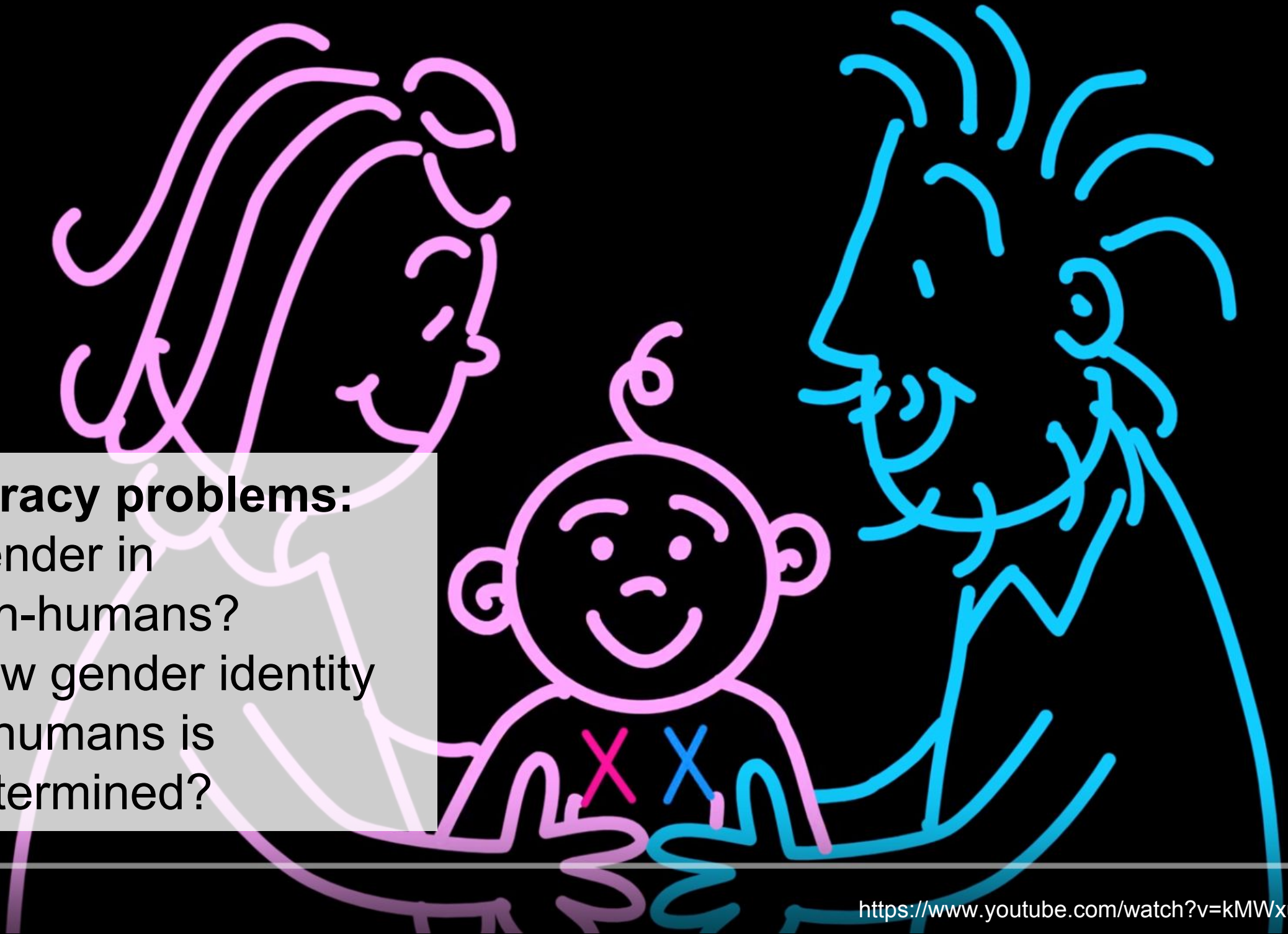
sexual selection

resources

inaccuracy: sex = gender

Accuracy problems:

- Gender in non-humans?
- How gender identity in humans is determined?



<https://www.youtube.com/watch?v=kMWxuF9YW38&vl=en>

inaccuracy: sex = gender

Accuracy problems:

- Gender in non-humans?
- How gender identity in humans is determined?

Inclusivity problems:

- Suggests that gender is biologically-based
- Erases diverse gender expressions and identities

<https://www.youtube.com/watch?v=kMWxuF9YW38&vl=en>

a different framework

Define “sex” and “sexual dimorphism”

Why?

So that it isn't confused with gender.

So that it isn't assumed that all organisms are sexually dimorphic or are all male or female.

a different framework

Define “sex” and “sexual dimorphism”

Sexual dimorphism:

The phenomenon in which individuals of different sexes of the same species have different genotypes and/or phenotypes.

a different framework

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“gamete dimorphism” (anisogamy)

“sex organ dimorphism”

“sex-associated phenotypic dimorphism”

a different framework

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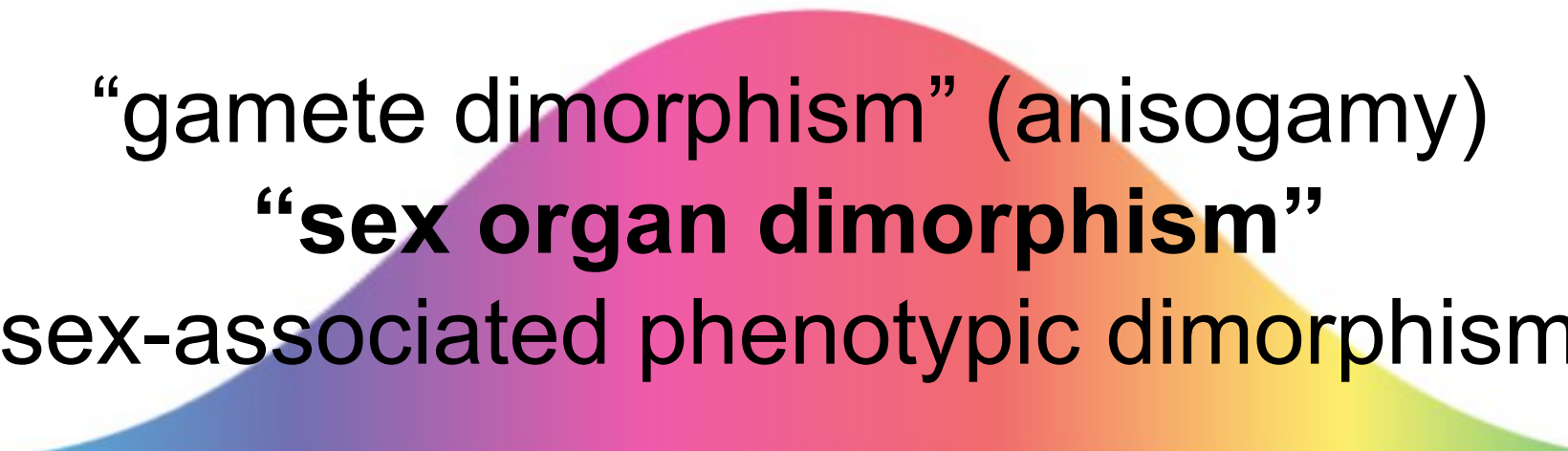
“sex-associated phenotypic dimorphism”

a different framework



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“sex organ dimorphism”
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a different framework



“gamete dimorphism” (anisogamy)
“**sex organ dimorphism**”
“sex-associated phenotypic dimorphism”

~ 6% of flowering plants
~ 65% of animal species (excluding insects)

Bachtrog D, Mank JE, Peichel CL, Kirkpatrick M, Otto SP, Ashman T-L, et al. (2014) Sex Determination: Why So Many Ways of Doing It? PLoS Biol 12(7)

a different framework

“gamete dimorphism” (anisogamy)

“sex organ dimorphism”

“sex-associated phenotypic dimorphism”



Gymnotus omarorum

a different framework

“gamete dimorphism” (anisogamy)

“sex organ dimorphism”

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Gymnotus omarorum



Goneplax rhomboides

a different framework

“gamete dimorphism” (anisogamy)

“sex organ dimorphism”

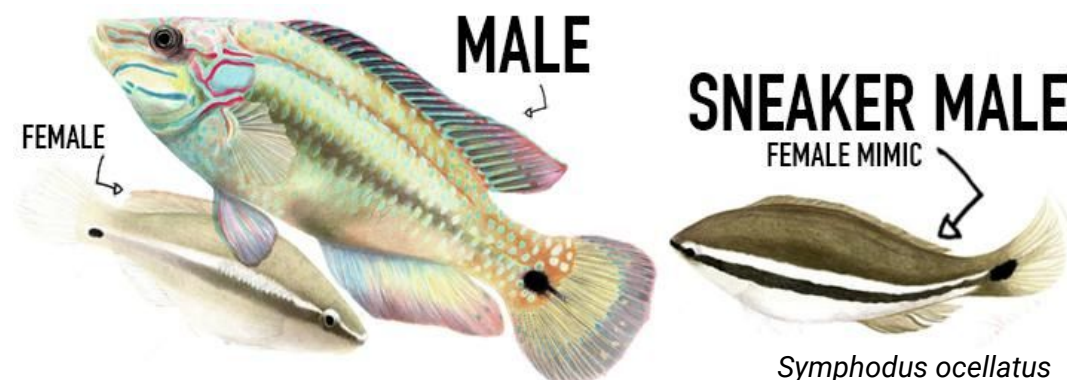
“sex-associated phenotypic dimorphism”



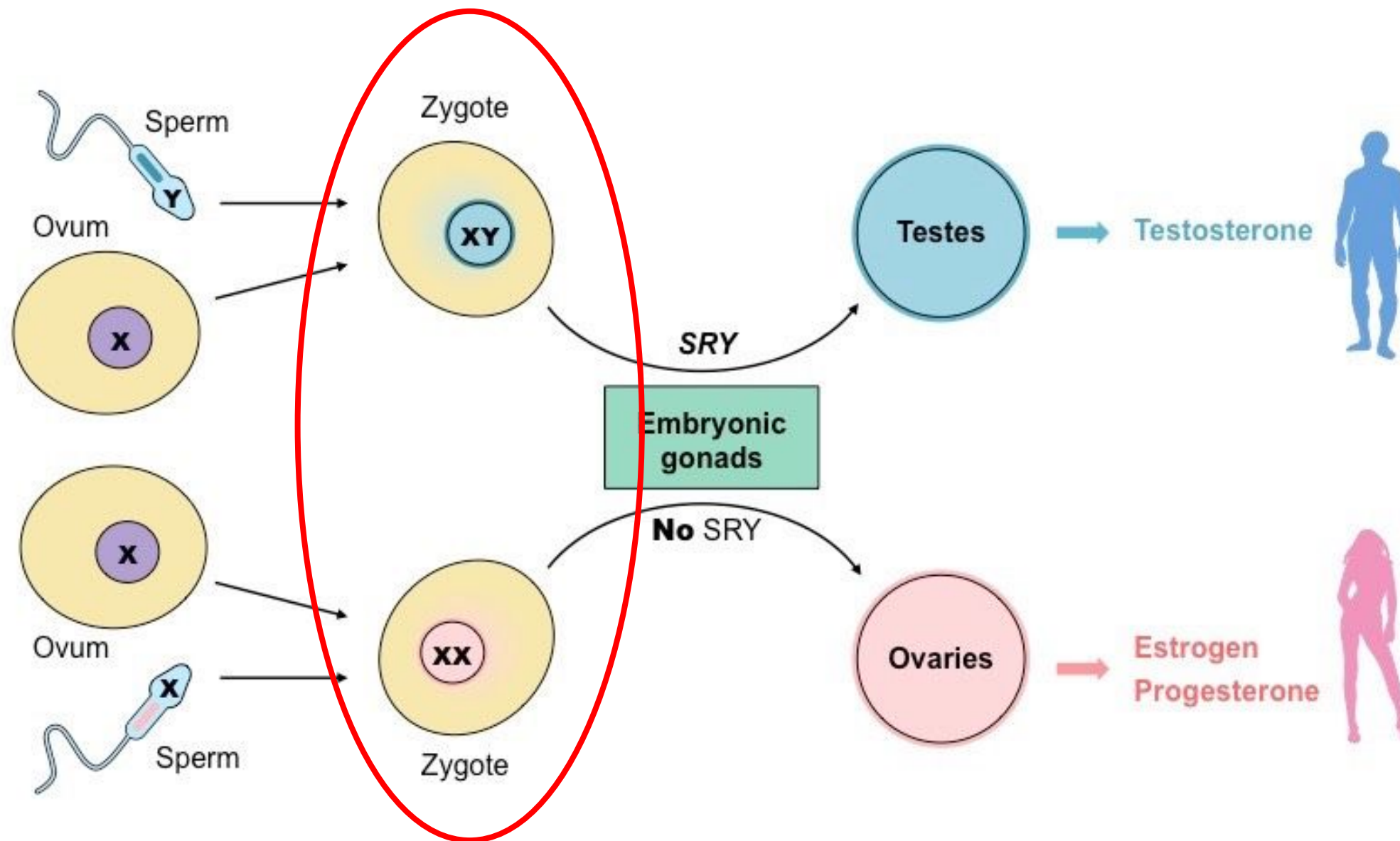
Gymnotus omarorum



Goneplax rhomboides

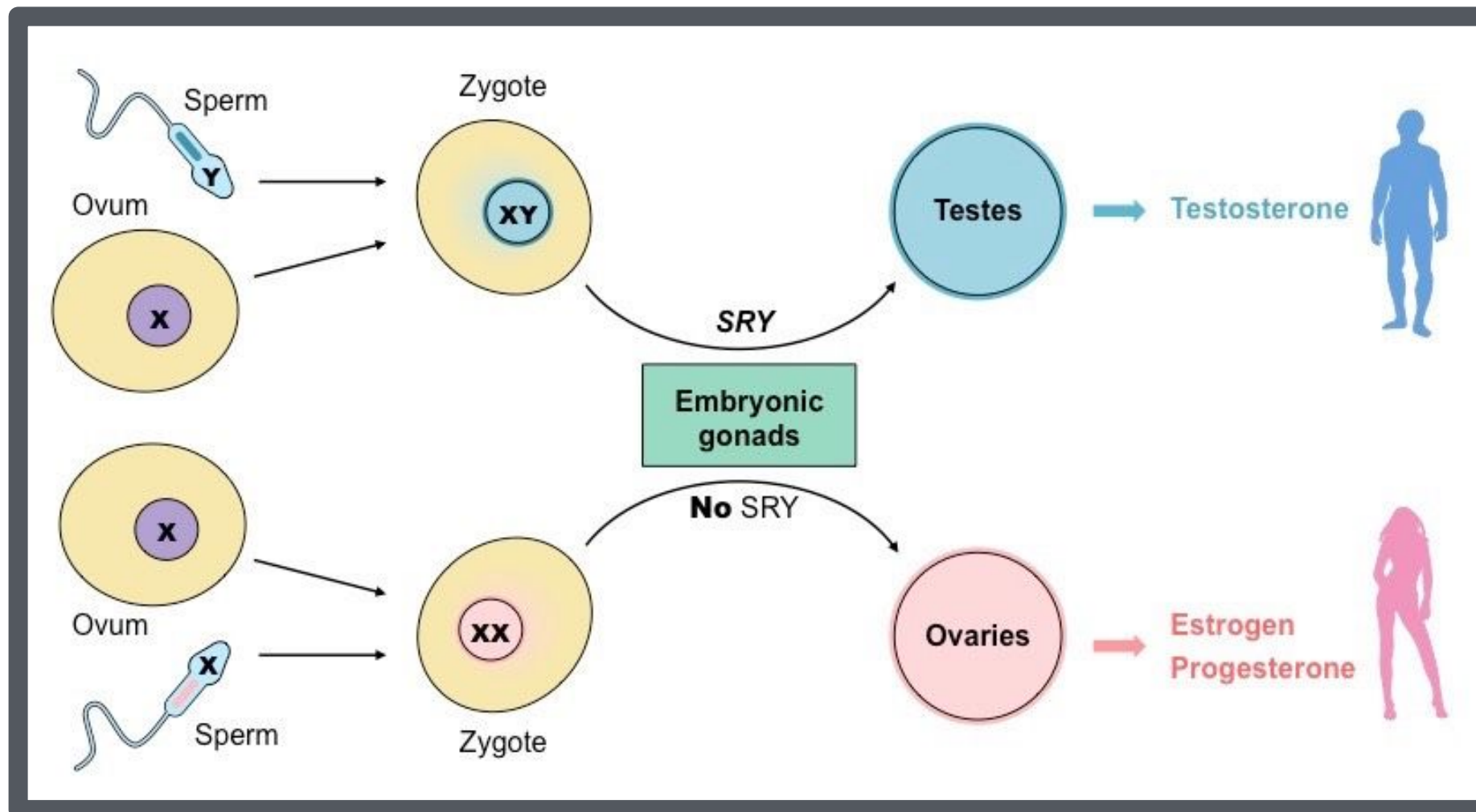


how it is taught



inaccuracies

?



diversity

sexual reproduction

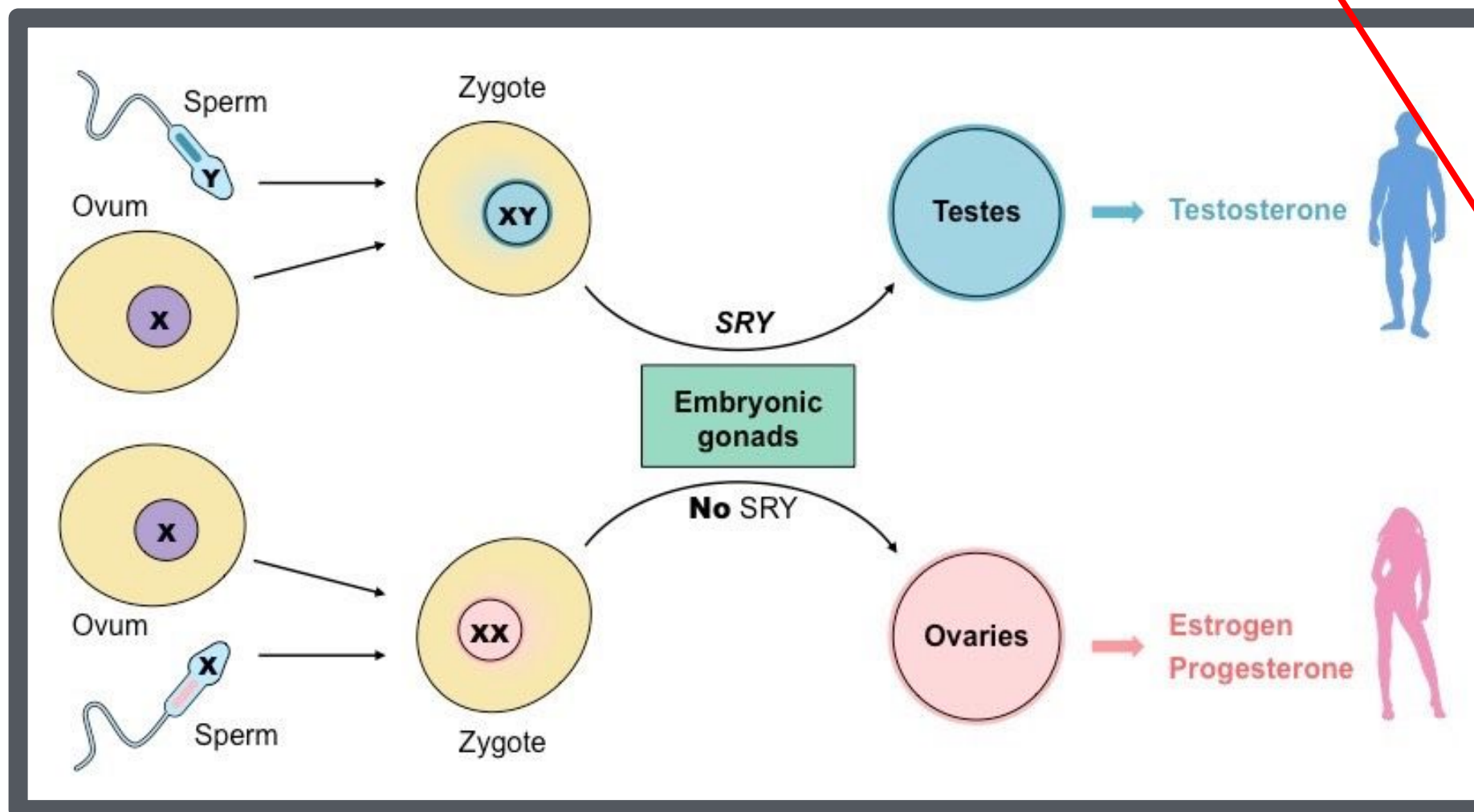
sex determination

sexual selection

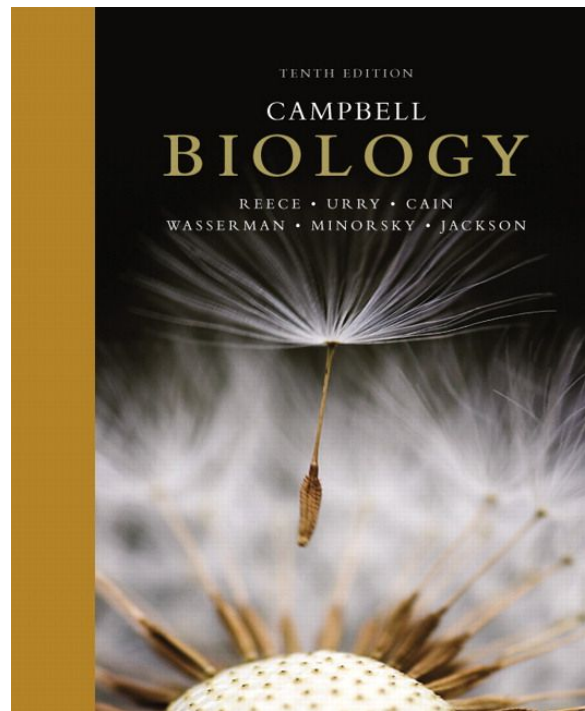
resources

inaccuracies

2. Other strategies and diversities are weird, rare or disordered



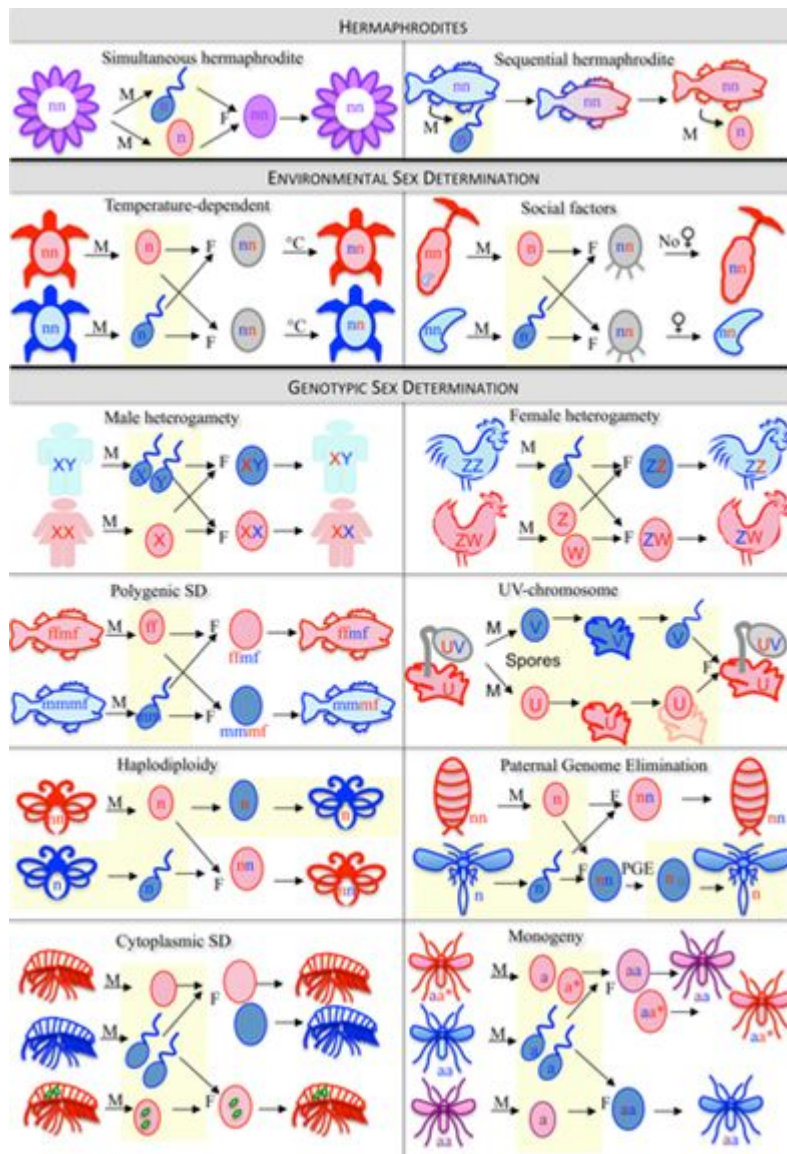
inaccuracies



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a different framework



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PLOS BIOLOGY

Essay

Sex Determination: Why So Many Ways of Doing It?

Doris Bachtrog^{1*}, Judith E. Mank², Catherine L. Peichel³, Mark Kirkpatrick⁴, Sarah P. Otto⁵, Tia-Lynn Ashman⁶, Matthew W. Hahn⁷, Jun Kitano⁸, Itay Mayrose⁹, Ray Ming¹⁰, Nicolas Perrin¹¹, Laura Ross¹², Nicole Valenzuela¹³, Jana C. Vamosi¹⁴, The Tree of Sex Consortium¹

diversity

sexual reproduction

sex determination

sexual selection

resources

a different framework

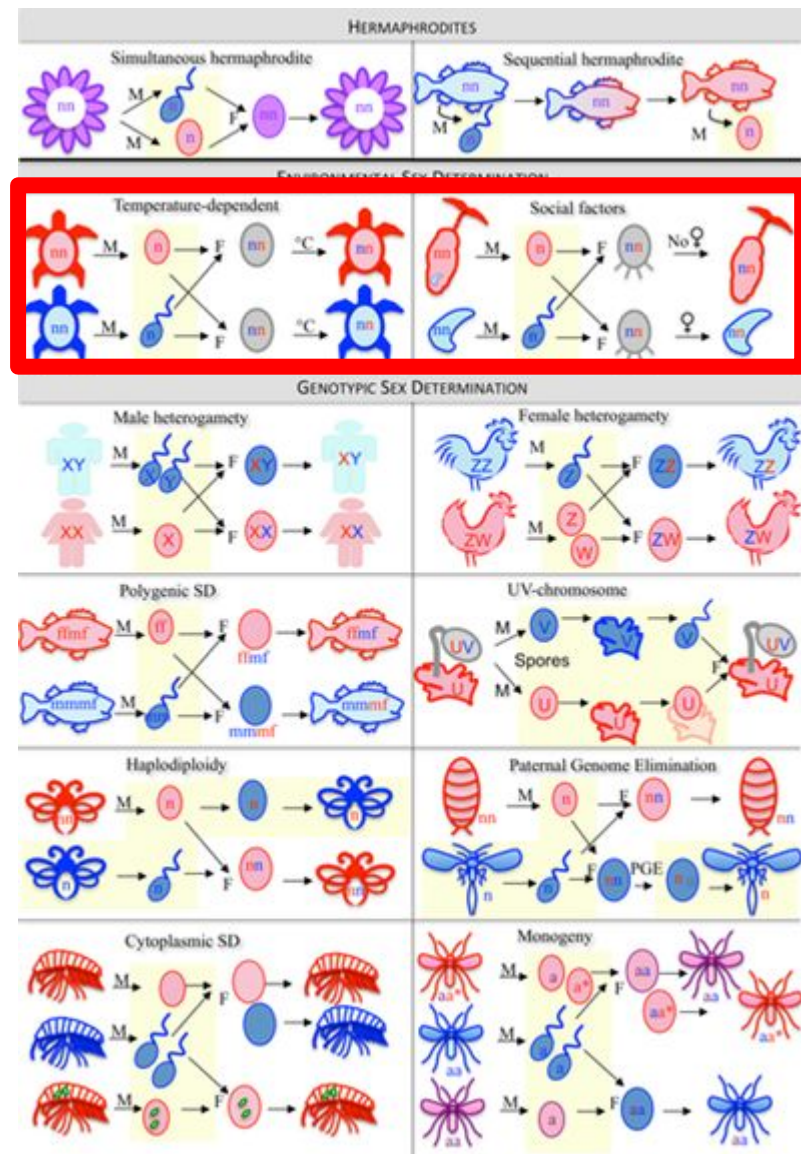


Photo: Sylvain Ledoyen

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diversity

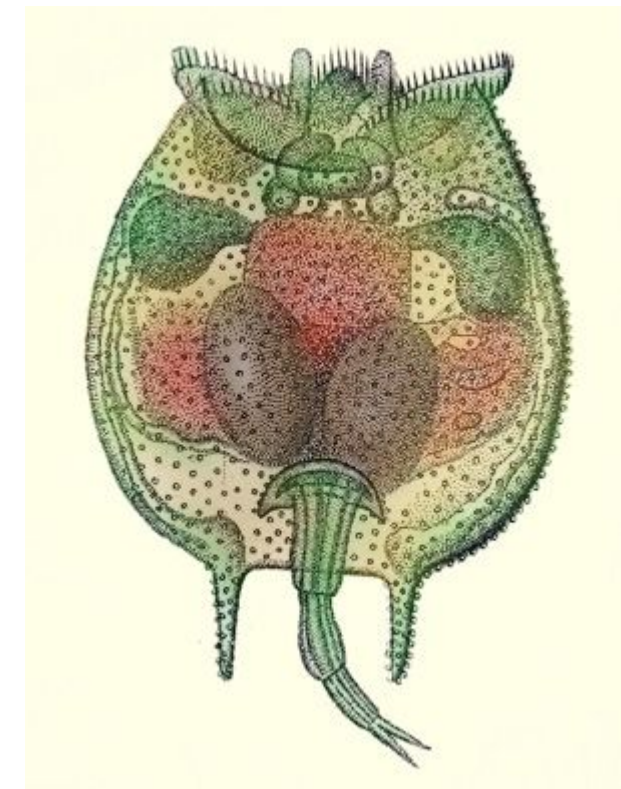
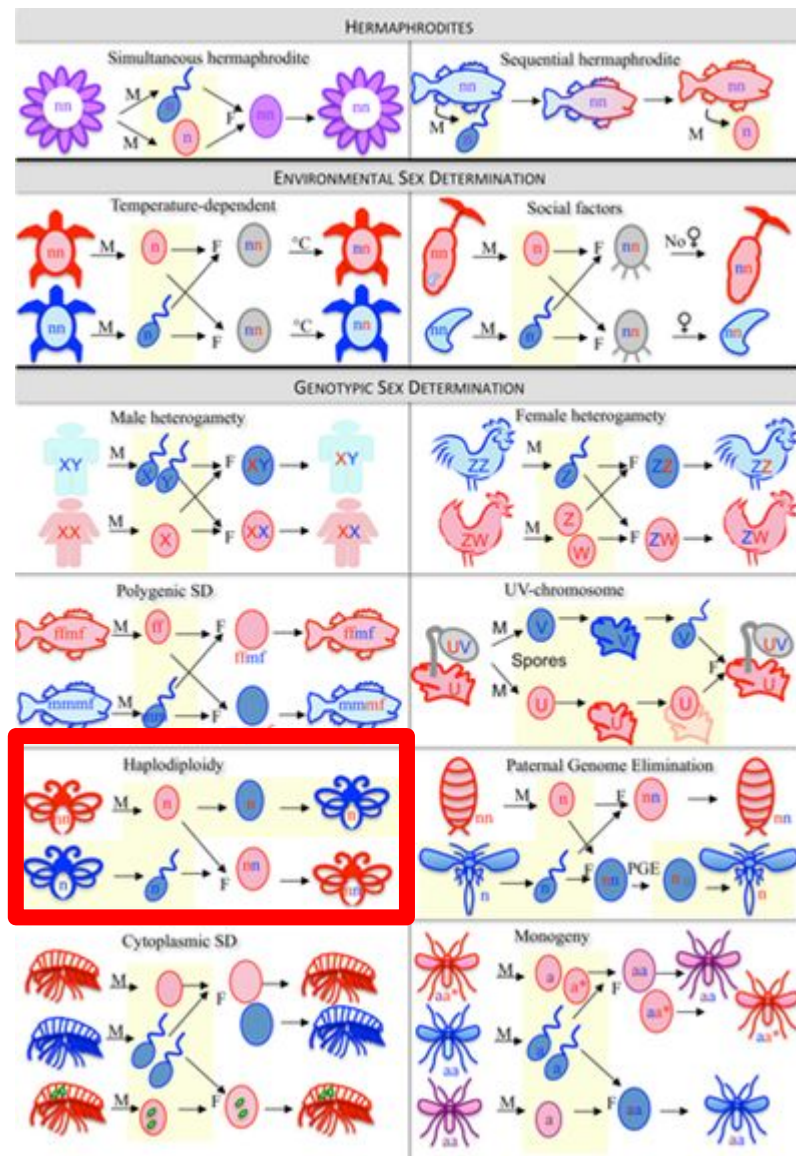
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diversity

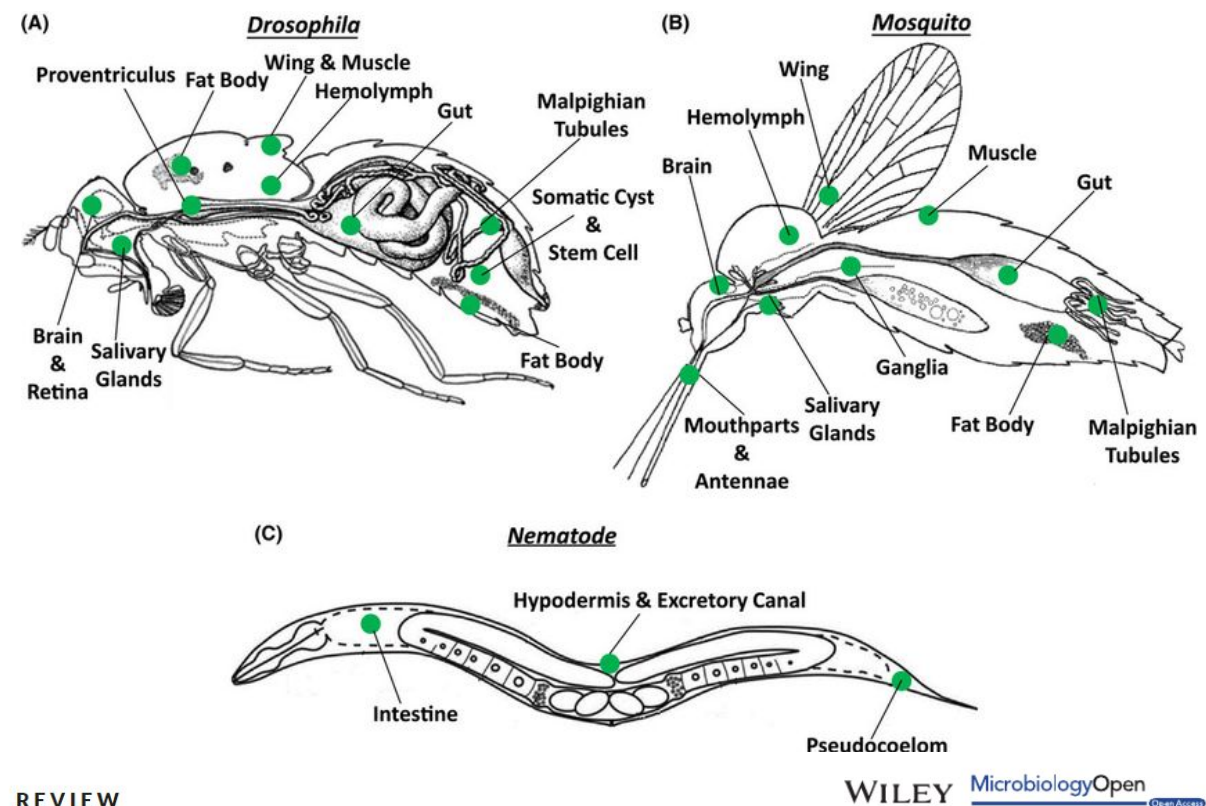
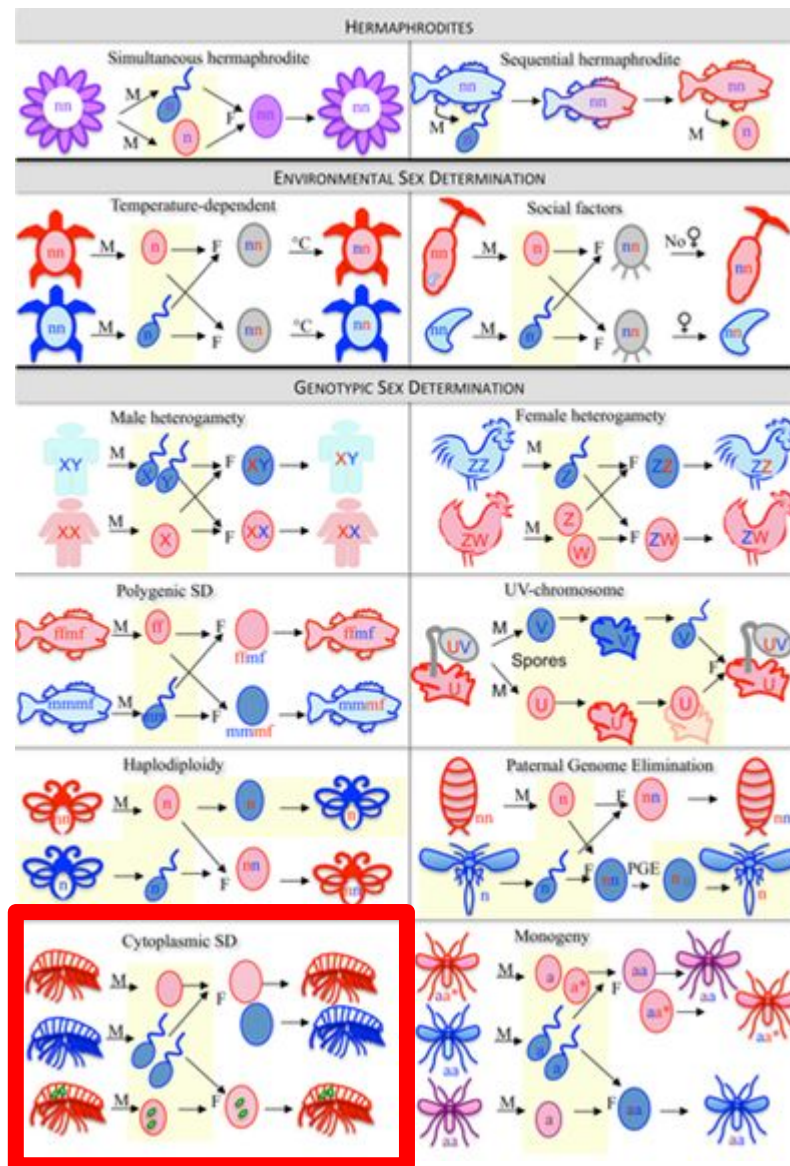
sexual reproduction

sex determination

sexual selection

resources

a different framework



REVIEW

The rich somatic life of *Wolbachia*

Jose E. Pietri¹ | Heather DeBruhl² | William Sullivan¹



OPEN ACCESS Freely available online

Essay

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diversity

sexual reproduction

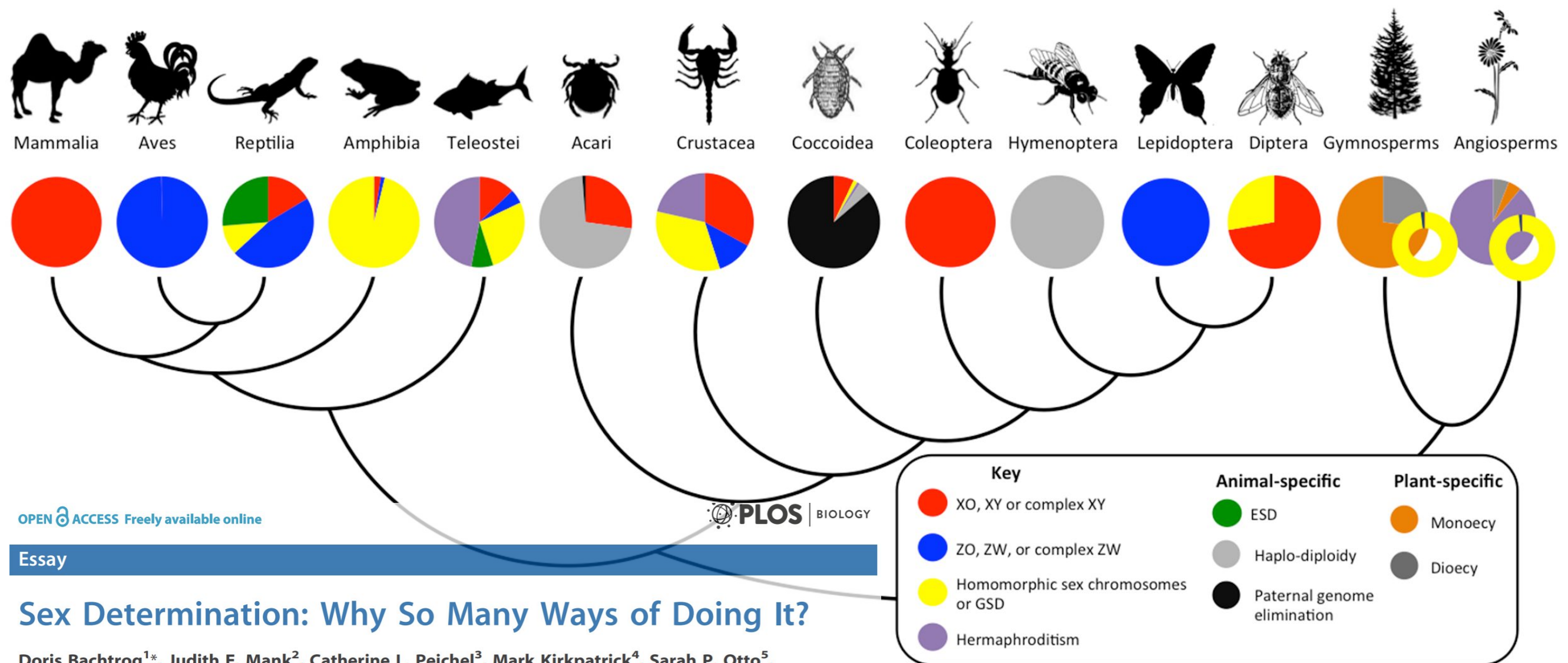
sex determination

sexual selection

resources

a different framework

Sex determination systems are diverse and can evolve quickly



diversity

sexual reproduction

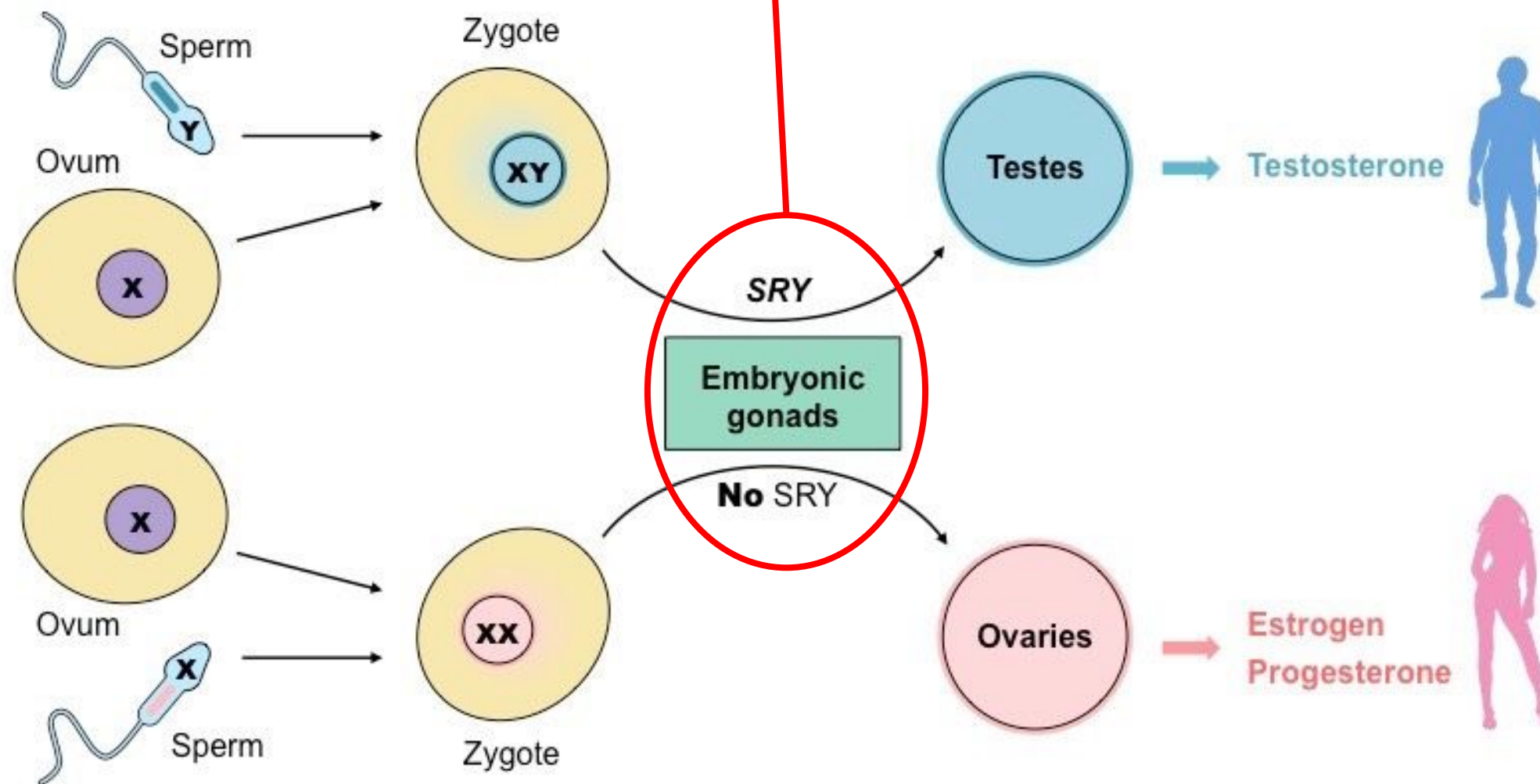
sex determination

sexual selection

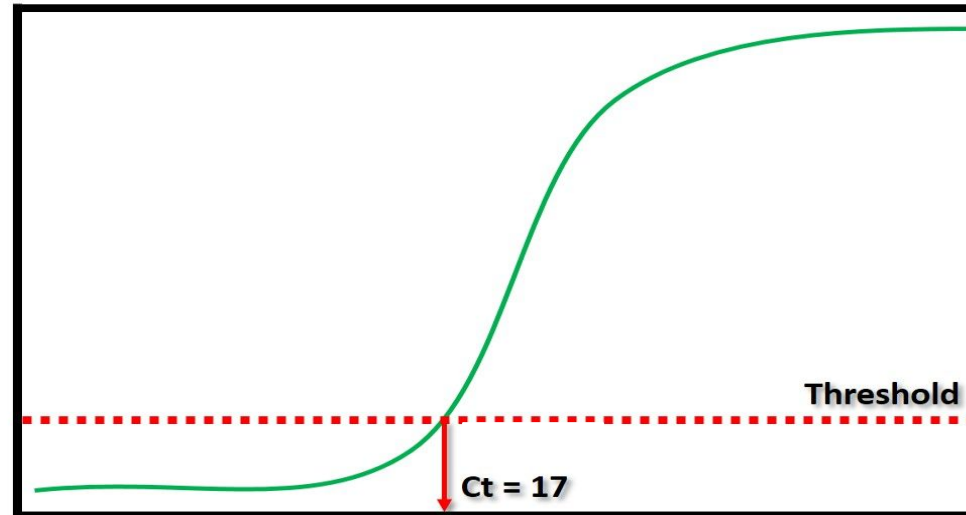
resources

inaccuracies

3. The “master switch”



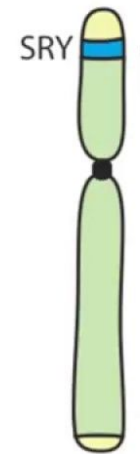
the “master switch”, debunked



the “master switch”, debunked



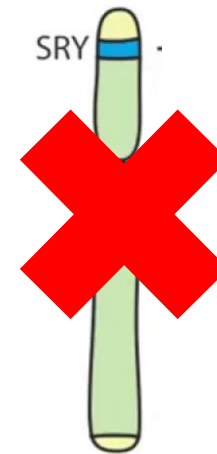
15-40% of
females:



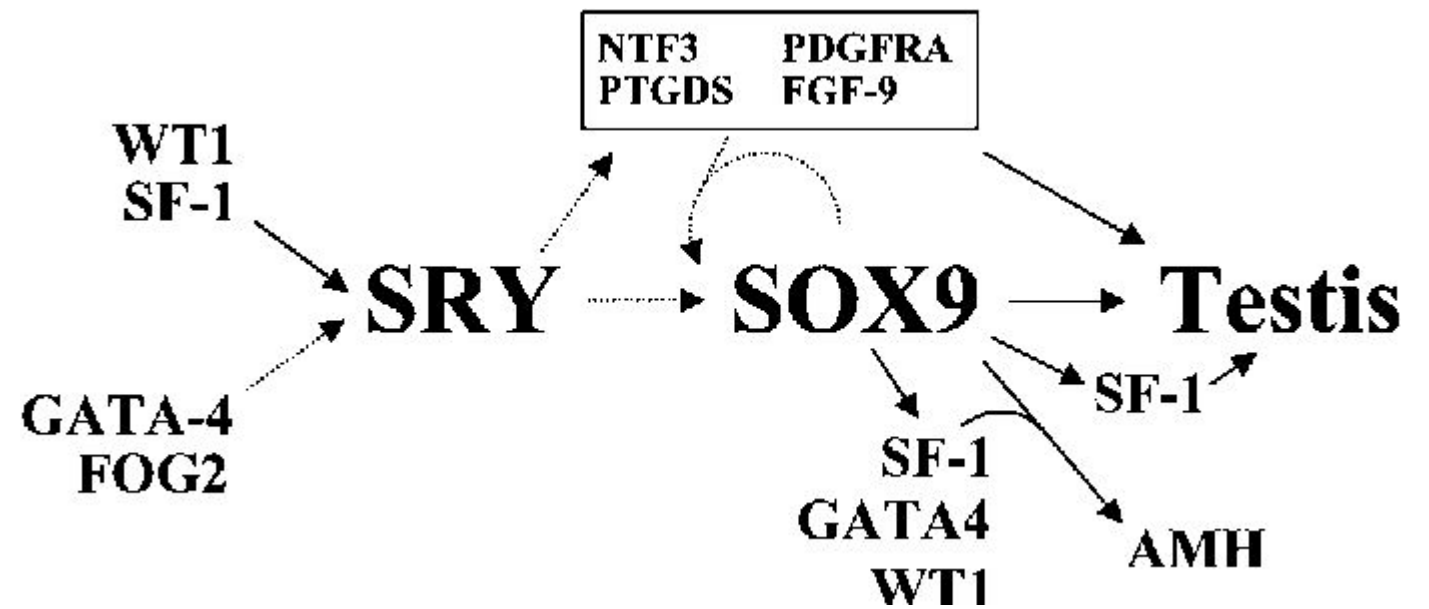
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diversity

sexual reproduction

sex determination

sexual selection

resources

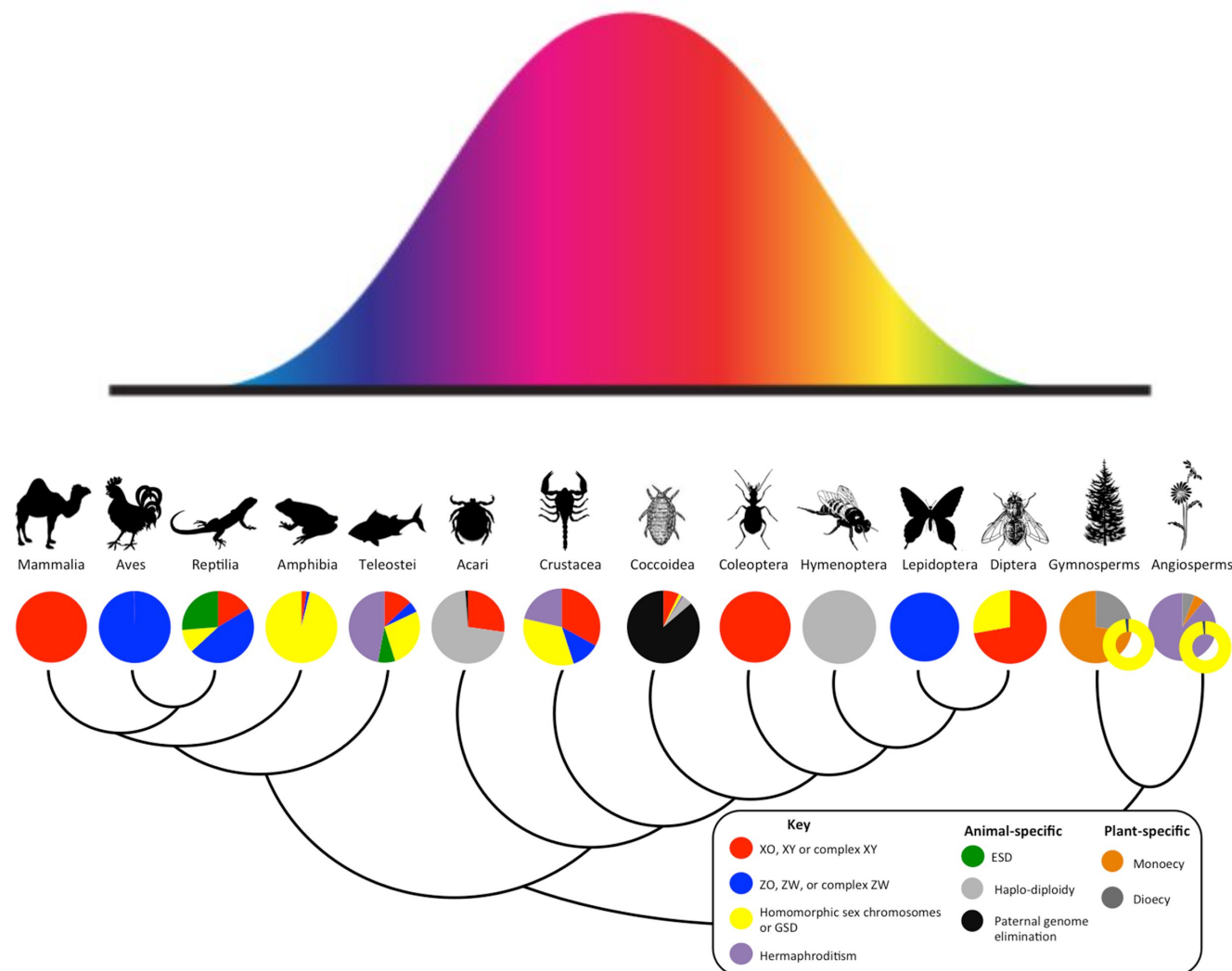
a different framework

Sex determination is a genetic/hormonal/environmental negotiation within and across species



a different framework

Sex determination is a genetic/hormonal/environmental negotiation within and across species



diversity

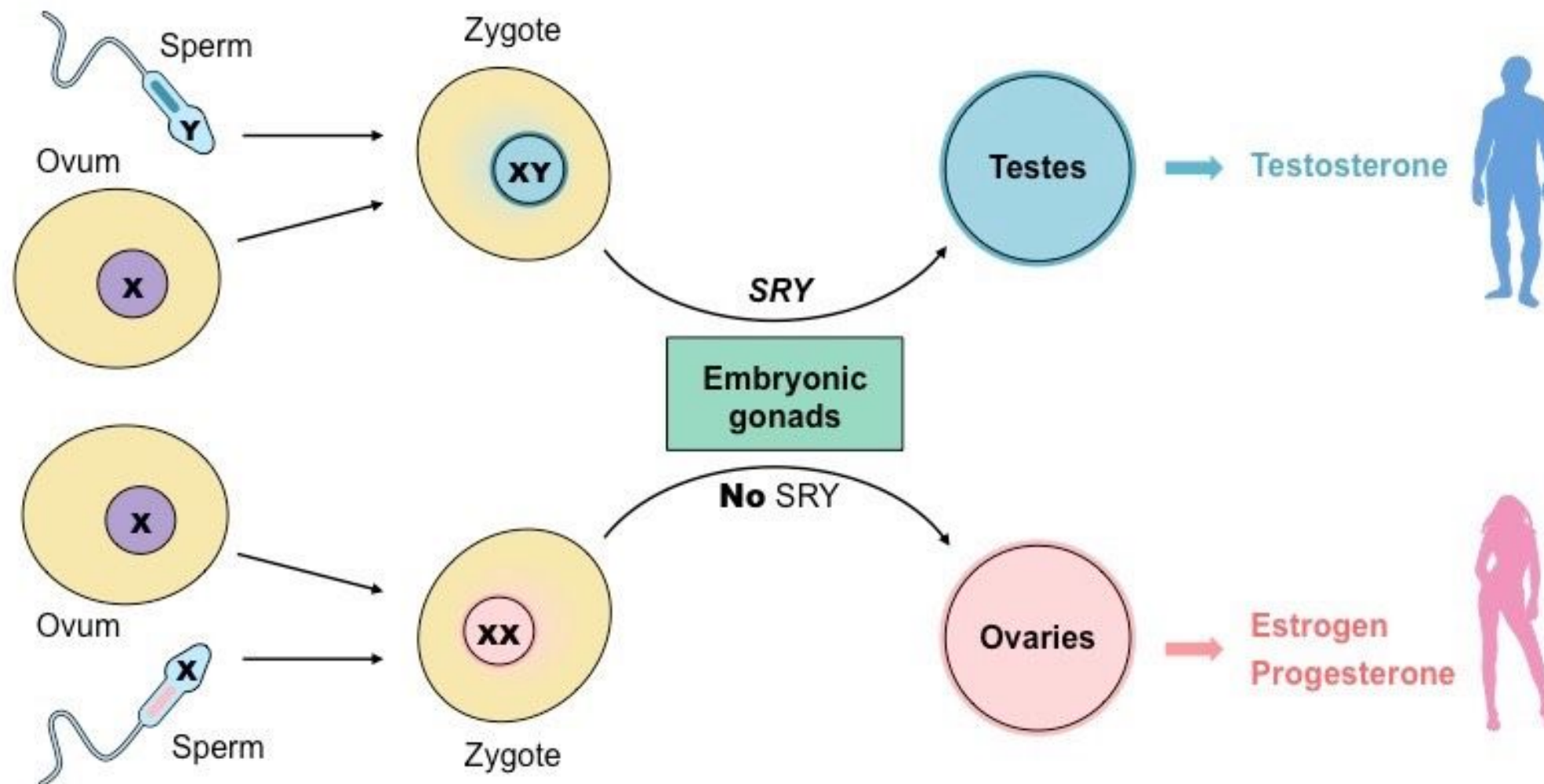
sexual reproduction

sex determination

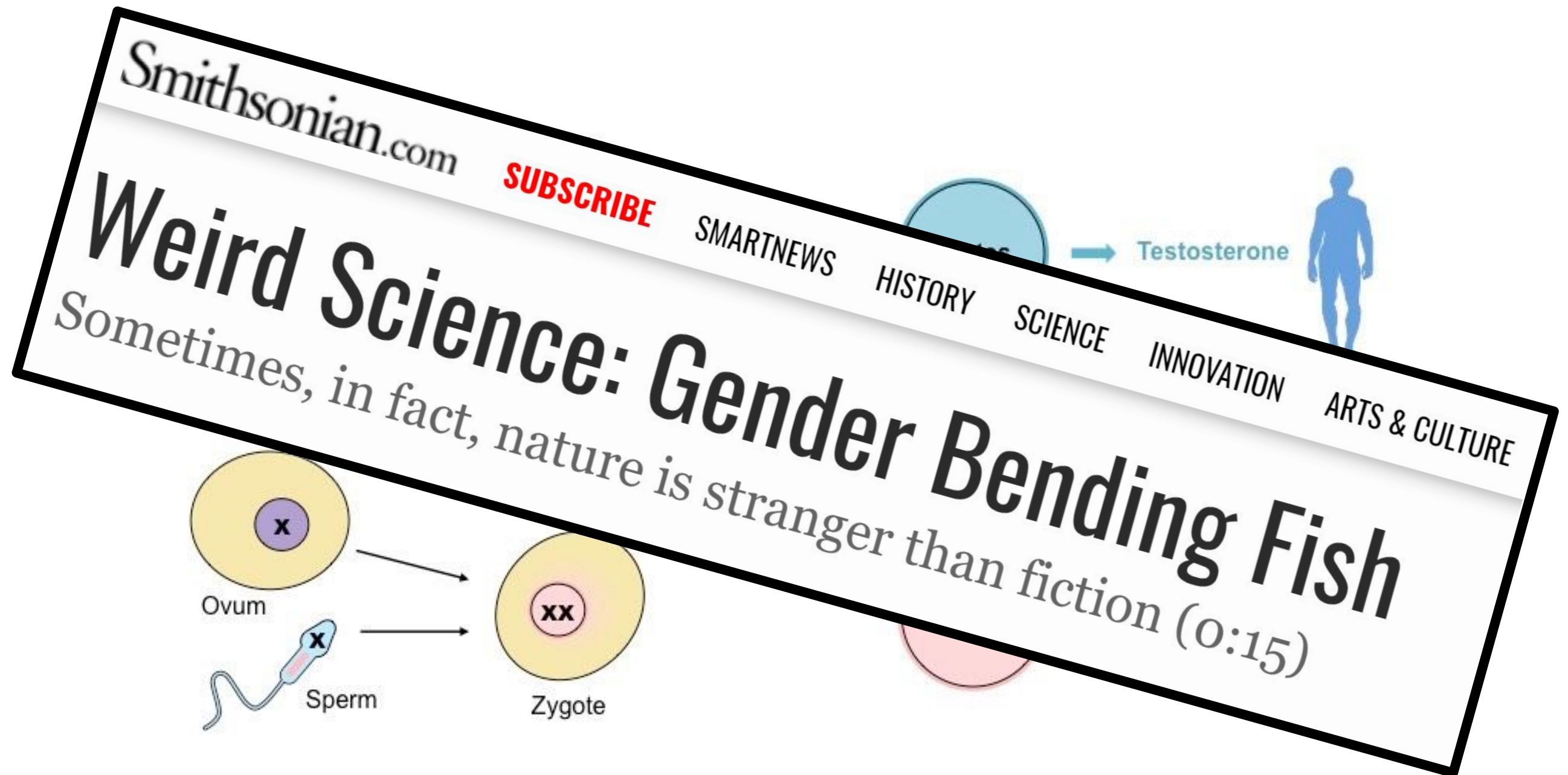
sexual selection

resources

inaccuracies



inaccuracies



diversity

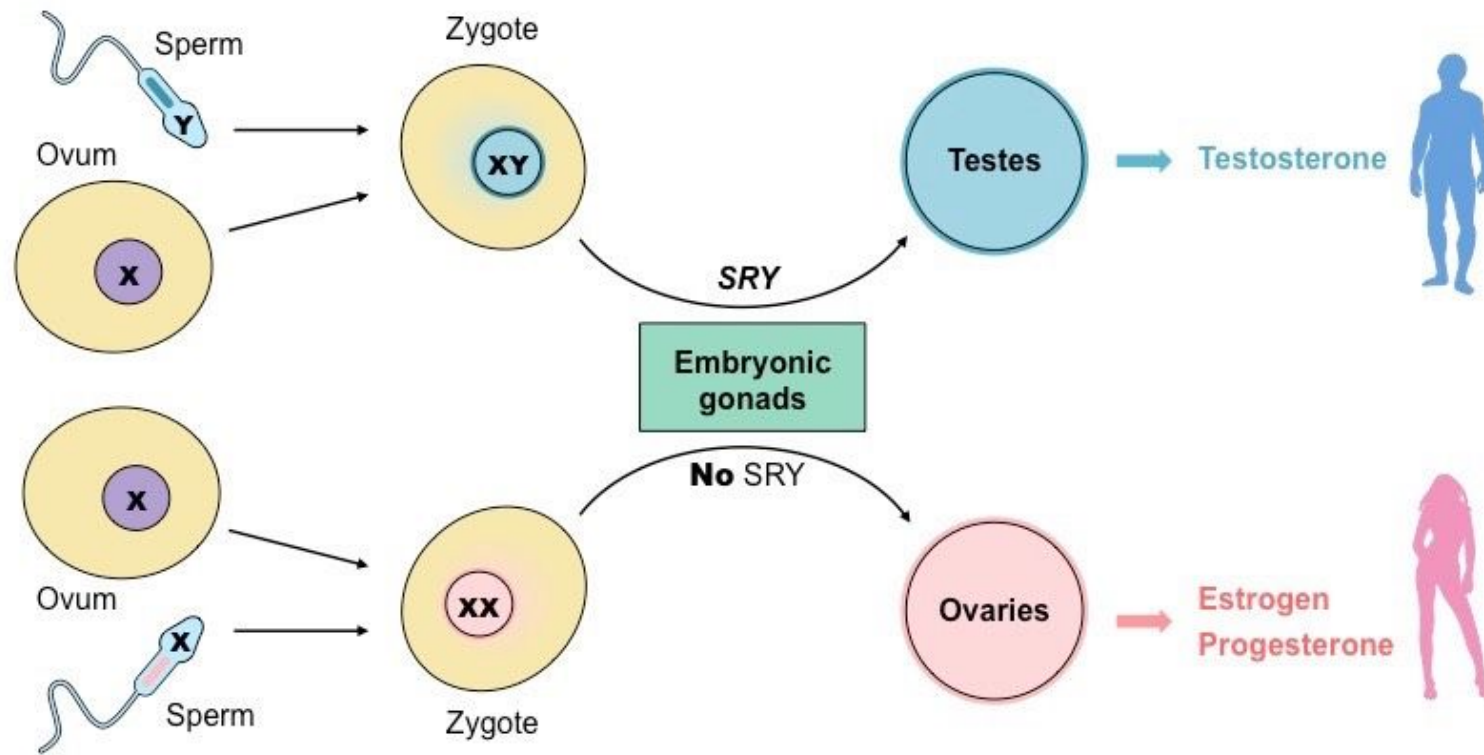
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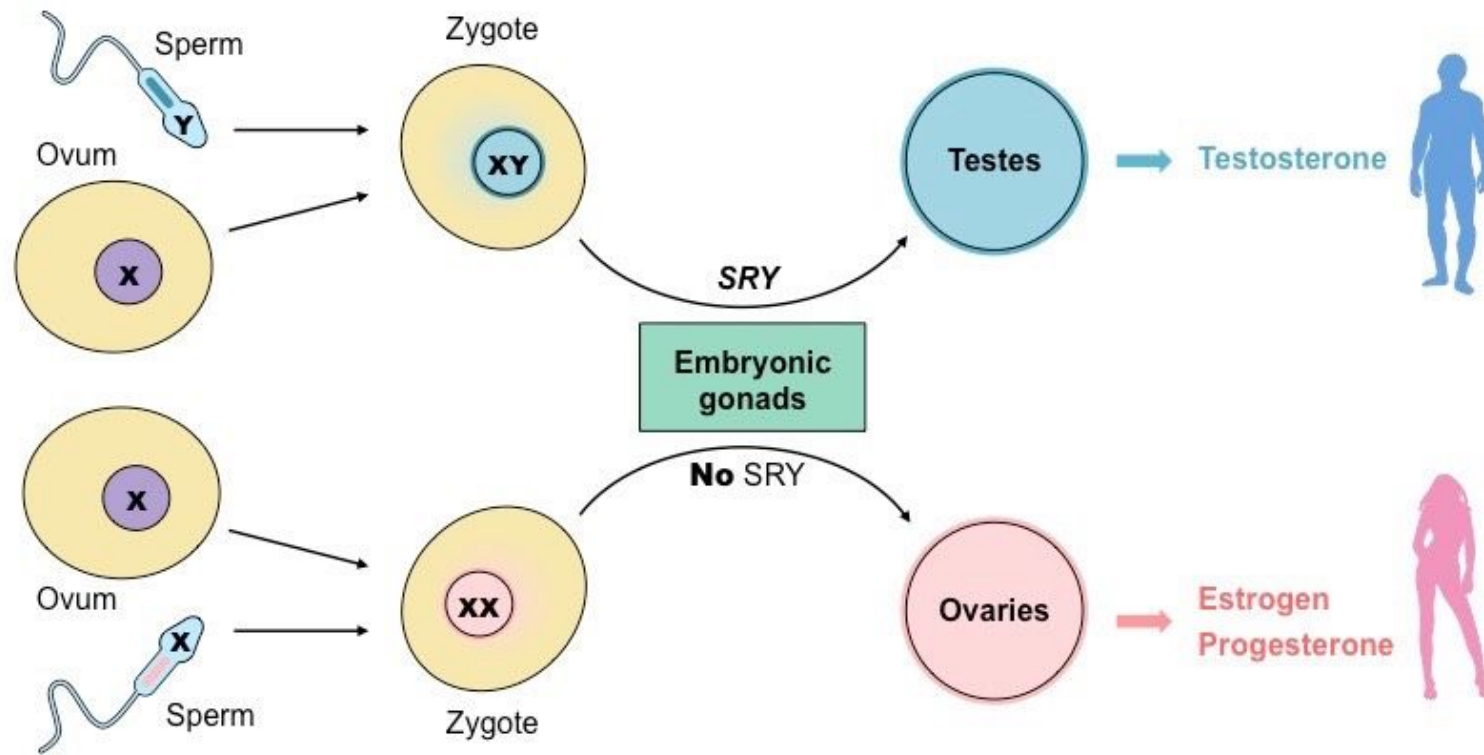


sex chromosome A chromosome responsible for determining the sex of an individual.
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Accuracy problems:

- Not all organisms have chromosome-determined sex
- It is not this deterministic

inaccuracies



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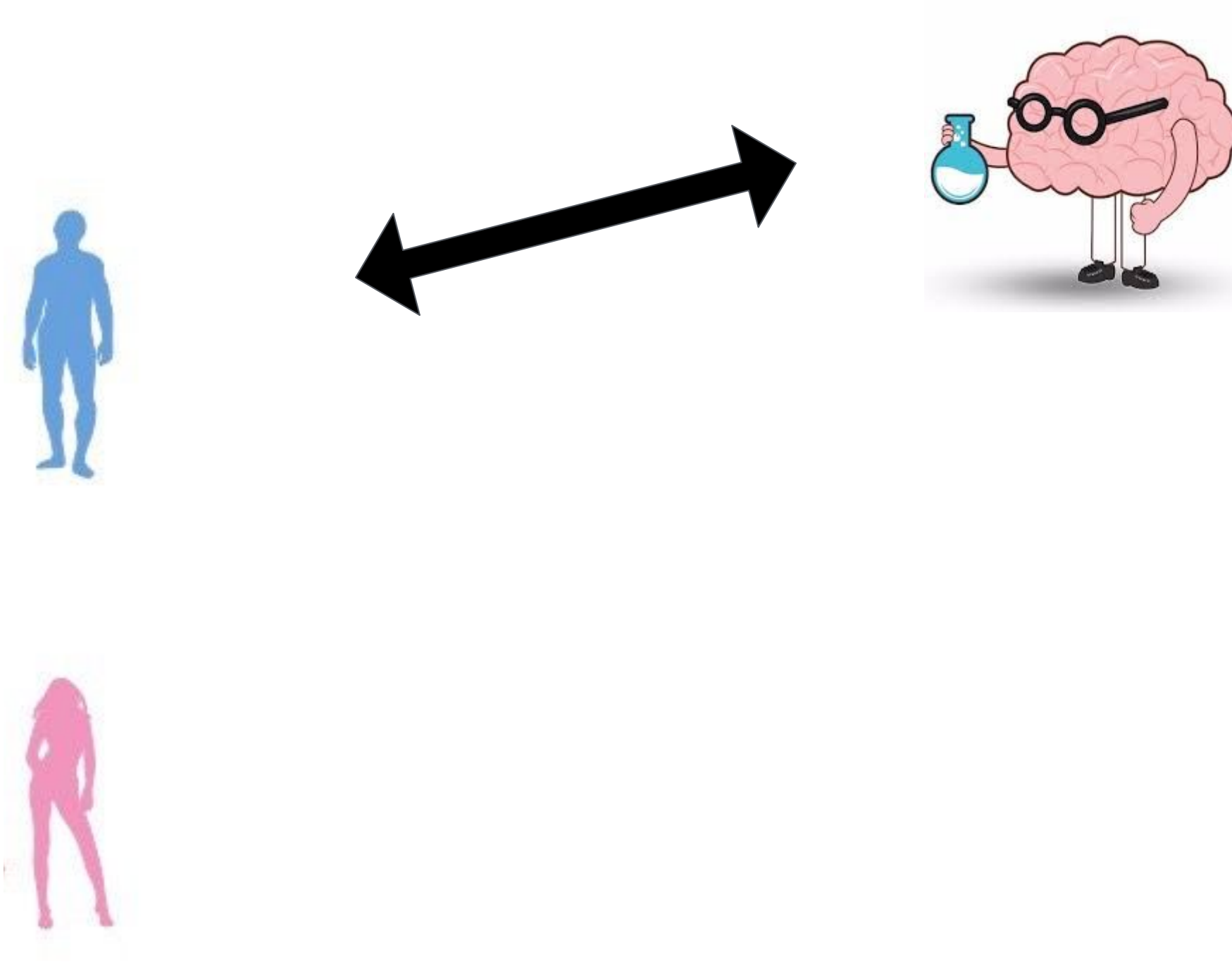
Accuracy problems:

- Not all organisms have chromosome-determined sex
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Inclusivity problems:

- Suggests that gender = biological sex
- Intersex students are erased or disordered
- Variation in sexual dimorphism and sexual characteristics is harder to understand

inaccuracies



diversity

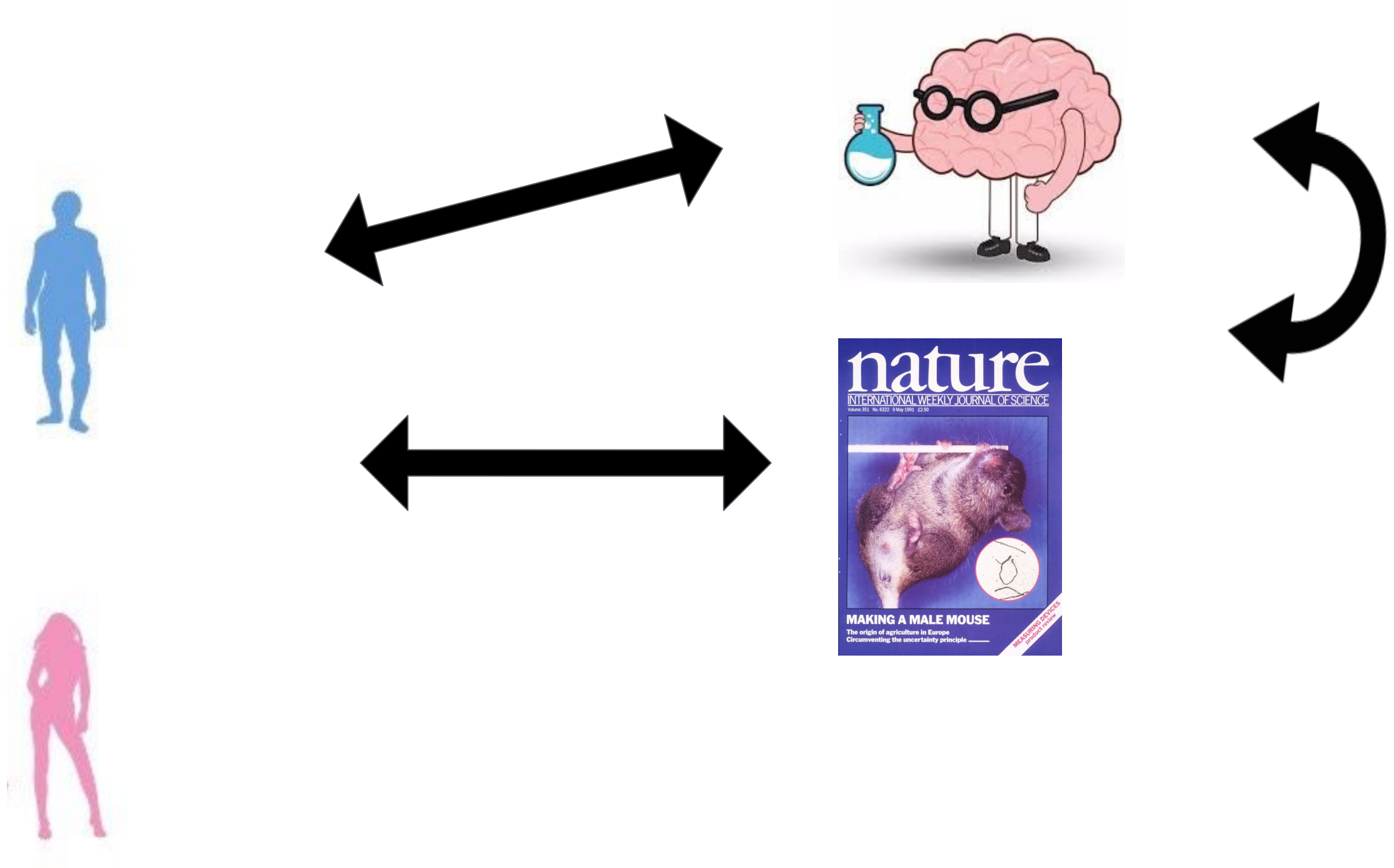
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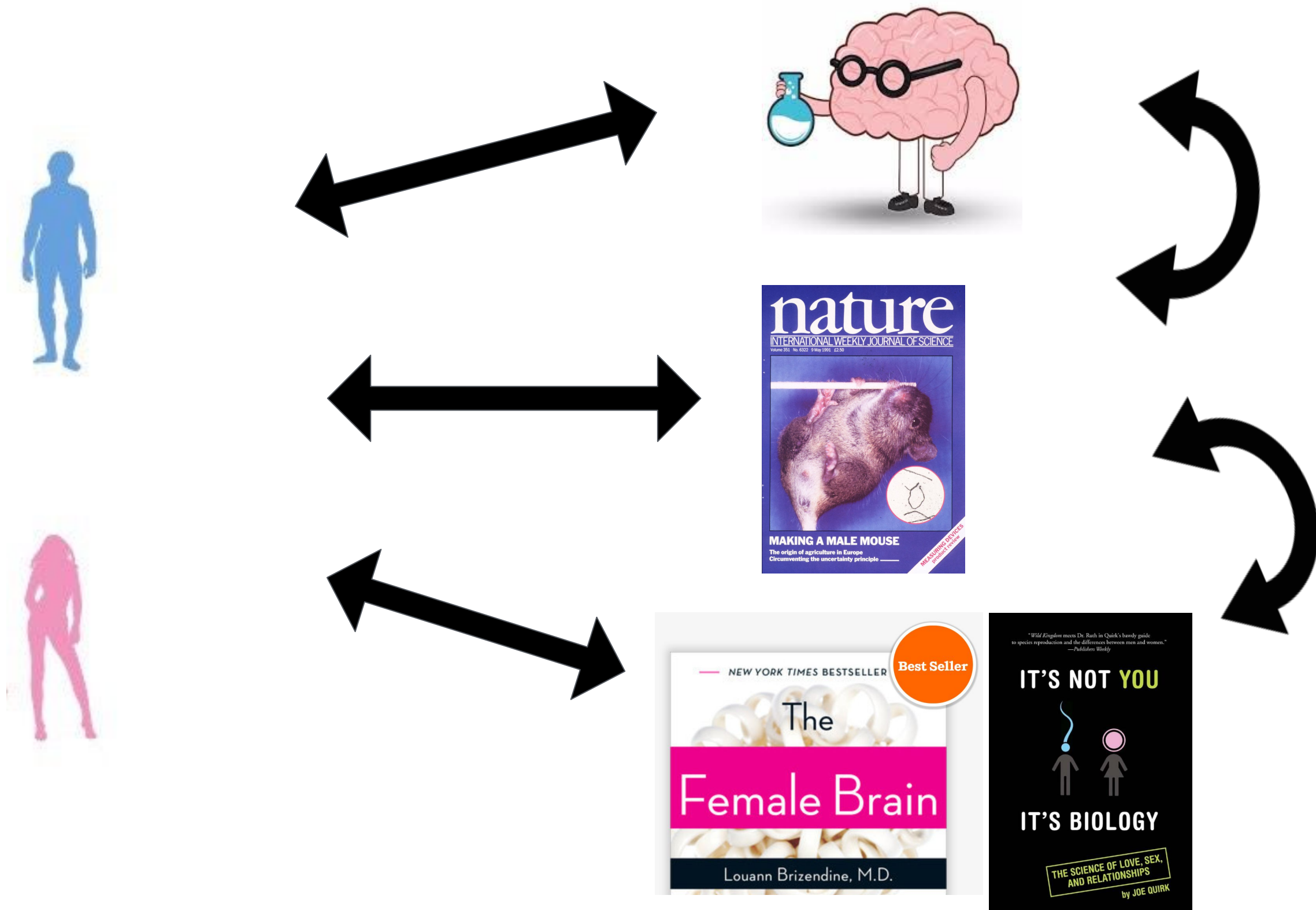
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diversity

sexual reproduction

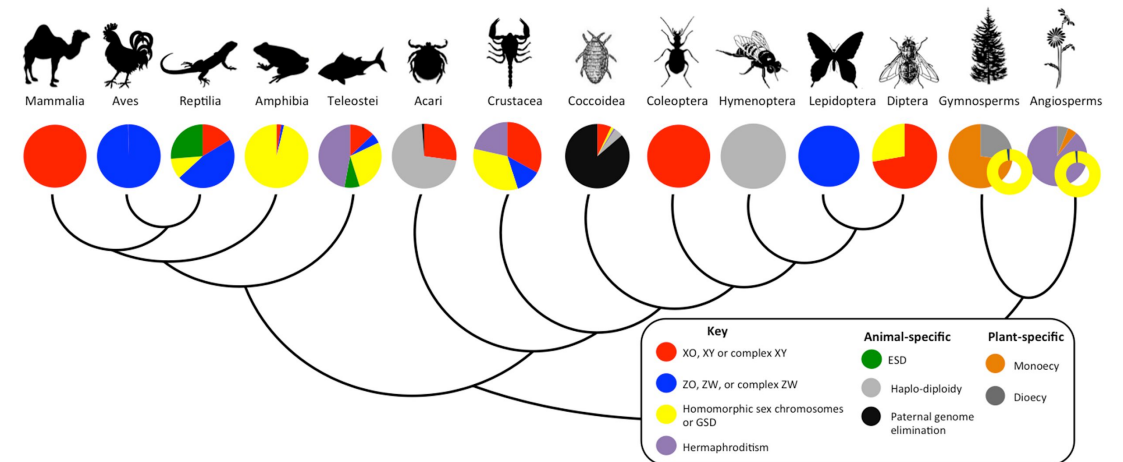
sex determination

sexual selection

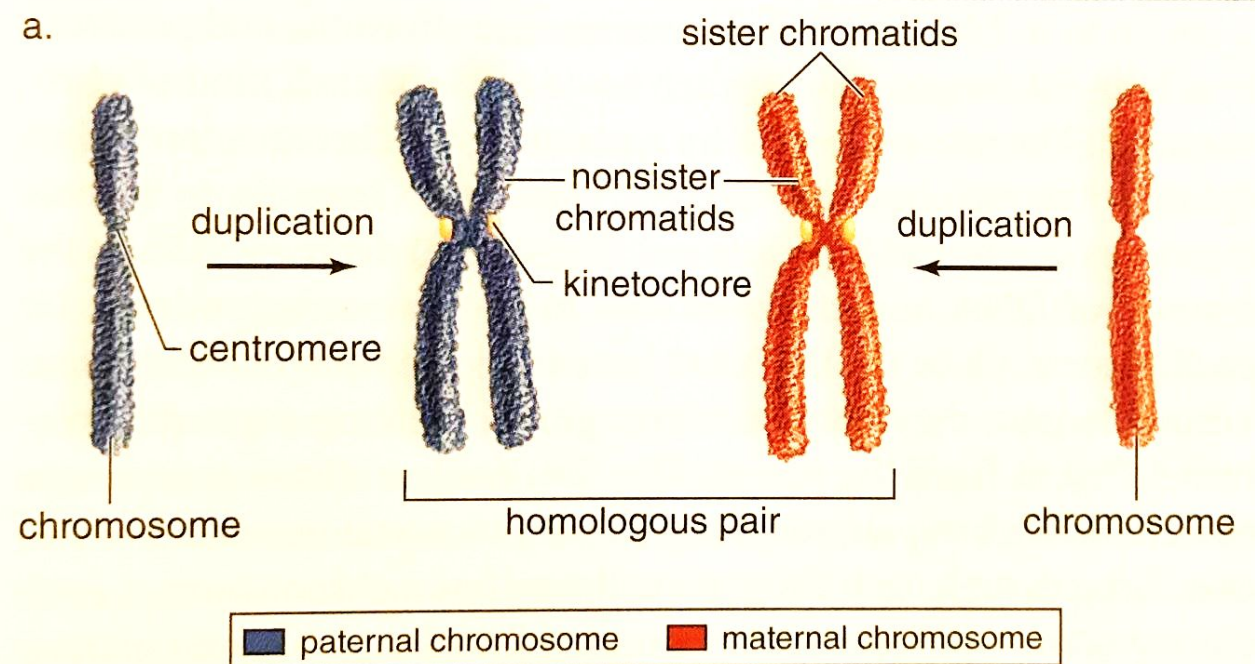
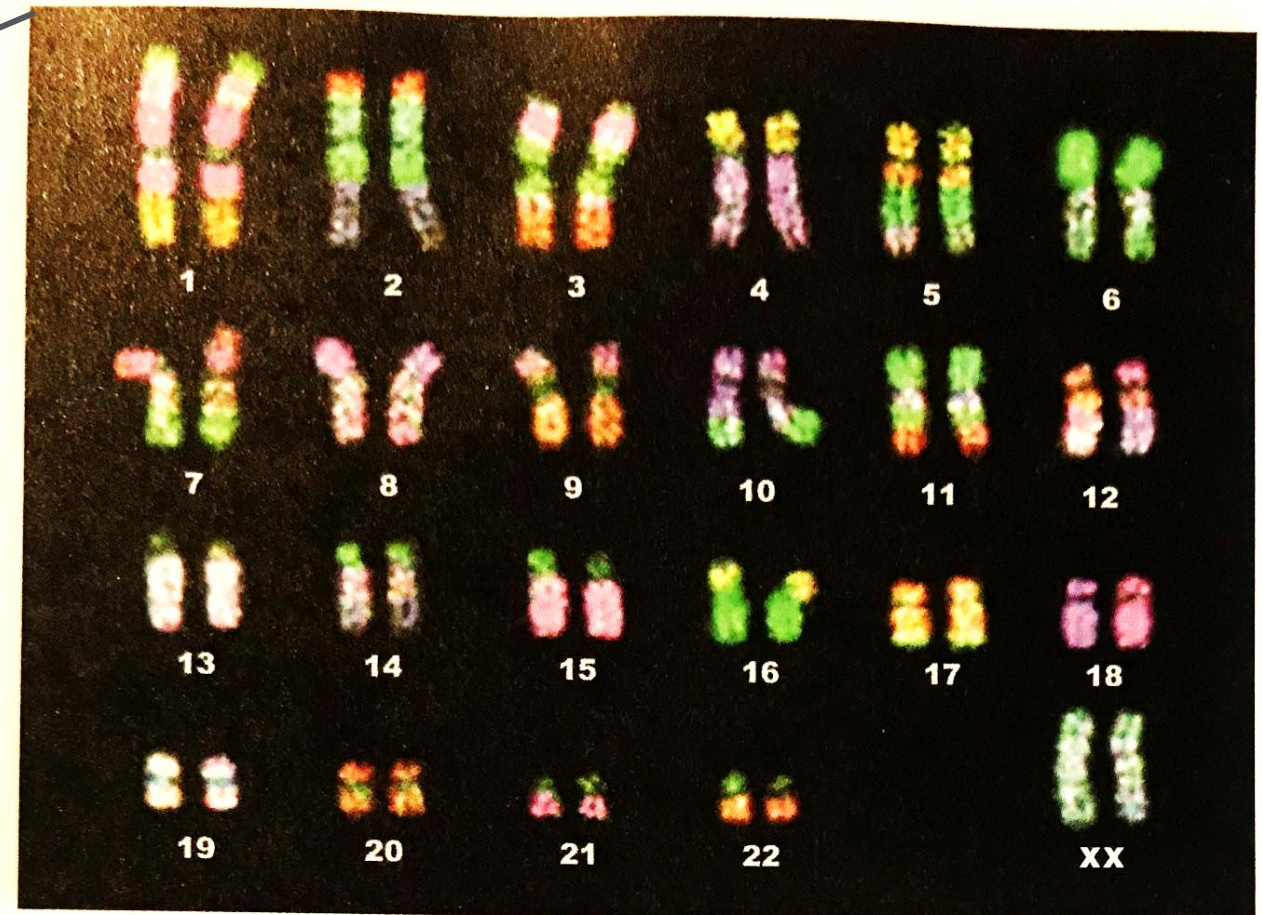
resources

a different framework

1. Define “sex” and “sexual dimorphism”.
2. Sex determination is a genetic/hormonal/environmental negotiation
3. Sex determination systems are diverse across species
4. Sex is one of many forms of variation within species

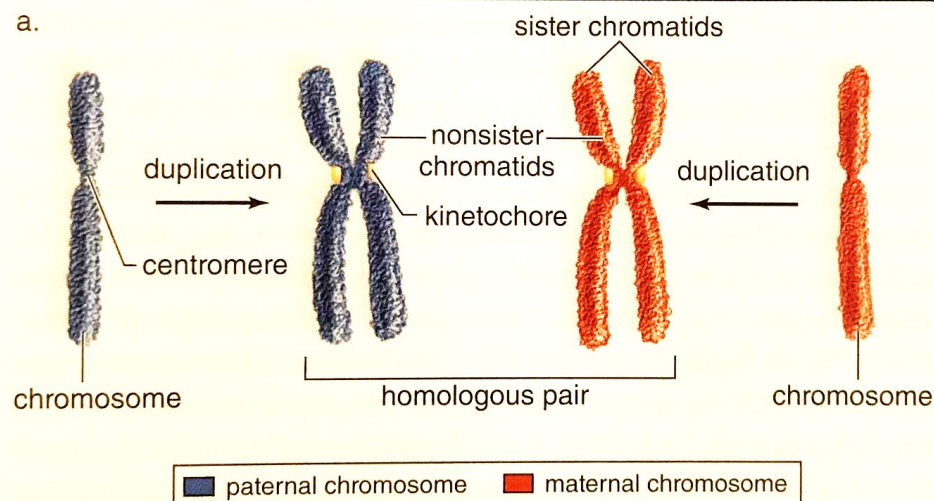
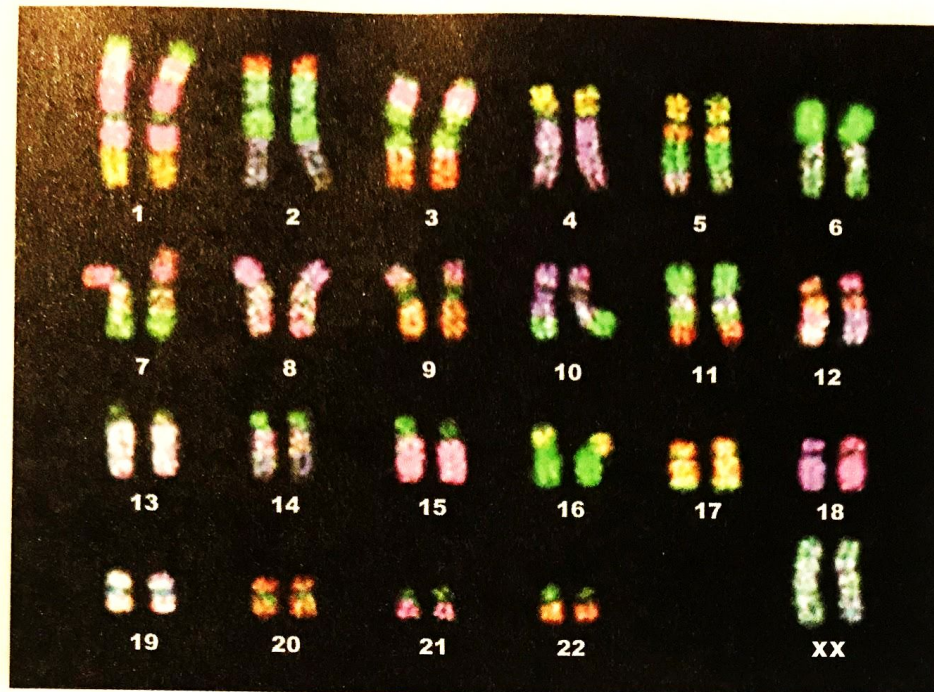


your turn



Biology, 12th Edition. 2016.
by Mader and Windelspecht.

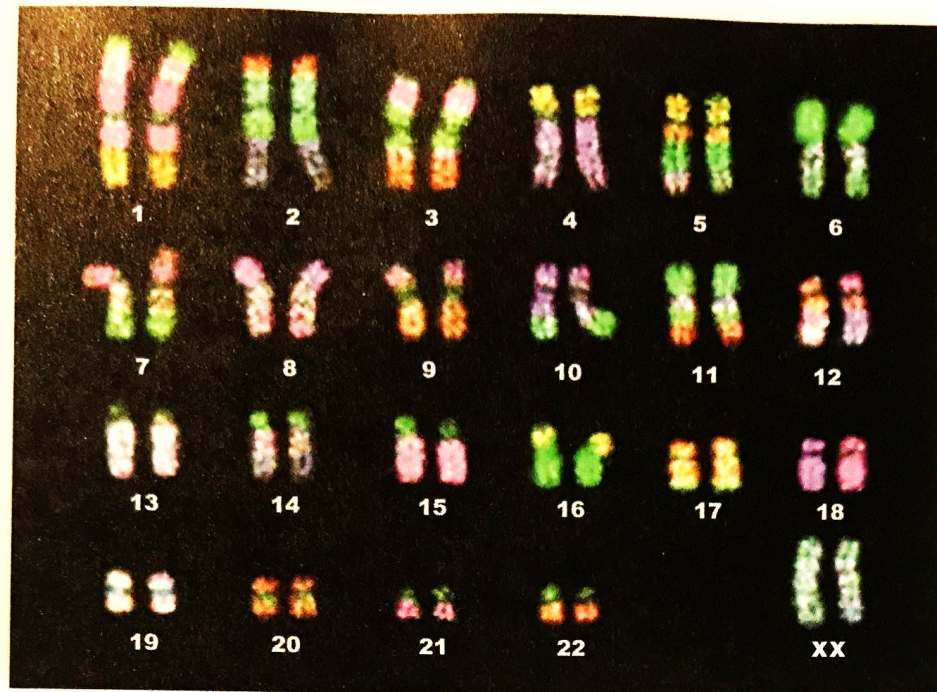
your turn



“Figure 10.1

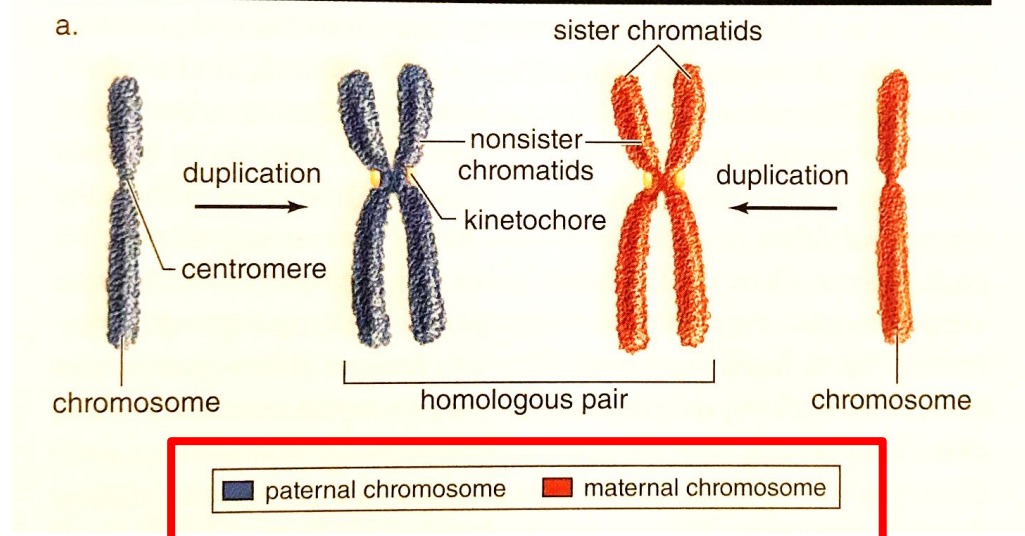
In this micrograph of stained chromosomes from a human cell, the pairs have been numbered 1-22 and XX. Note that chromosome pairs 1-22 are autosomes, coding for nonsex traits, whereas the XX pair includes the sex chromosomes and helps determine human gender.”

thoughts?



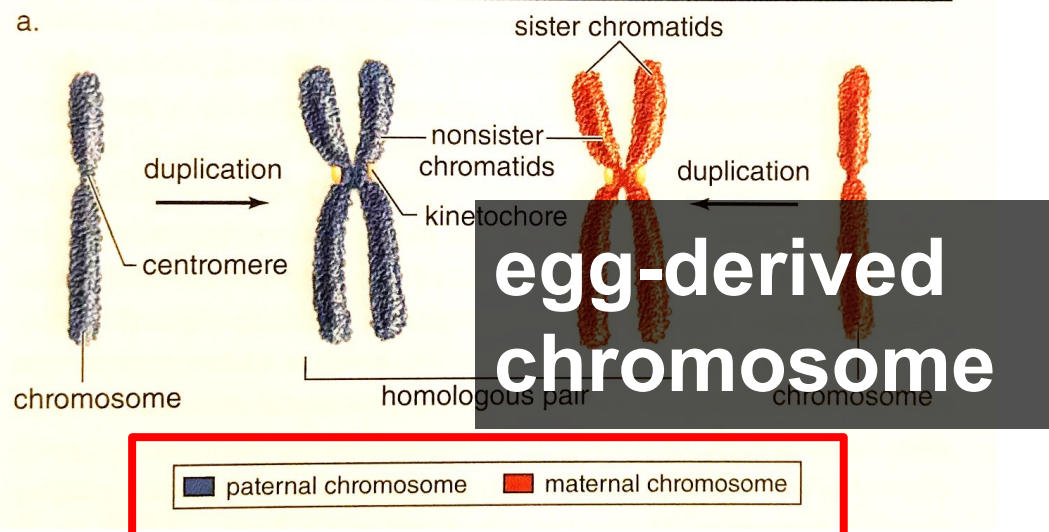
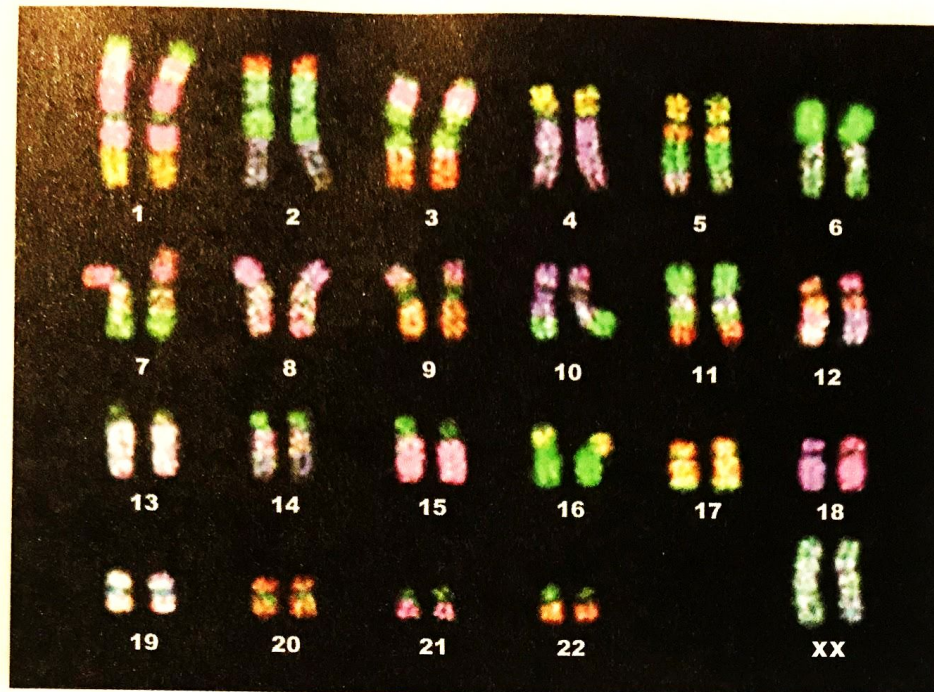
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Biology, 12th Edition. 2016.
by Mader and Windelspecht.

thoughts?



“Figure 10.1

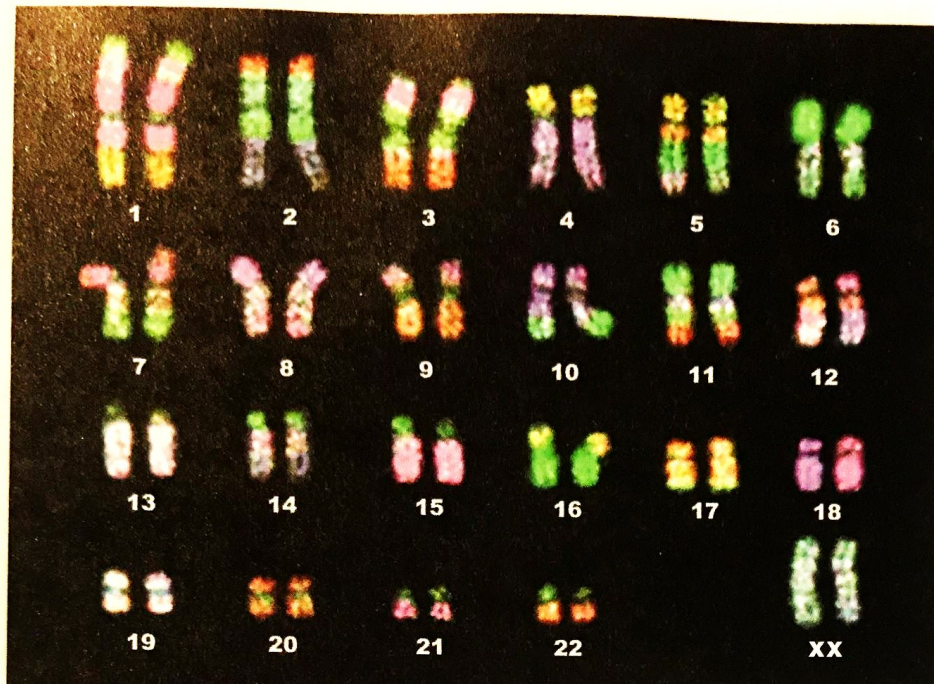
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determine biological sex

sperm-derived
chromosome

Biology, 12th Edition. 2016.
by Mader and Windelspecht.

a different framework



Sex chromosomes:

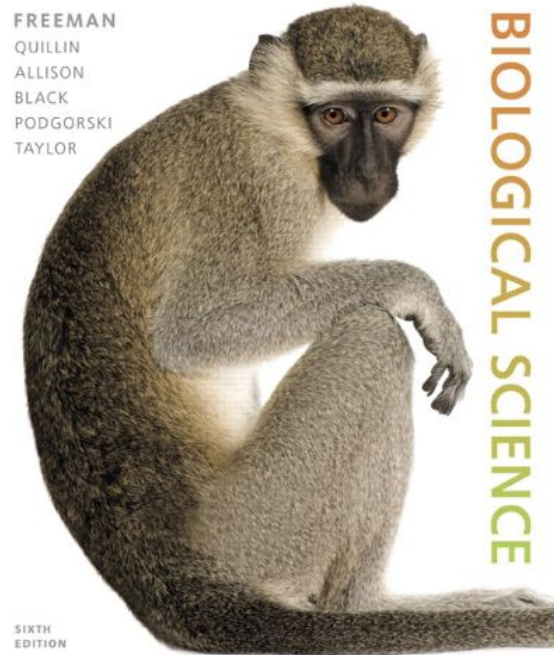
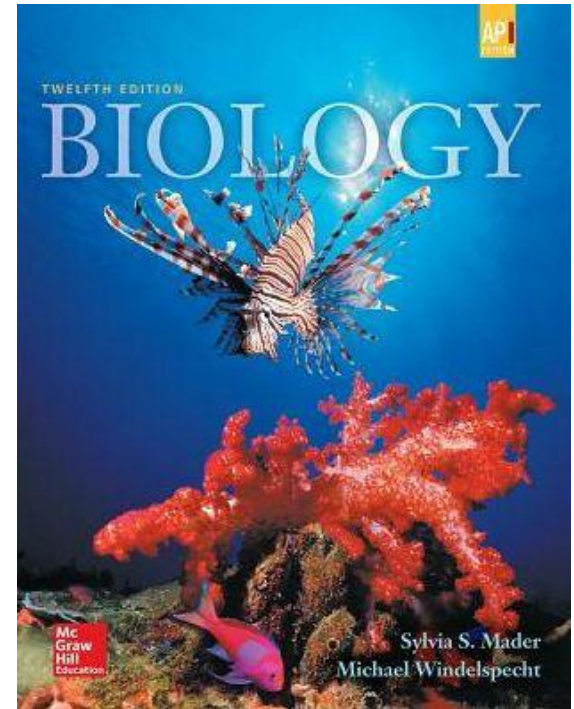
Chromosomes whose shape, number, and combination tends to be associated more with one biological sex than another in sexually dimorphic species, and influence the development of primary and secondary sexual characteristics. Compare with autosome.



Sex chromosomes are one component of complex negotiations between multiple genetic, hormonal, and environmental factors that determine biological sex, the importance of which vary across species.

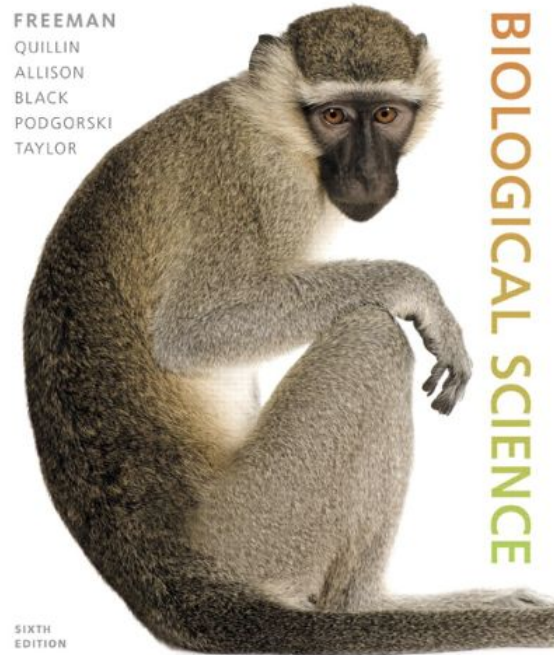
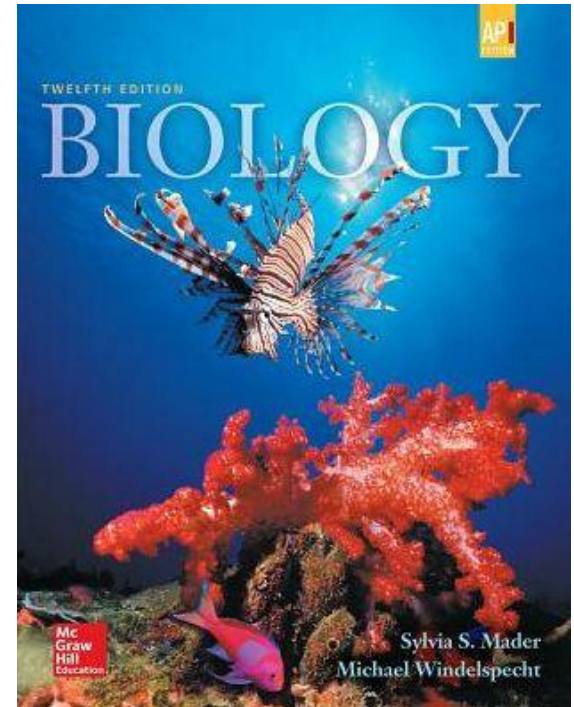
sexual selection

Sexual selection: “changes in males and females, often due to male competition and female selectivity, leading to increased fitness”



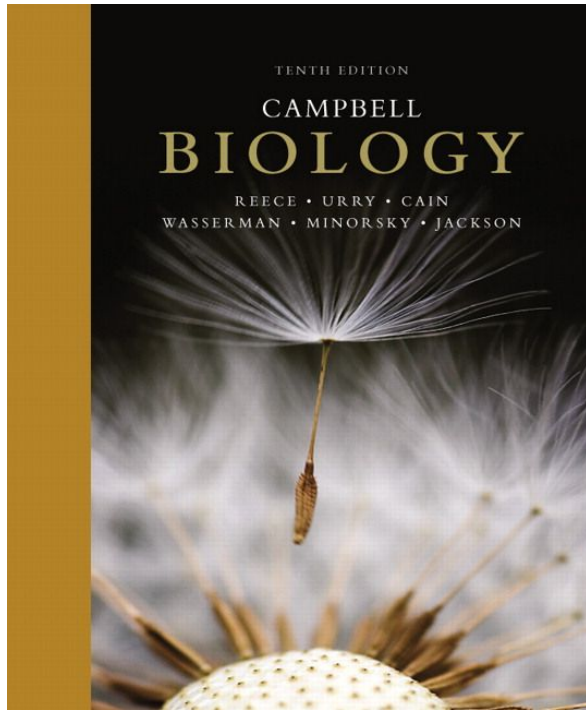
Sexual dimorphism results from sexual selection:
In elephant seals and most other animals studied, most females that survive to adulthood get a mate. In contrast, many males do not. Because sexual selection tends to be much more intense in males than females, males tend to have many more traits that function in courtship or male-male competition. State another way, sexually selected traits often (but not always) differ sharply between the sexes.

Sexual selection: “changes in males and females, often due to **male competition** and **female selectivity**, leading to **increased fitness**”



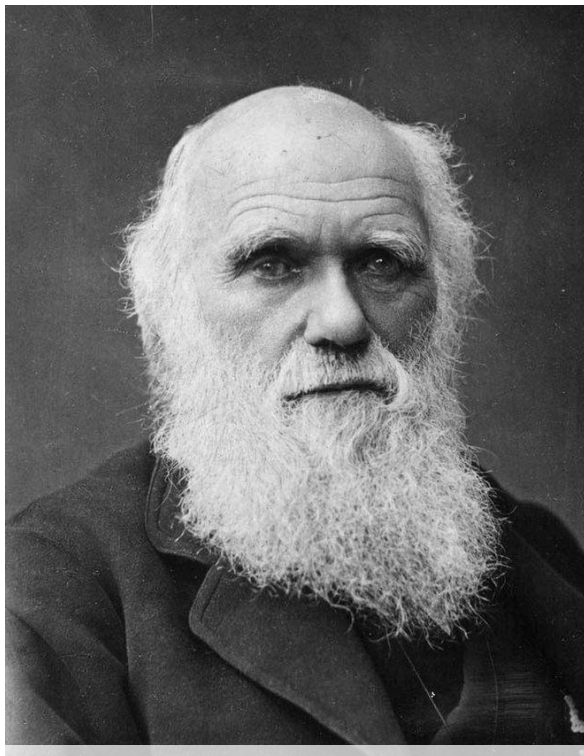
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sexual selection



Campbell Biology 10th Edition. 2014. by: Reece, Urry, Cain, Wasserman, Minorsky.

[link](#)



The definition can dictate conversation:

“Type of natural selection that favors individuals with traits that increase their ability to obtain **mates** or choose good **mates**”

“Selection occurring due to the advantage which some individuals have over other individuals of the same sex and species solely in terms of **reproduction**”

diversity

sexual reproduction

sex determination

sexual selection

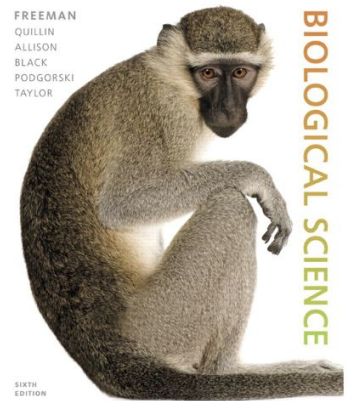
resources

how it is taught

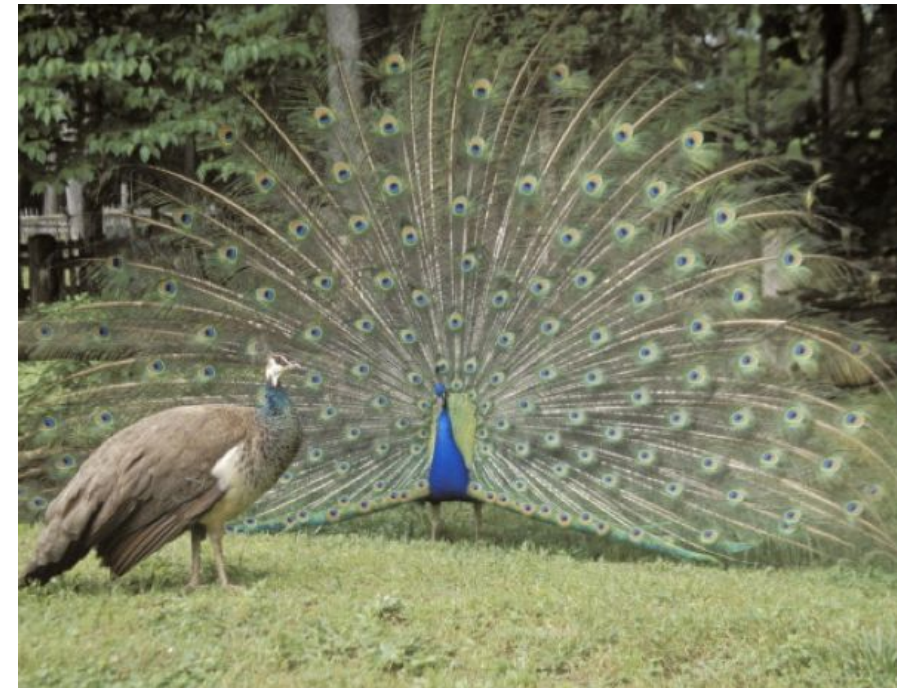
Text books and past research generally focus on:

Mammals (and birds)

Highly sexually dimorphic species



see Fuselier et al., 2018



diversity

sexual reproduction

sex determination

sexual selection

resources

how it is taught

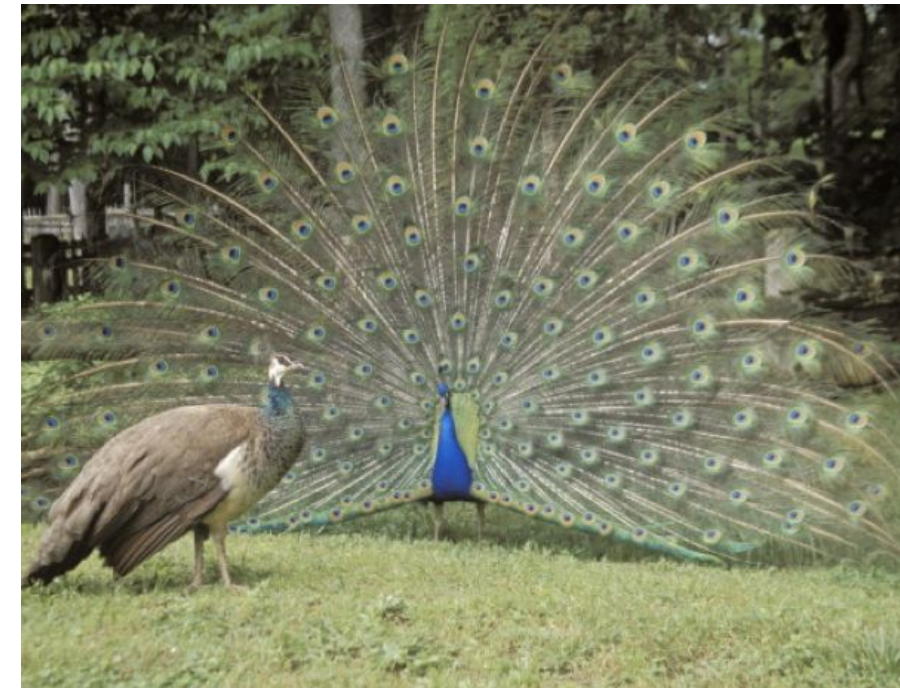
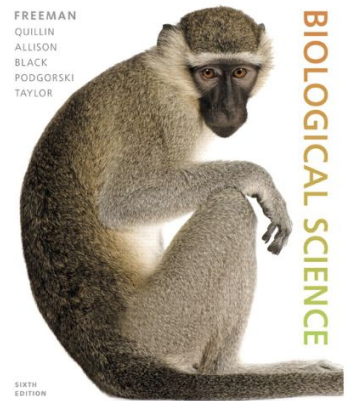
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male-male competition and aggression

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diversity

sexual reproduction

sex determination

sexual selection

resources

how it is taught

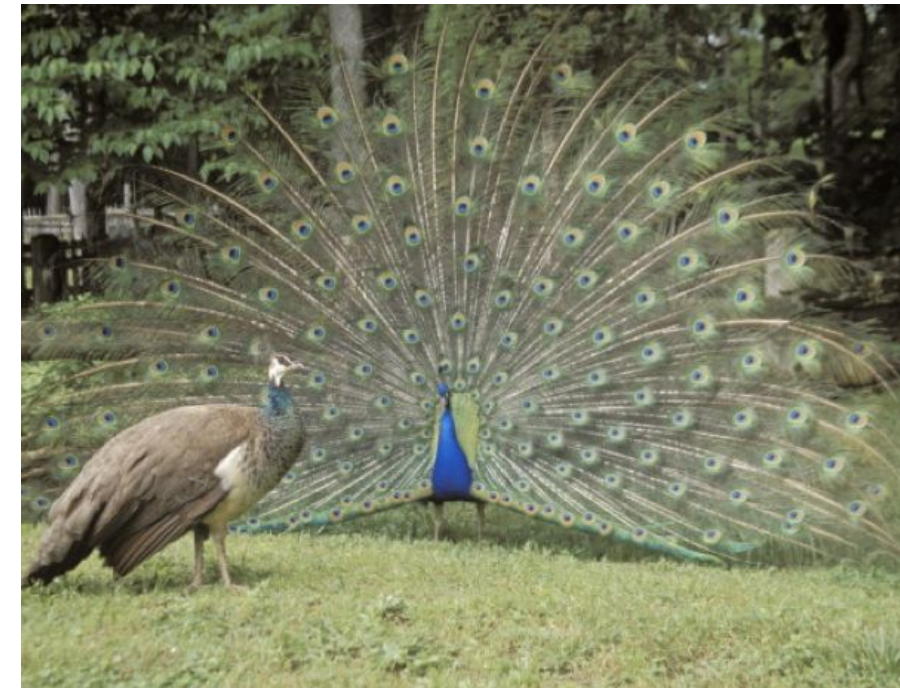
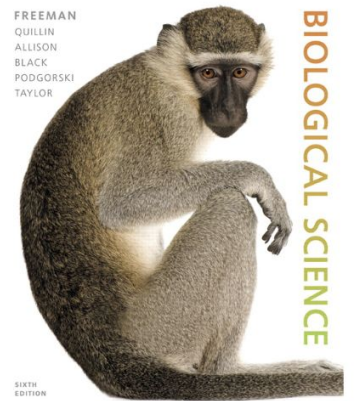
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sexual selection model to explain this

diversity

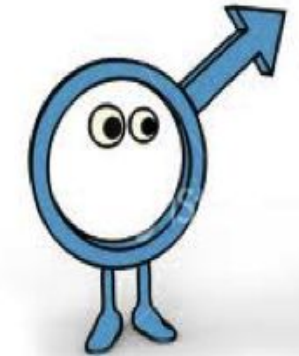
sexual reproduction

sex determination

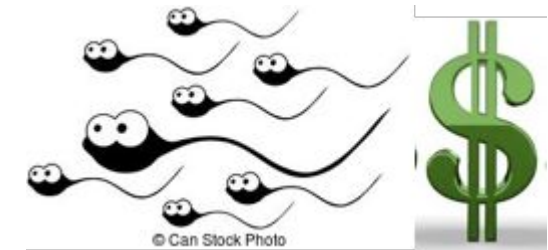
sexual selection

resources

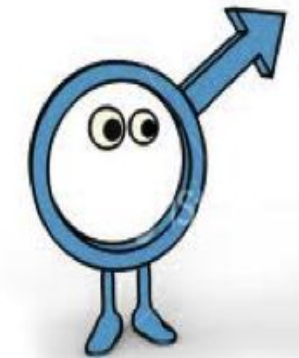
how it is taught



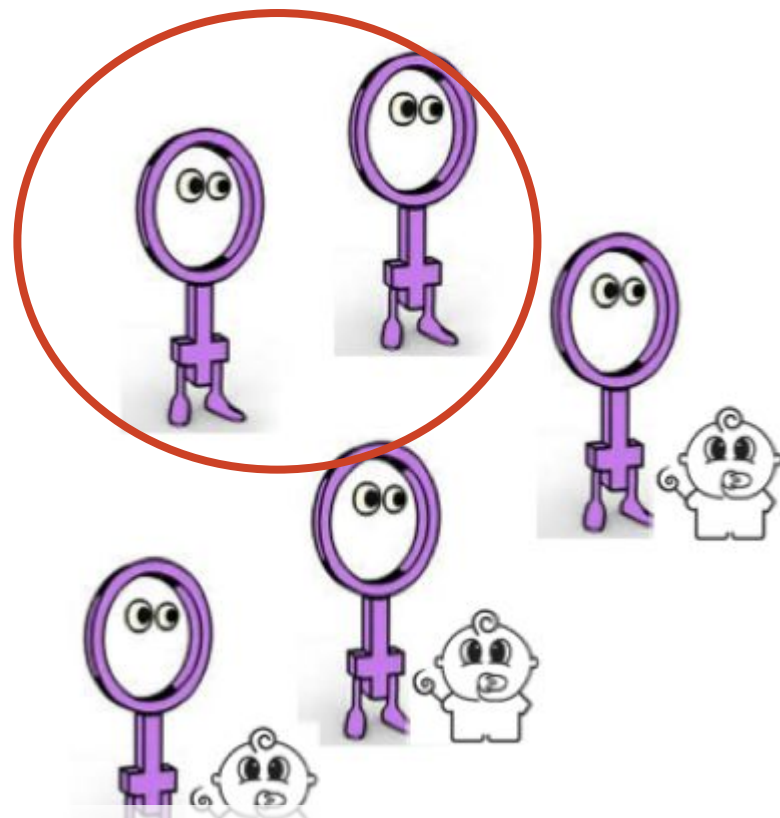
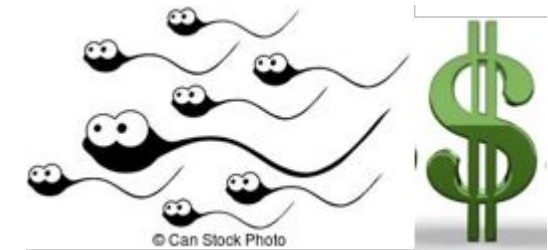
**Males have higher
potential rates of
reproduction**



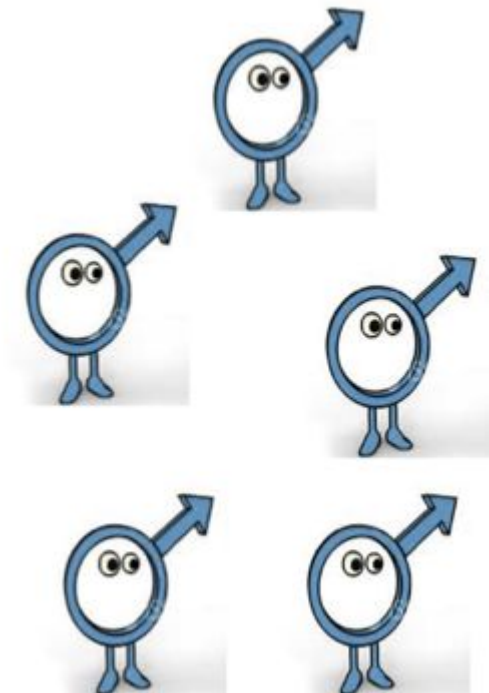
how it is taught



Males have higher potential rates of reproduction



Biased operational sex ratio



diversity

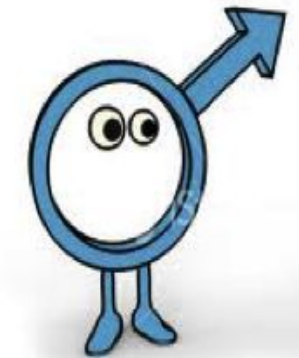
sexual reproduction

sex determination

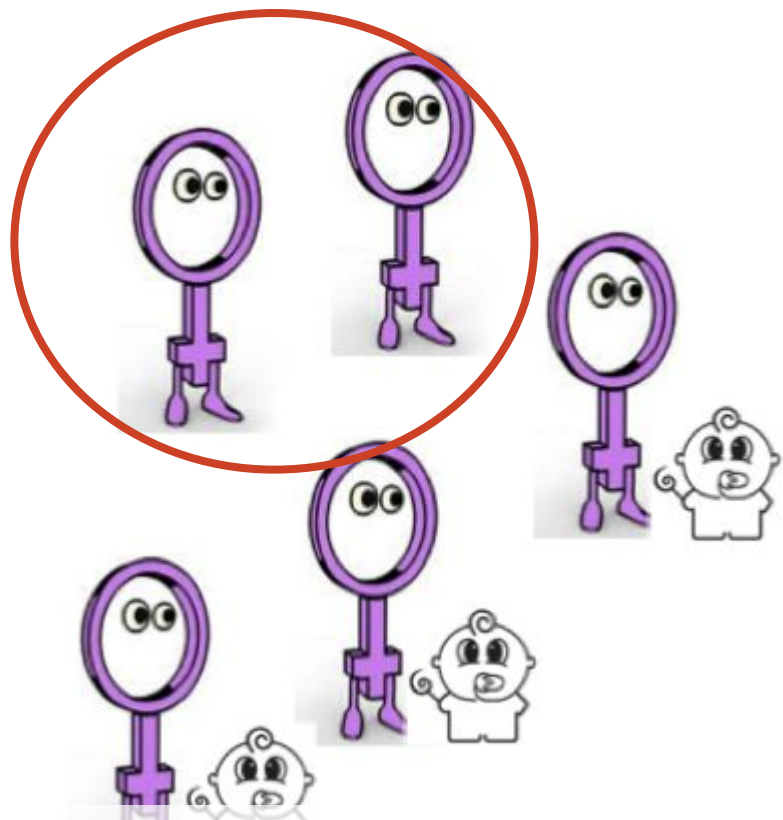
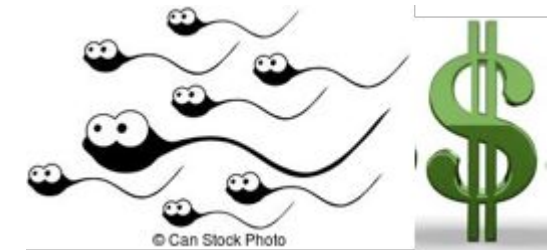
sexual selection

resources

how it is taught

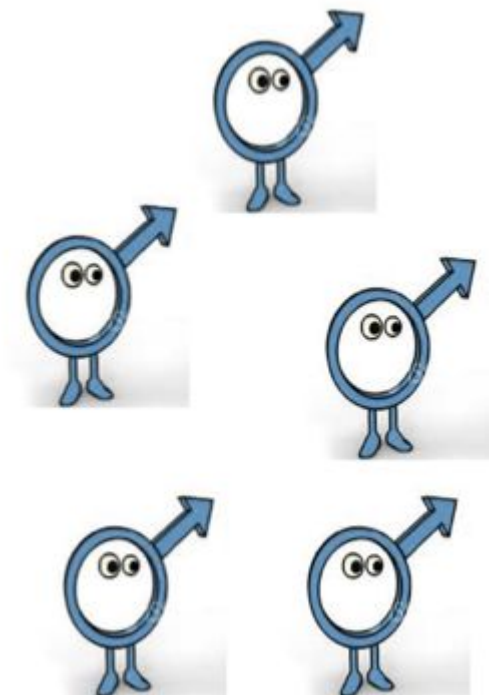


Males have higher
potential rates of
reproduction



Biased operational sex
ratio

**Female choice
&
Male competition**



diversity

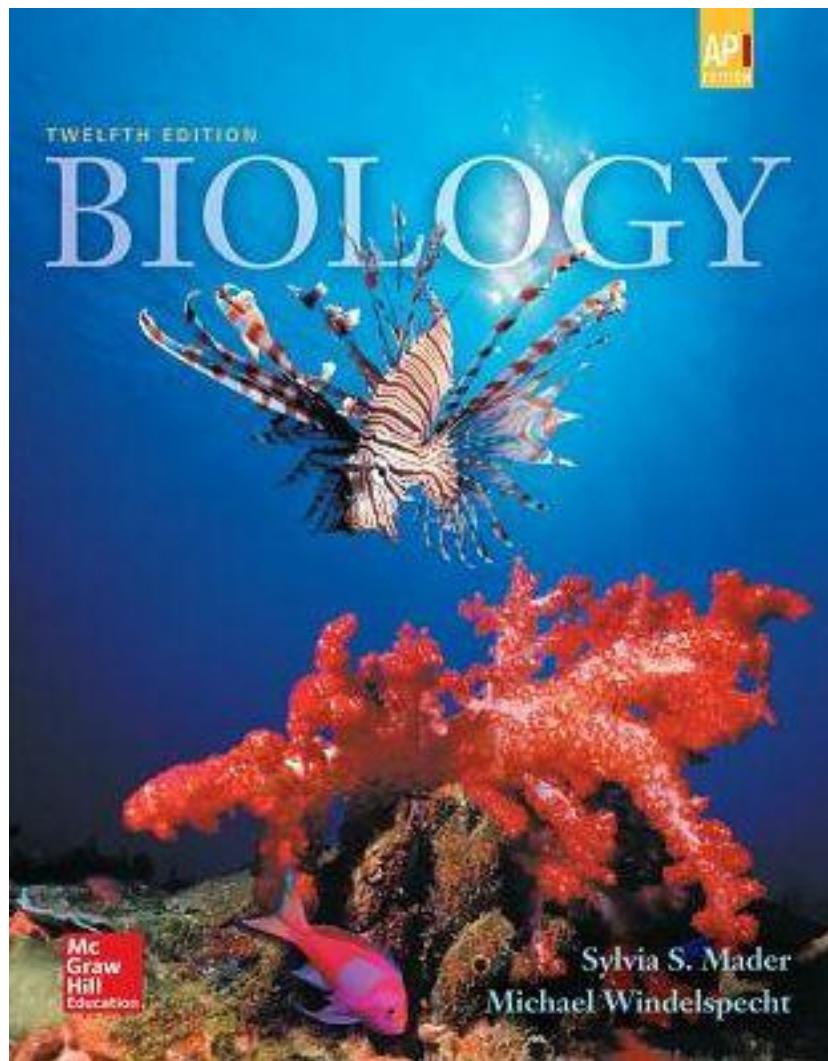
sexual reproduction

sex determination

sexual selection

resources

how it is taught

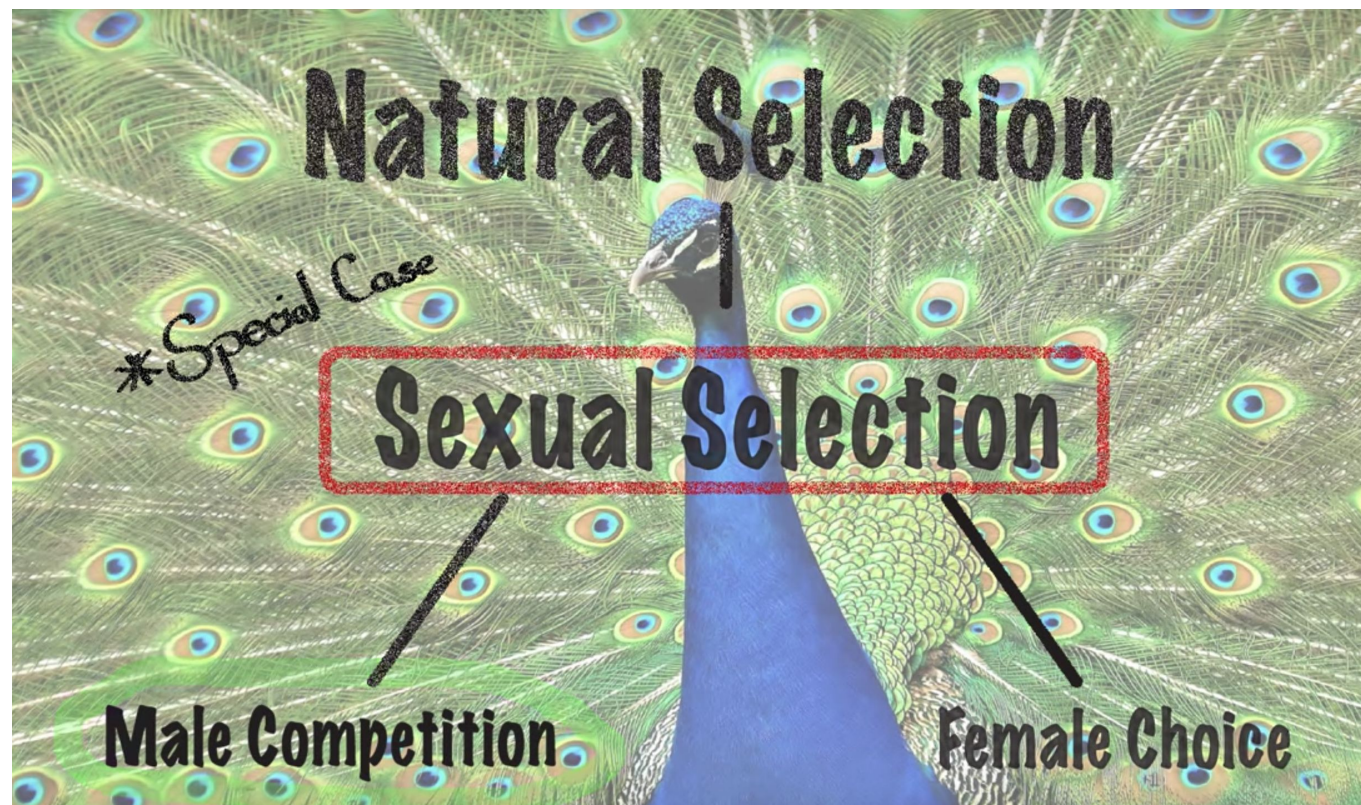


Biology, 12th Edition. 2016. by Mader and Windelspecht.

Sexual selection most often occurs due to female choice, which leads to male competition. **Because most females produce a limited number of eggs relative to the number of sperm produced by the male, it is adaptive for a female to be choosy about their mate.** If they choose a male that passes on features to a male offspring that will cause him to be chosen by other females, the parents' fitness has increased.

how it is taught

Sex difference in gamete size



diversity

sexual reproduction

sex determination

sexual selection

resources

Misconceptions

Sets up false dichotomies:

- i. Cheap vs Expensive reproduction
- ii. Competitive vs Choosy
- iii. Strong sexual selection on traits vs no direct sexual selection
- iv. Aggressive/Elaborate vs Passive/(sometimes)choosy



diversity

sexual reproduction

sex determination

sexual selection

resources

Misconceptions

Model doesn't encompass diversity

Across taxa, social systems, species



Within species:

Across populations and
individuals of the same sex

diversity

sexual reproduction

sex determination

sexual selection

resources

male-male
competition



Increasingly recognized that many sex-specific models of reproductive behaviour **inadequately explain the highly variable patterning of** mate acquisition, pair bonding and parenting both within and across species. Reproductive decision-making is a dynamic process, influenced by many individual, population-, and context-specific characteristics” Schacht et al. 2017

collective biological knowledge

diversity

sexual reproduction

sex determination

sexual selection

resources

male-male
competition



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{ collective biological knowledge }

Most textbook images did not reflect the shift happening in the scientific community. Images highlighted primarily the classic view of sexual selection focused on males. Examples typical of a more realistic, complicated understanding received little attention...Images of males were more common than images of females, **females were depicted for fewer concepts than males,** and **images of males and females reinforced stereotypical sex roles.** - Fusilier et al., 2018

diversity

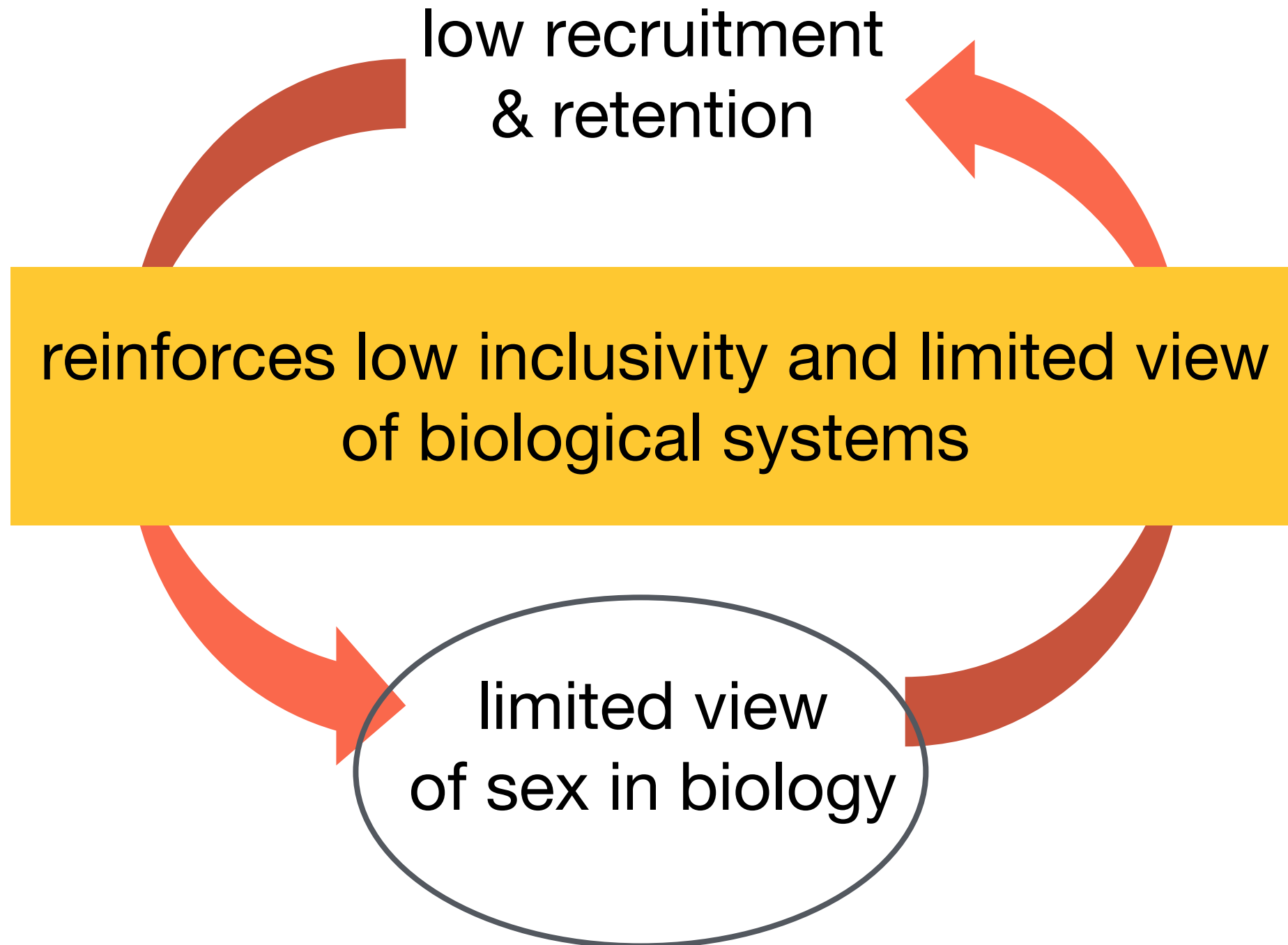
sexual reproduction

sex determination

sexual selection

resources

inclusivity



diversity

sexual reproduction

sex determination

sexual selection

resources

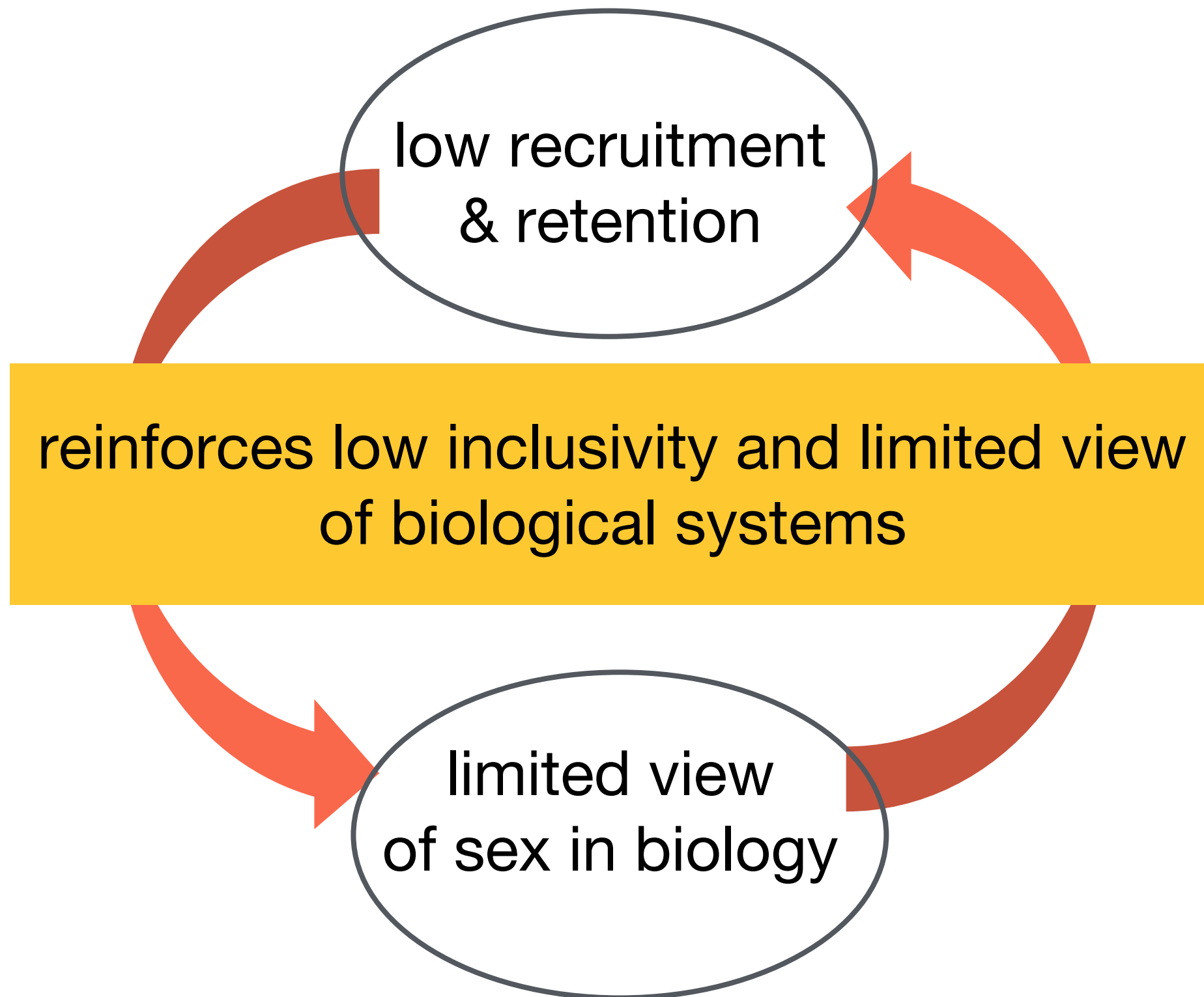
inclusivity

Inclusivity Problems:

1. Non-binary students
2. Nontraditional family structures and/or sexual orientation
 - a. Offspring care without sex
 - b. Sex without offspring
 - c. homosexuality, asexuality, etc.
3. Students who do not identify with traditional “sex roles”



inclusivity



diversity

sexual reproduction

sex determination

sexual selection

resources

a different framework

low recruitment
& retention

BREAK THE CYCLE

limited view
of sex in biology

diversity

sexual reproduction

sex determination

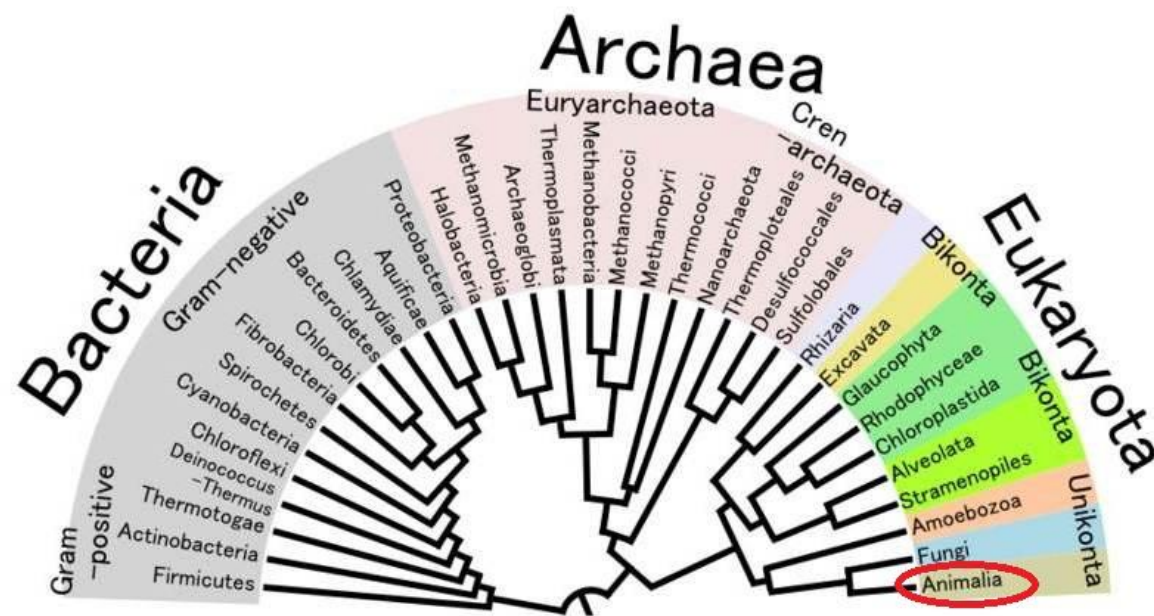
sexual selection

resources

a different framework

I. Put in context -

What question are we really answering?



diversity

sexual reproduction

sex determination

sexual selection

resources

a different framework

2. Present diversity in mating/reproductive strategies first

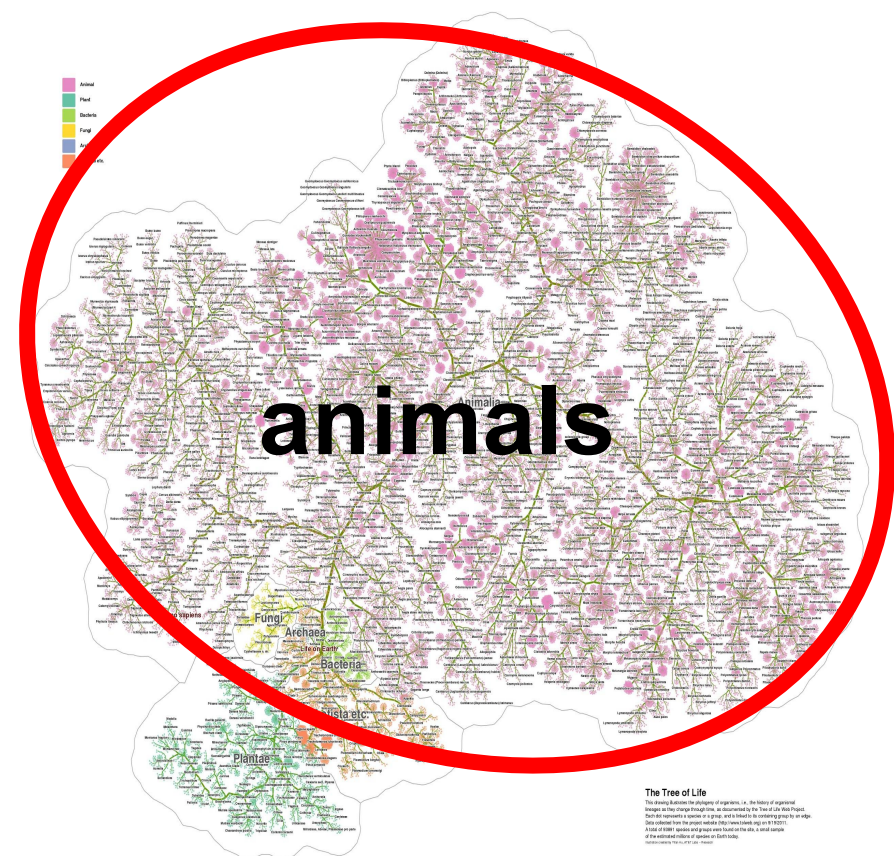
Variation within and across taxa, species, populations, sexes, and individuals

Secondary sex characteristics

Sexual dimorphism

Mating system

Offspring investment



diversity

sexual reproduction

sex determination

sexual selection

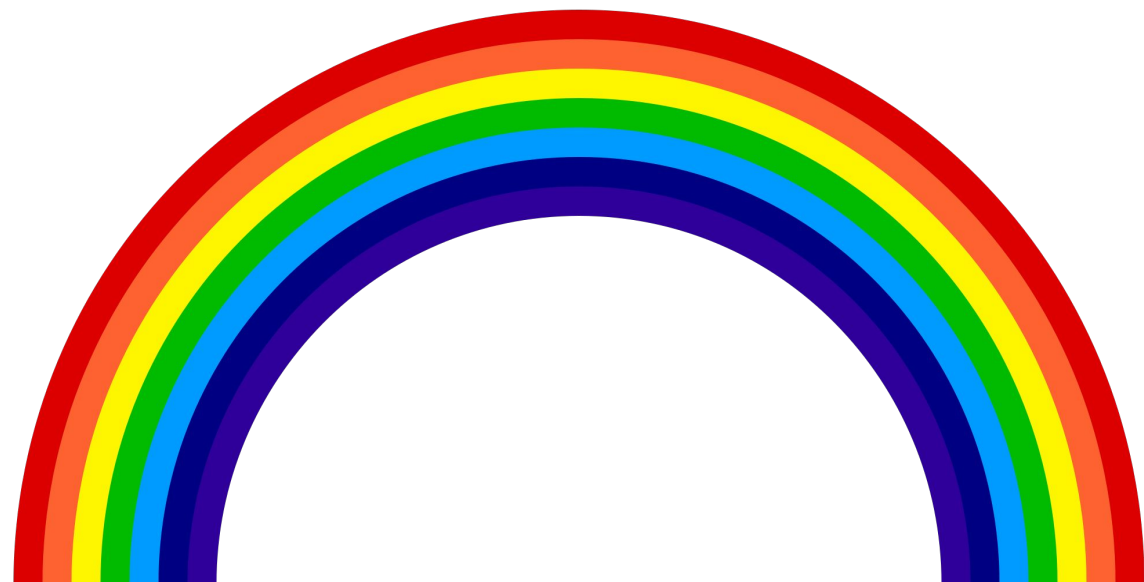
resources

a different framework

Example: **Every individual must make major decisions about mating.**

1. How choosy am I? *How do I choose?*
2. How much do I invest in gaining access to mates? *What strategy do I use?*
3. How much do I invest in gametes/offspring initially? Do I stay or do I go?

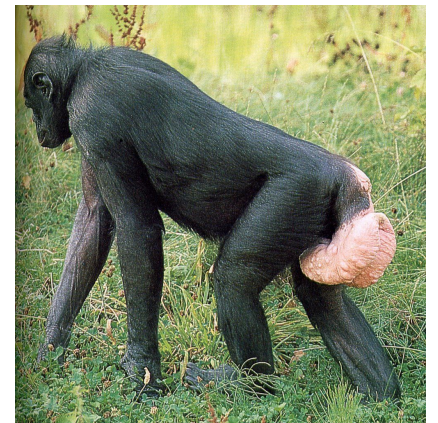
Diverse answers to these sets of questions → a wide variety of mating strategies and systems



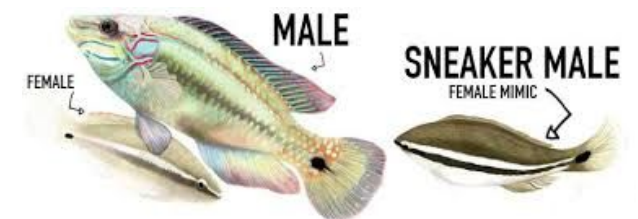
a different framework

3. Ask questions about diversity and patterns we see

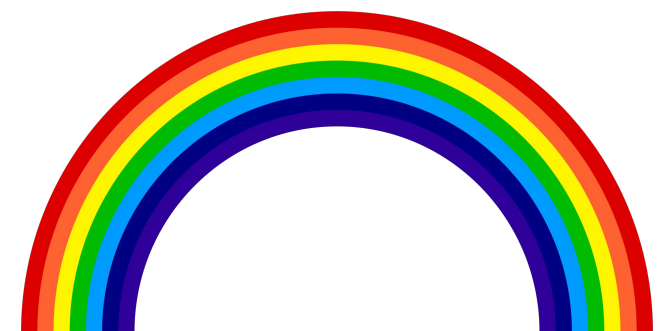
How might sex and species-specific traits evolve (framing: both female and male, choosy and competitive)?



Why don't all individuals of the same sex/species act the same?



Why might this individual variation be important?



diversity

sexual reproduction

sex determination

sexual selection

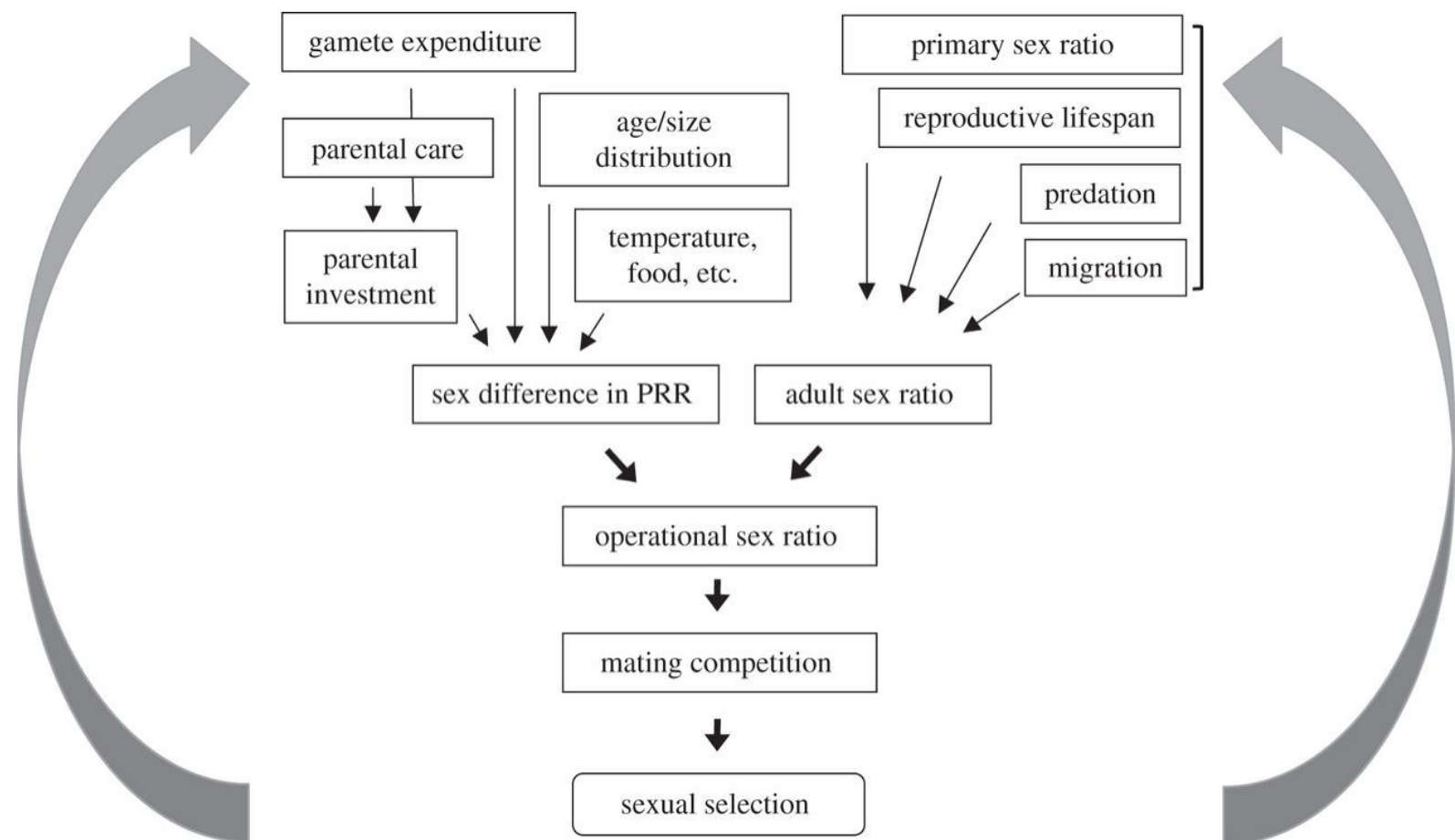
resources

a different framework

3. Present sexual selection theory as a model to understand diversity

On average, some strategies will be more optimal in terms of reproduction than others, depending on **many** (often) dynamic factors, **including** sex and individual circumstances

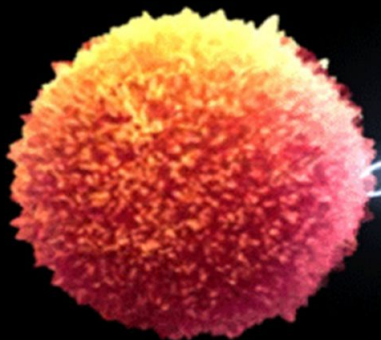
** Updated model



a different framework

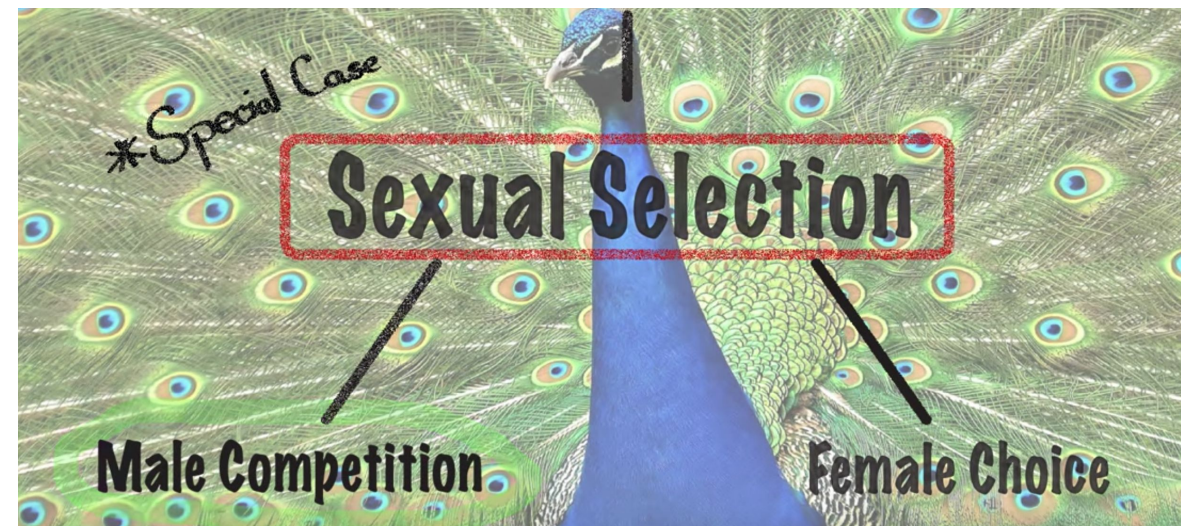
gamete expenditure

Anisogamy



Female limitation: Number of eggs produced
Male limitation: Number of eggs they can fertilize

Before: Gives impression that reproductive strategies are determined solely by sex



sexual selection



diversity

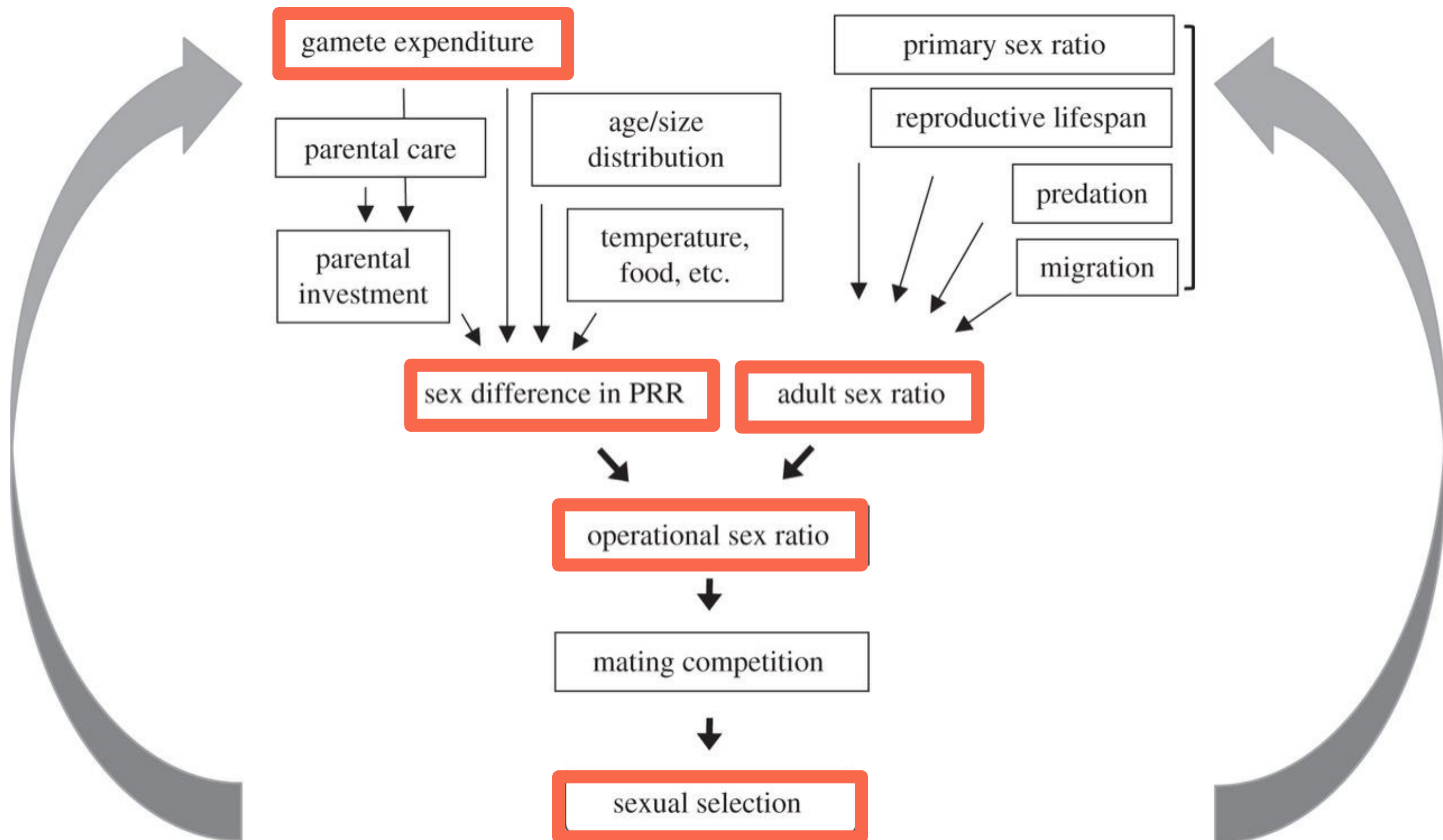
sexual reproduction

sex determination

sexual selection

resources

a different framework



Kvarnemo & Simmons, 2013 (not even remotely complete/six years old but still so much better!)

diversity

sexual reproduction

sex determination

sexual selection

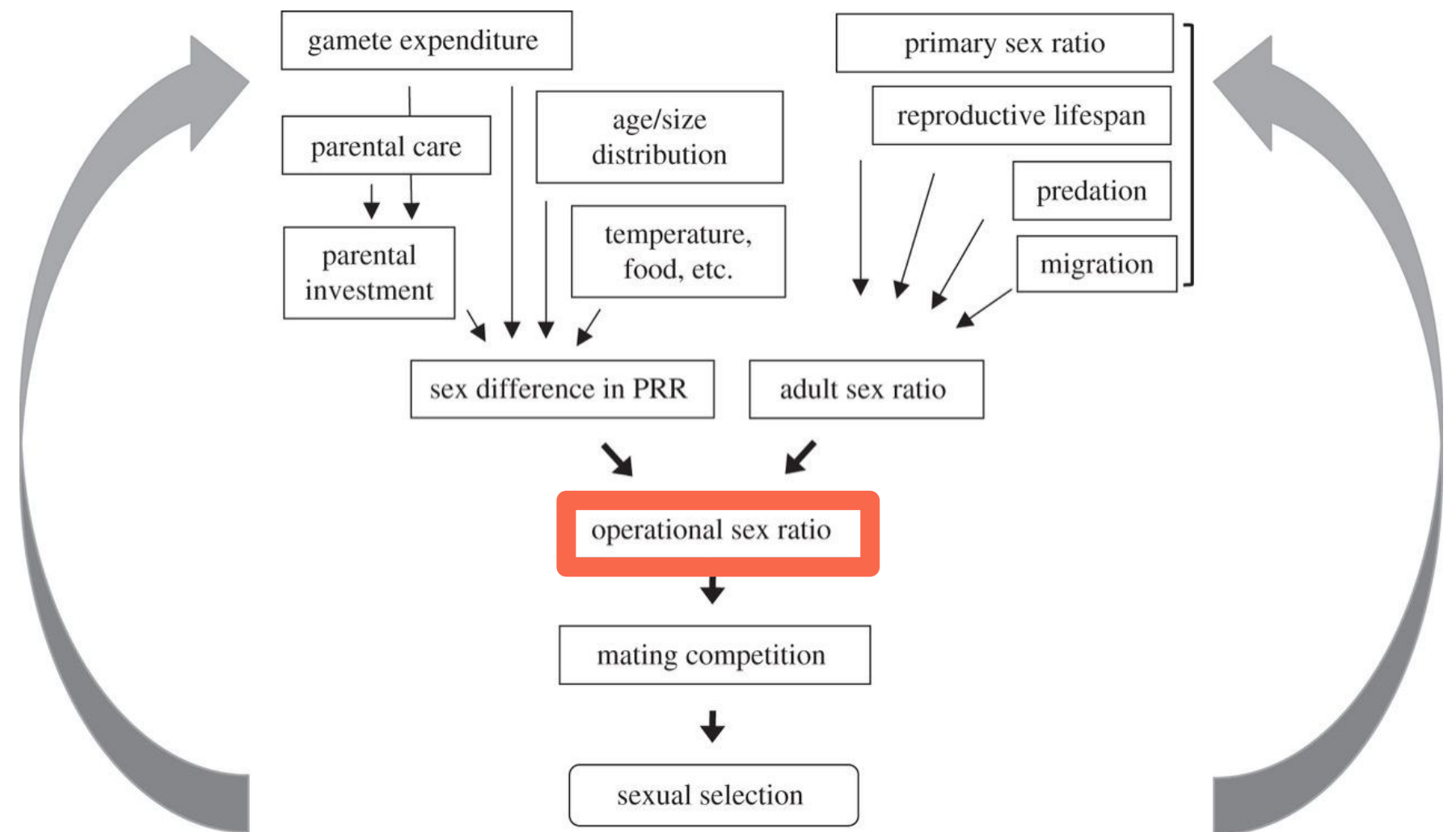
resources

a different framework



Focus on:

- Operational sex ratio
 - influenced by processes including anisogamy and adult sex ratio
- The nature of models and historical context



male-male
competition



Increasingly recognized that many sex-specific models of reproductive behaviour **inadequately explain the highly variable patterning of** mate acquisition, pair bonding and parenting both within and across species. Reproductive decision-making is a dynamic process, influenced by many individual, population-, and context-specific characteristics”
Schacht et al. 2017

collective biological knowledge

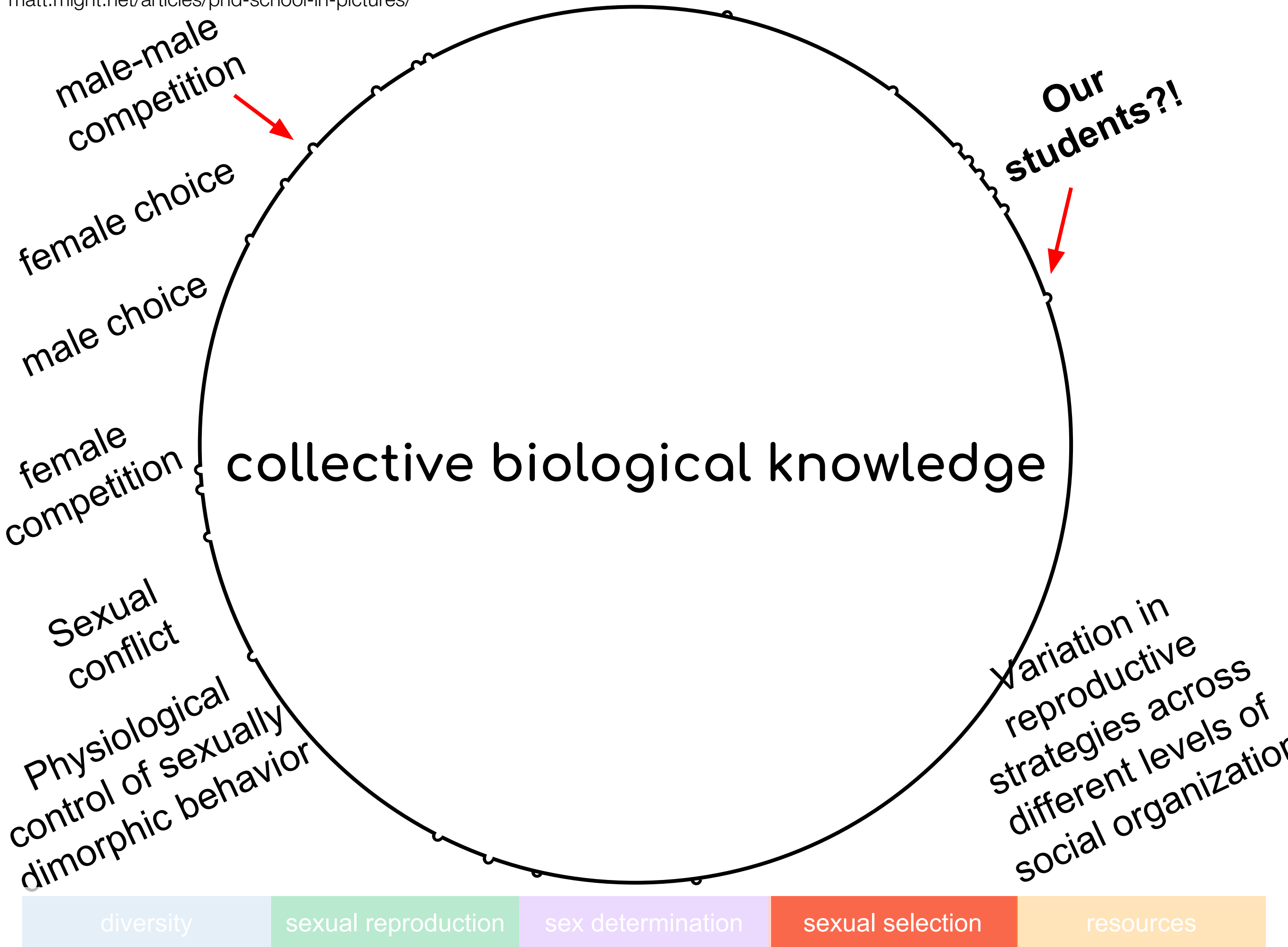
diversity

sexual reproduction

sex determination

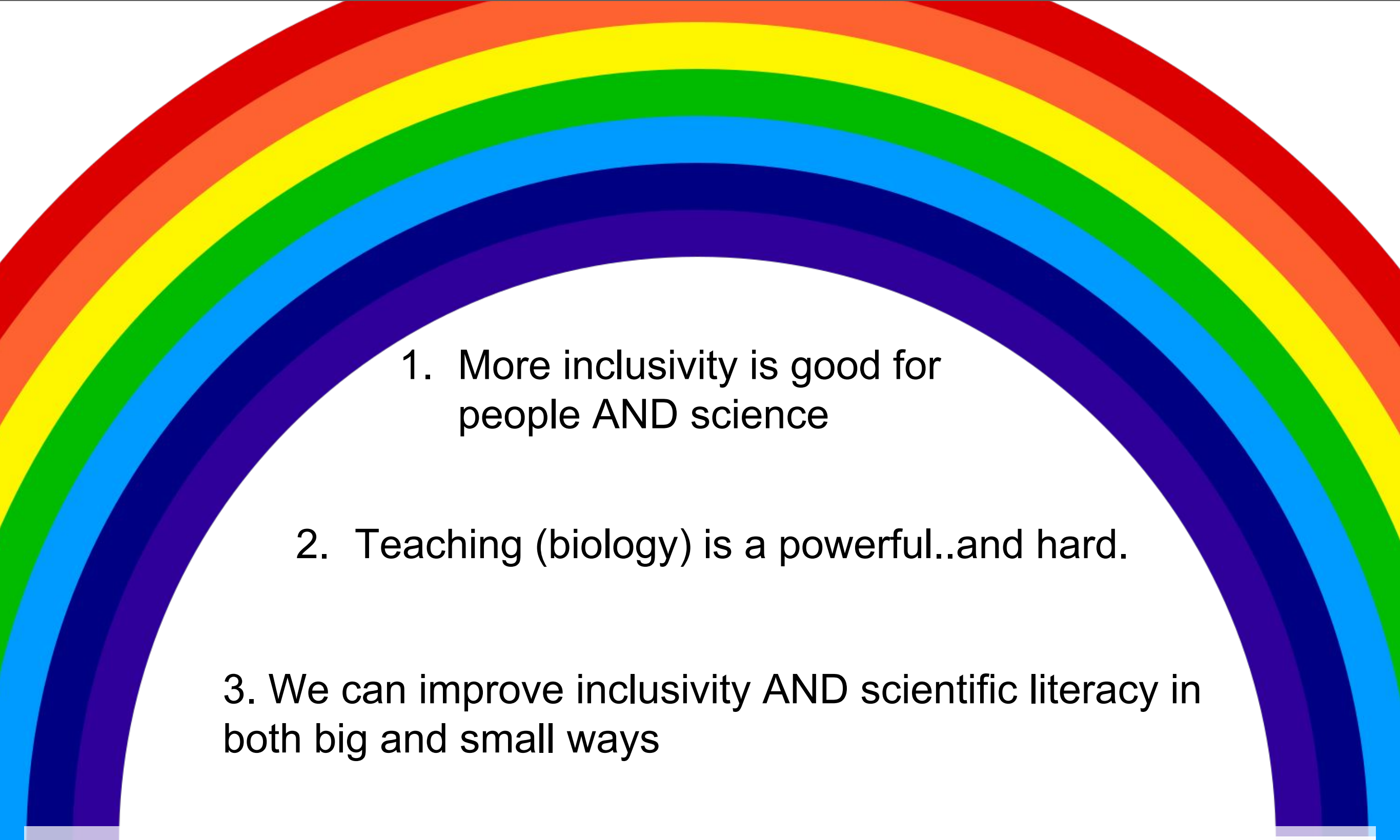
sexual selection

resources



takeaways & resources

takeaways

- 
1. More inclusivity is good for people AND science
 2. Teaching (biology) is a powerful..and hard.
 3. We can improve inclusivity AND scientific literacy in both big and small ways

diversity

sexual reproduction

sex determination

sexual selection

activity

takeaways

How can we minimize this?

1. Present or explore diversity first
2. Don't hide the iterative process. Model it!
3. Update your definitions/language
4. Contextualize: biological, historical/social

resources

soon to be posted! slides, definitions, other resources



www.projectbiodiversify.org

diversity

sexual reproduction

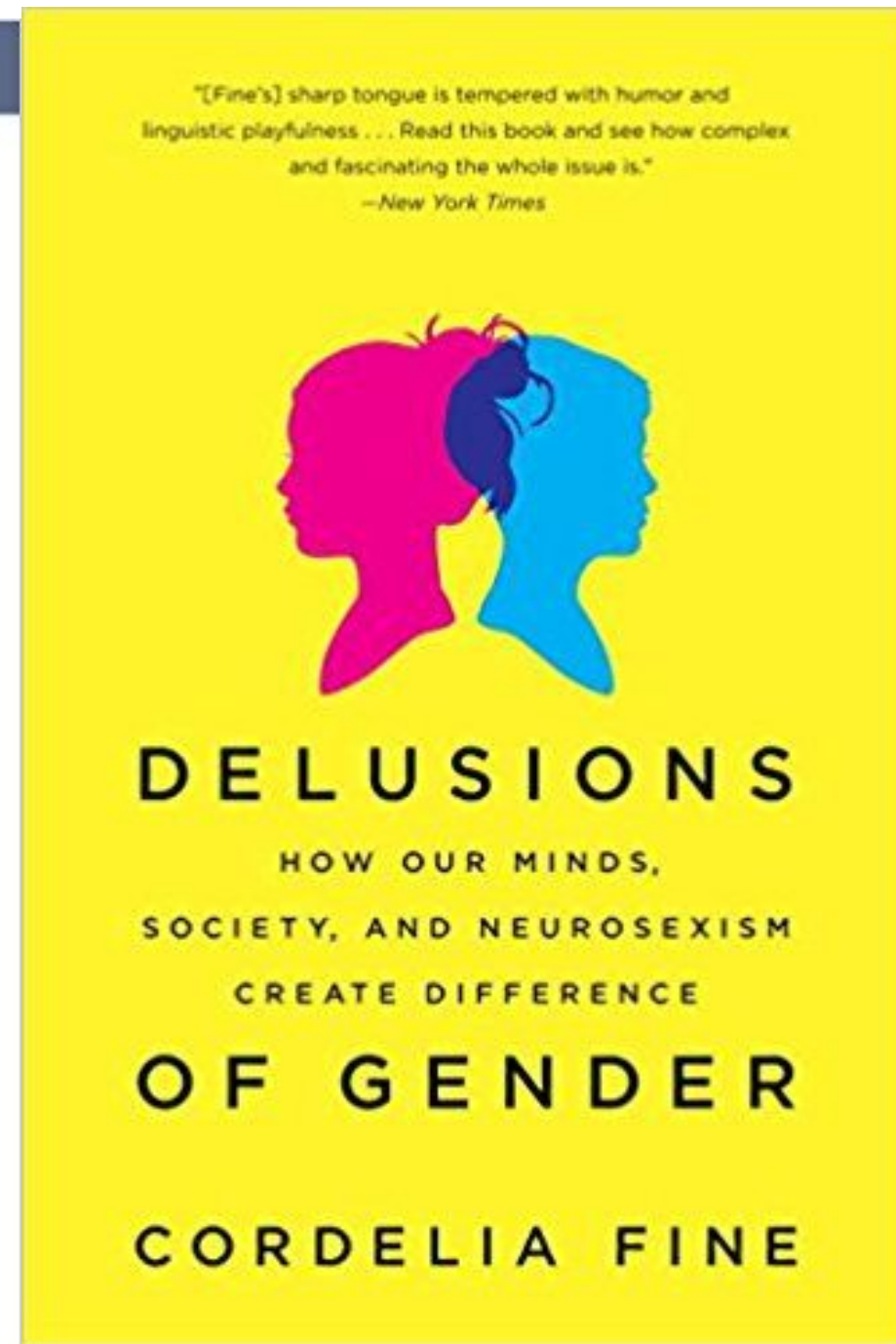
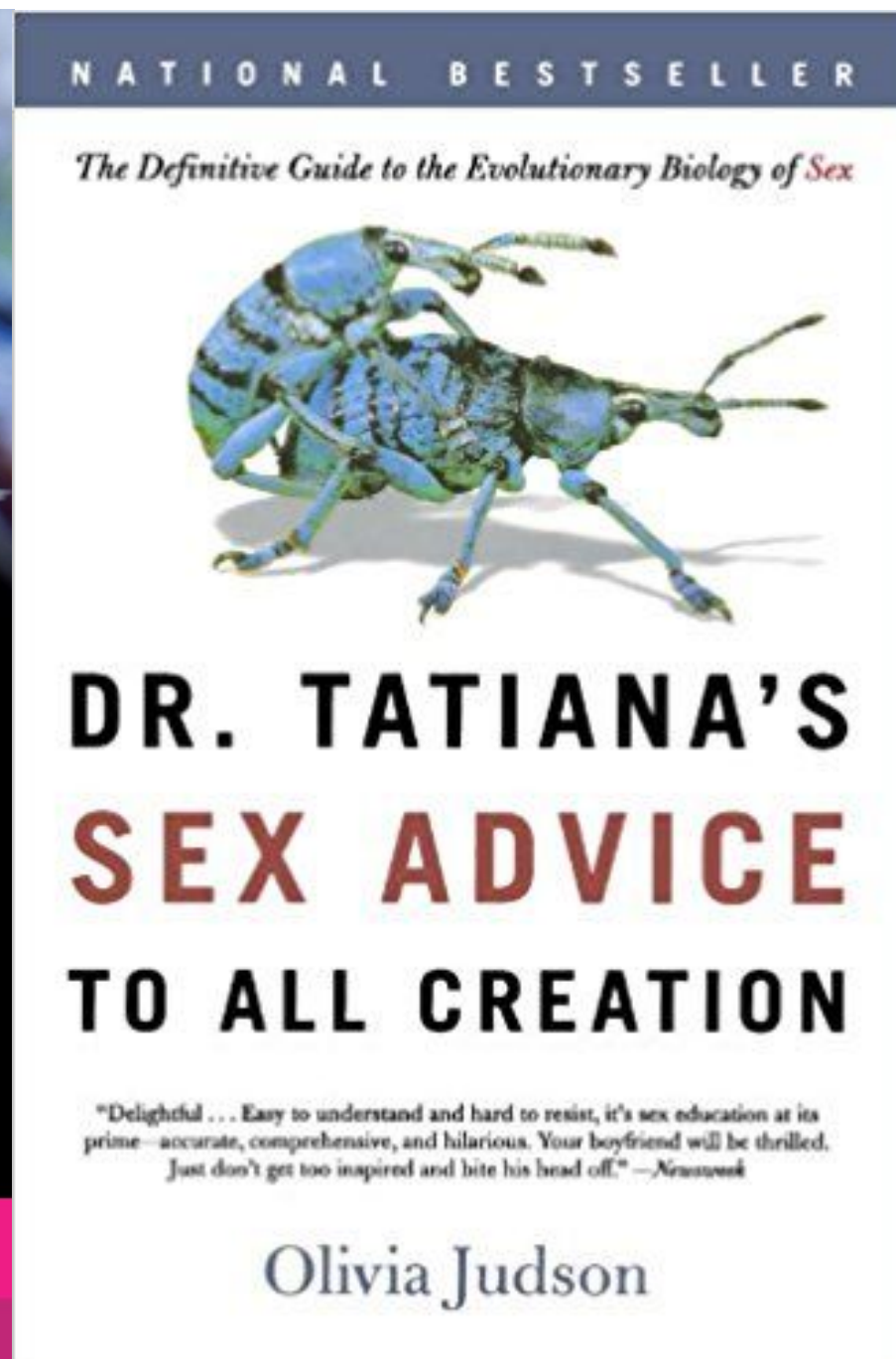
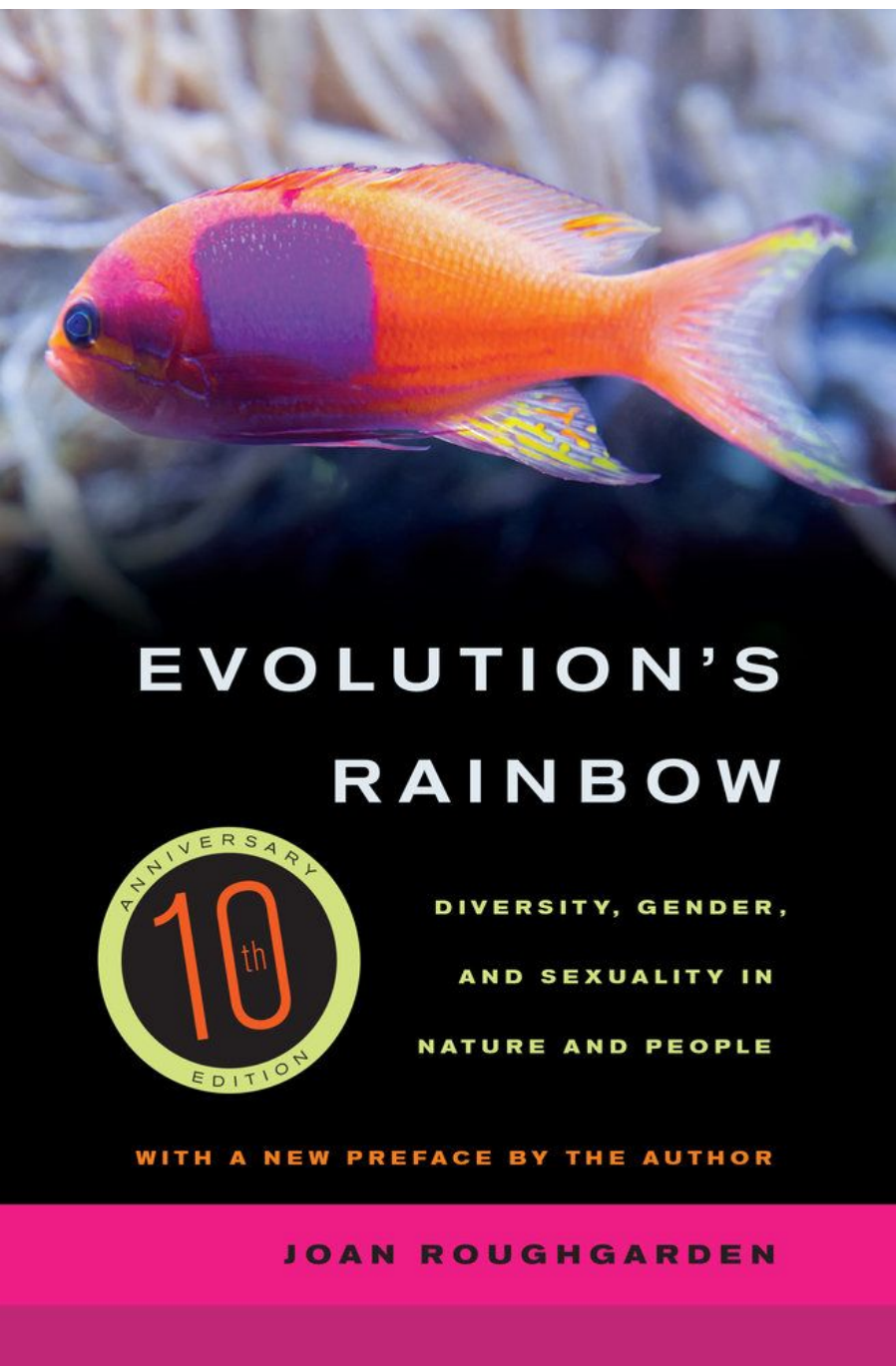
sex determination

sexual selection

resources

resources

(none are perfect, but all have some great content)



diversity

sexual reproduction

sex determination

sexual selection

resources

resources

VISION: future: have ready-made slides to expedite process of updating lectures



www.projectbiodiversify.org

diversity

sexual reproduction

sex determination

sexual selection

resources

questions?

diversity

sexual reproduction

sex determination

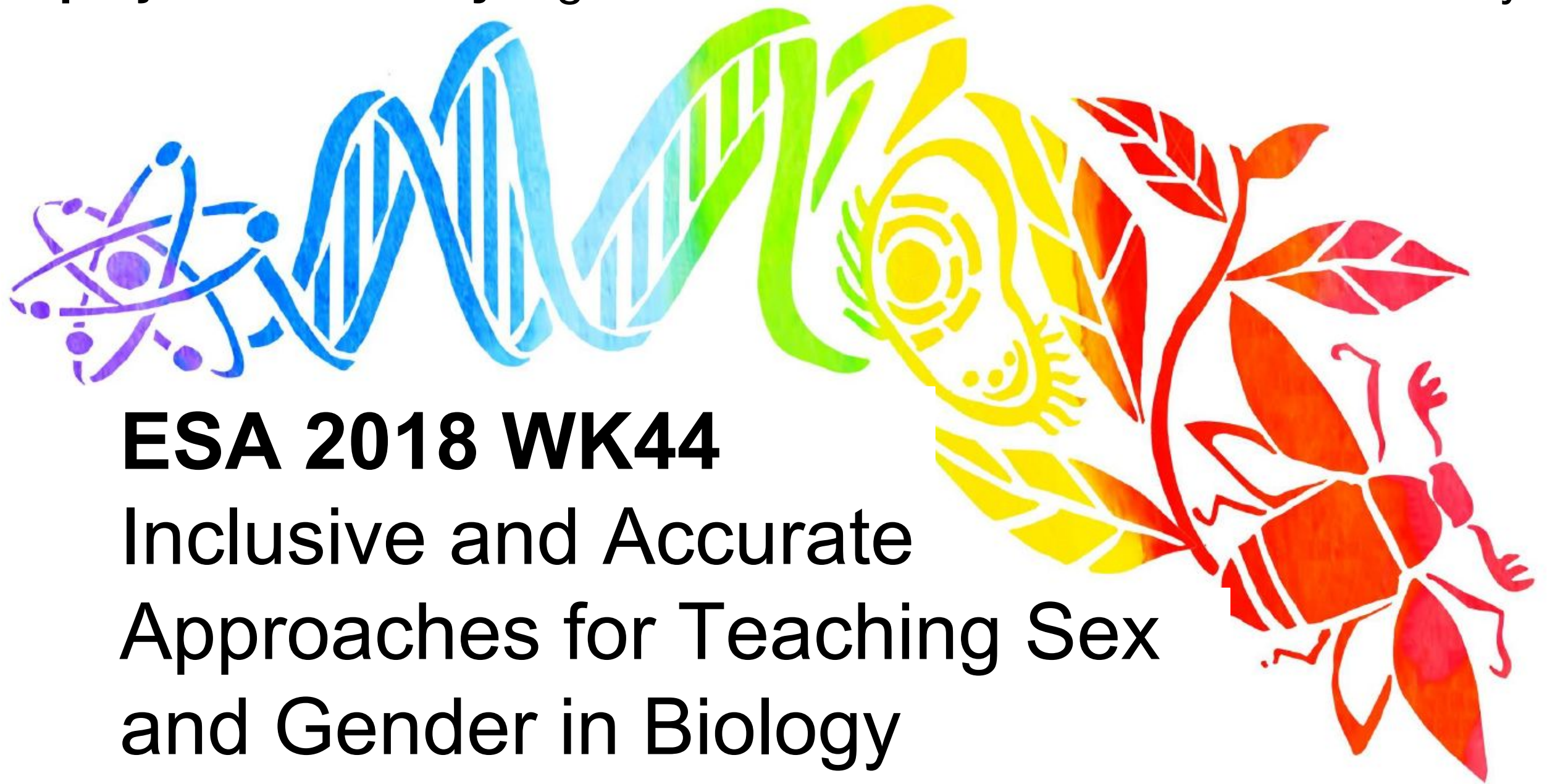
sexual selection

resources

thank you!!

we value your feedback :)

make sure we get your e-mail
for feedback form!



ESA 2018 WK44

Inclusive and Accurate Approaches for Teaching Sex and Gender in Biology

Alex Webster

she/her/hers

@alxweb

Ash Zemenick

they/them/theirs

@mtn_ash

Sarah Jones

she/her/hers

@jones943