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Lecture 8b:

CULTURE IN INSECTS

Outline

- **Introduction**
  - A brief history of animal culture
  - Main empirical approaches
  - Patterns *versus* mechanisms
- **Insect social learning**
- **Evidence for insect culture**
- **Defining animal culture**

Part 1

- **Cultural transmission of sexual preferences in *D. melanogaster***
- **General conclusion**
- **Final remarks**
- **Challenges for the future**

Part 2

- Applying this mechanistic definition to a given animal model
- By testing the 4 **+ 1** criteria in that system

Criterion 1

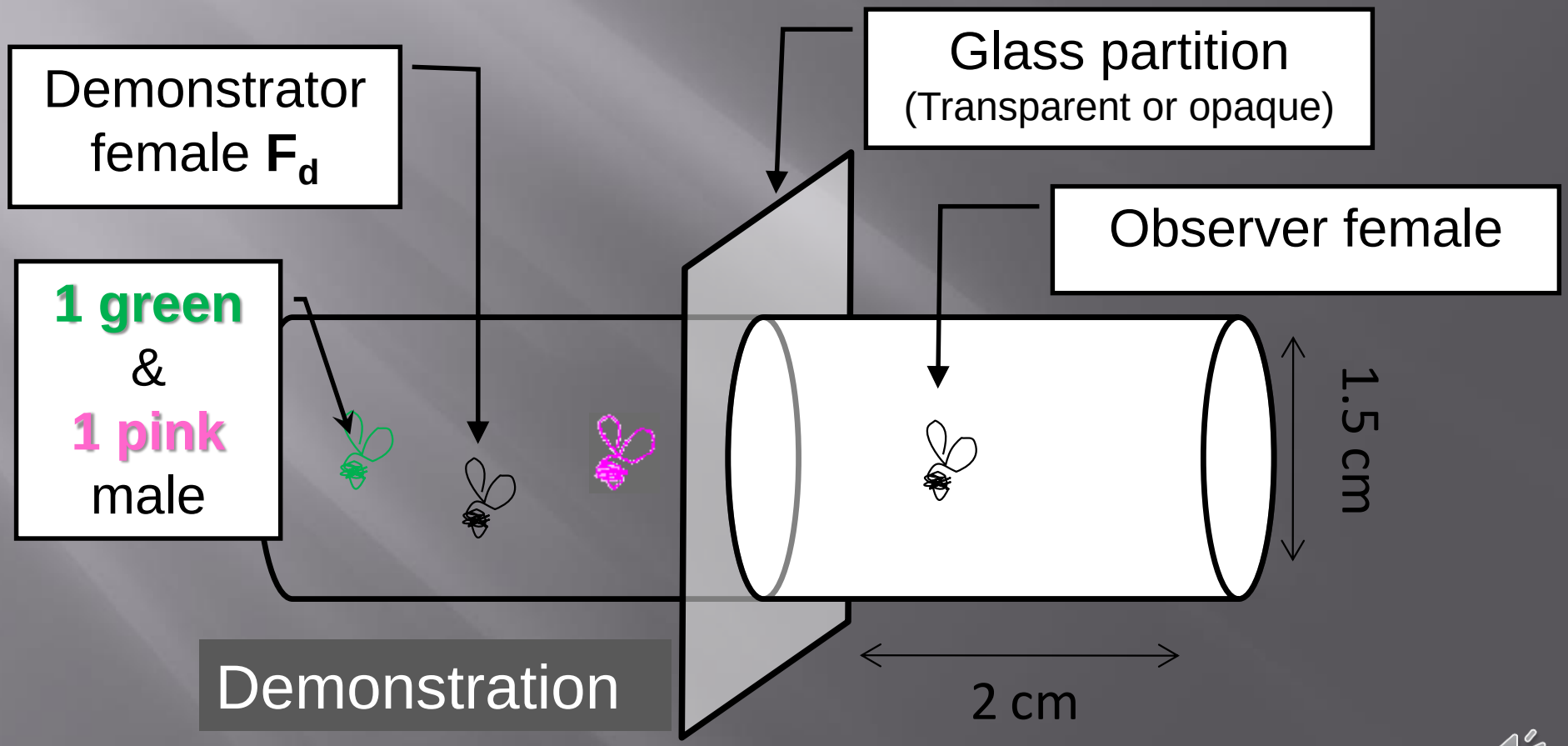
SOCIAL LEARNING

SOCIAL TRANSMISSION

AMONG INDIVIDUAL ANIMALS

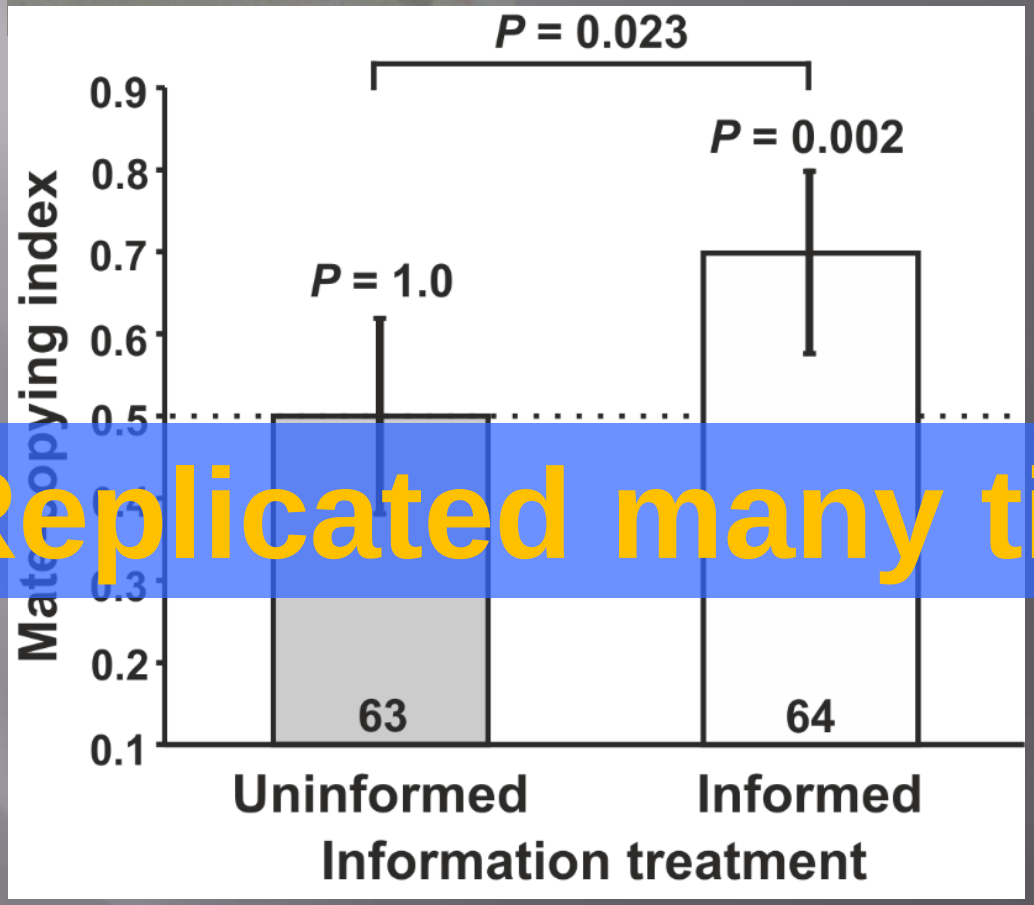
Criterion 1: social learning

- **One live Demonstration** of **one female** choosing between **1 green** and **1 pink** males



Mery et al. 2009 Current Biology; Dagaeff et al. 2016 Anim Behav

Results



Replicated many time

After seeing a demonstration for one colour, observer females showed a bias for males of the colour that was selected during the demonstration

Mery *et al.* 2009 *Curr Biol*; Dagaeff *et al.* 2016 *Anim Behav*; Danchin *et al.* 2018 *Science*

Criterion 1

SOCIAL LEARNING

SOCIAL TRANSMISSION

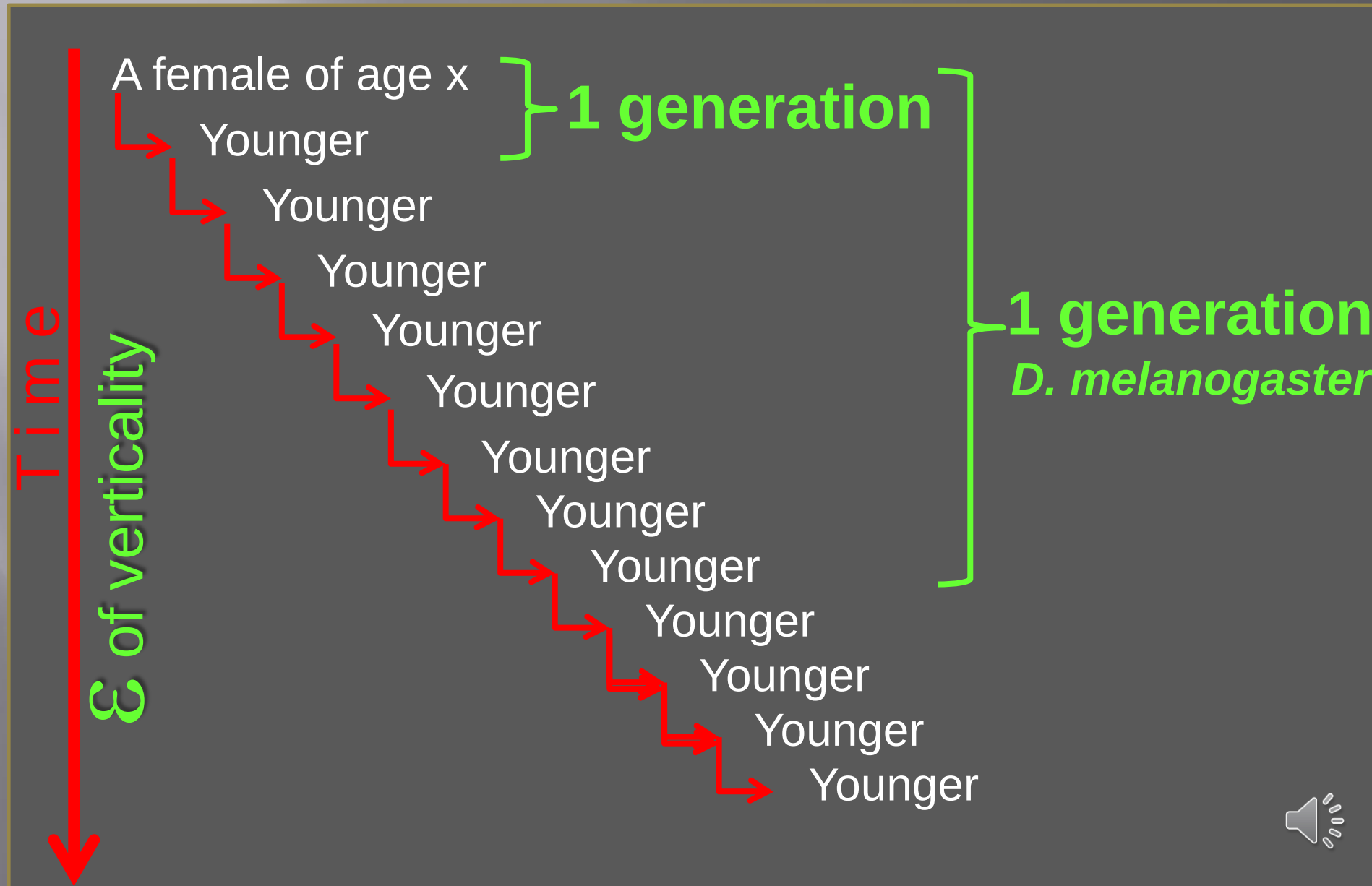
AMONG INDIVIDUAL ANIMALS

Criterion 2

ACROSS AGE-CLASSES *TRANSMISSION*

ONLY INFORMATION THAT IS TRANSMITTED ACROSS AGE-CLASSES CAN EVOLVE

Principle


A female of age x
Younger
Younger
Younger
Younger
Younger
Younger
Younger
Younger
Younger
Younger
Younger
1 generation
1 generation
D. melanogaster
Time
ε of verticality

Design

Horizontal

Across age-classes

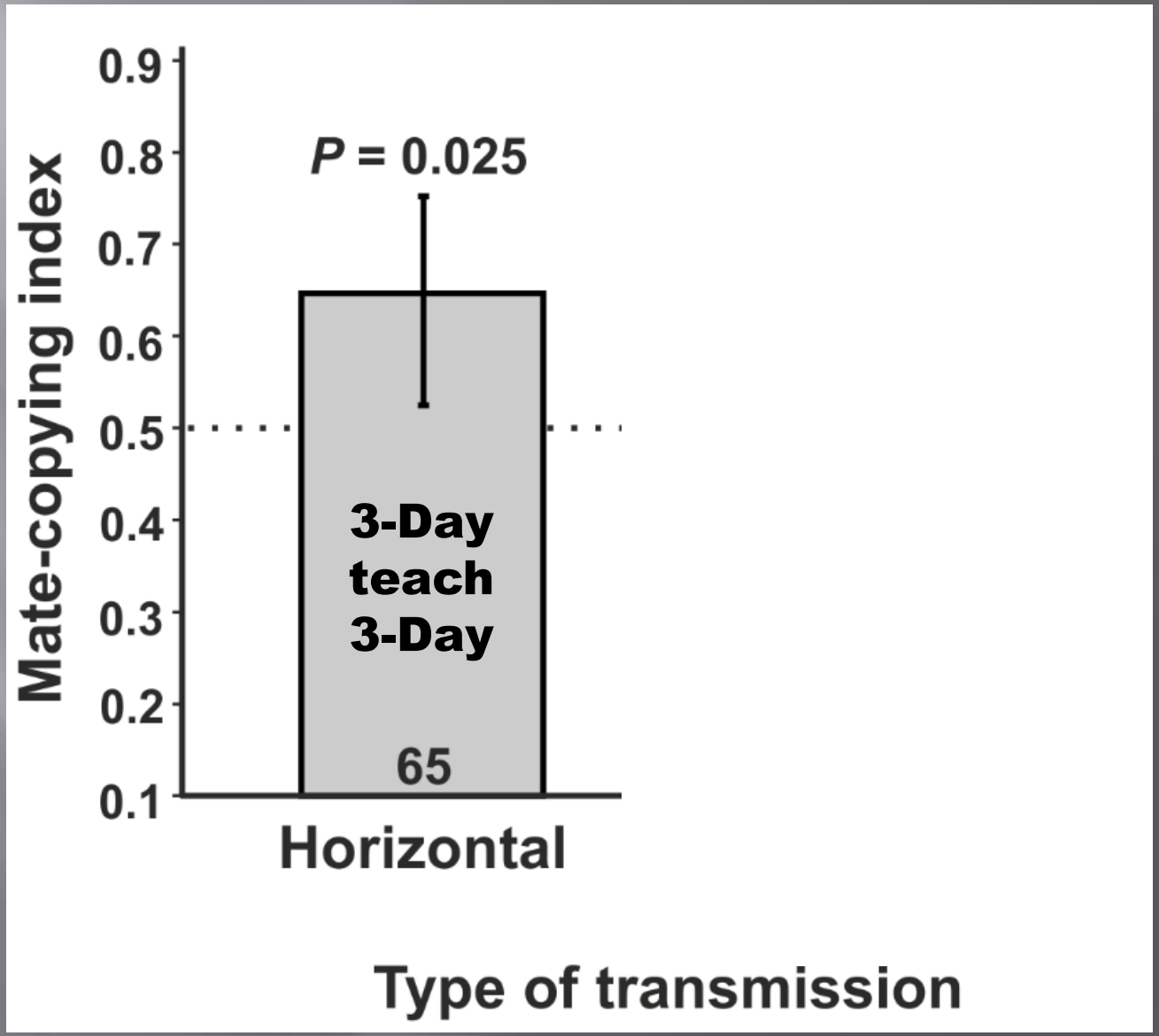
Demonstrator female (3-day)

Demonstrator female (14-day)

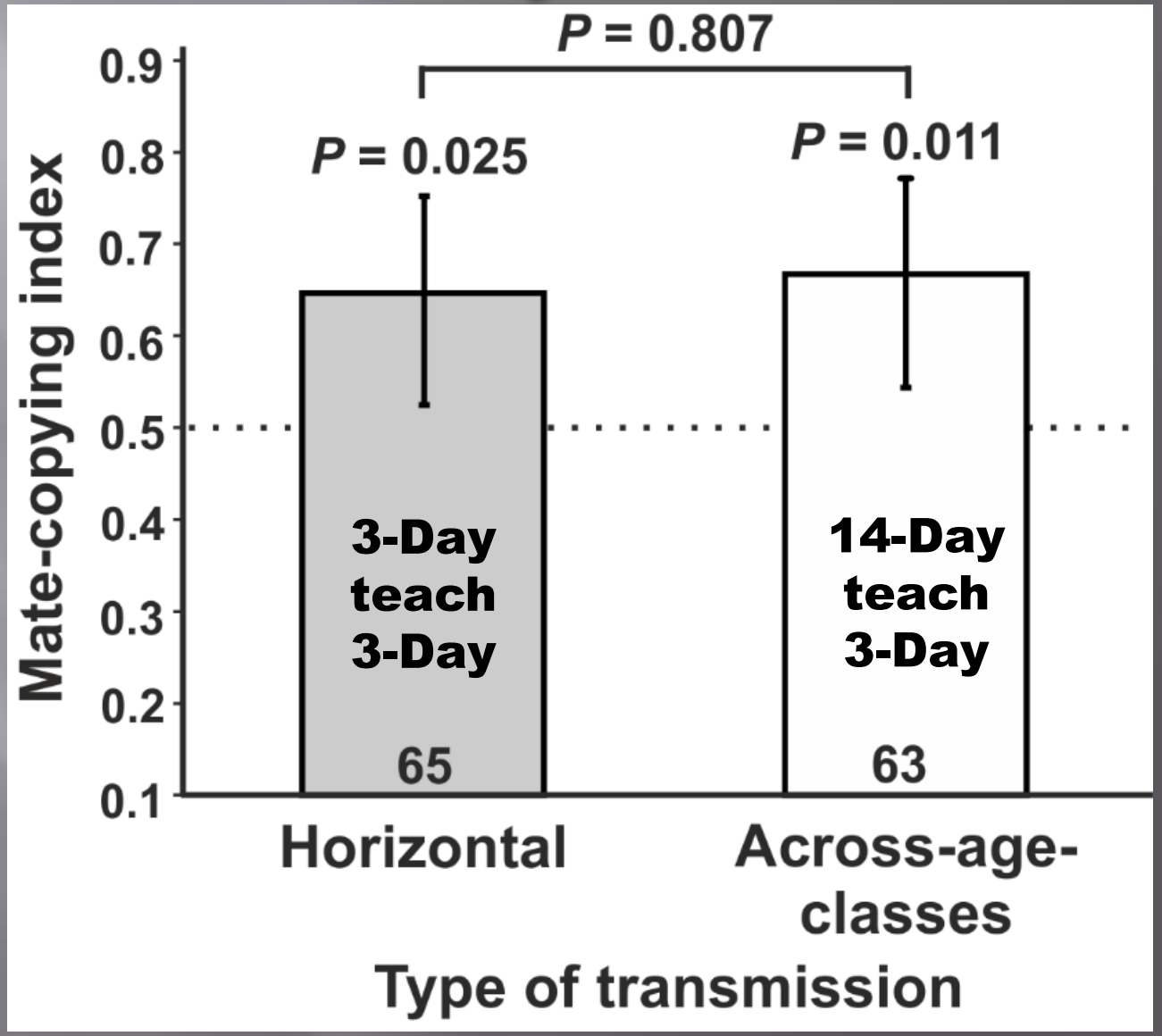
Larval development: 11 days

Observer female (3-day)

Across age-classes



Across age-classes



Danchin *et al.* 2018. *Science*

Transmission also works across-age-classes => information can persist

Criterion 2

ACROSS AGE-CLASSES *TRANSMISSION*

ONLY INFORMATION THAT IS TRANSMITTED ACROSS AGE-CLASSES CAN EVOLVE

Criterion 3

LONG LASTING SOCIAL EFFECTS

WE ONLY TRANSMIT HABITS

TO WHICH WE STICK

- => Flies do build long-term memory (24h and above)
- implying *de novo* protein synthesis
- =>memorized for a long time

Danchin et al. 2018. *Science*

Criterion 3

LONG LASTING SOCIAL EFFECTS

WE ONLY TRANSMIT HABITS

TO WHICH WE STICK

Criterion 4

TRAIT-BASED COPYING

ONLY TRAIT-BASED PREFERENCES CAN BE TRANSMITTED

Accross age classes

- Drosophila females do not only learn to prefer a given male over another male but learn to

"Prefer any male of a given color phenotype"

Criterion 4

TRAIT-BASED COPYING

ONLY TRAIT-BASED PREFERENCES CAN BE TRANSMITTED

Conclusions

- **Drosophila social learning meets the 4 criteria** that had been claimed important

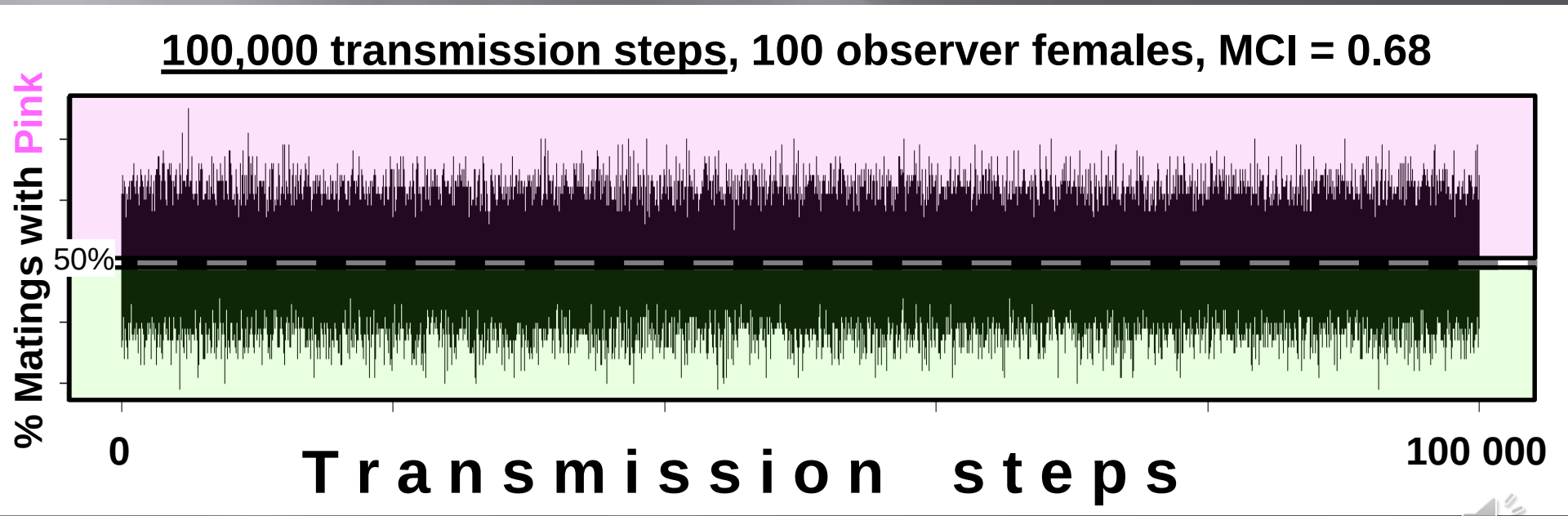
- *Is it enough to create and maintain cultural traditions?*

  - The main marker of culture,
  - and main approach to study animal culture

Danchin *et al.* 2018. *Science*

- Model of a **transmission chain** in which learners of step *t* become demonstrators of step *t+1*

- => 4 criteria: **NO traditions emerge**

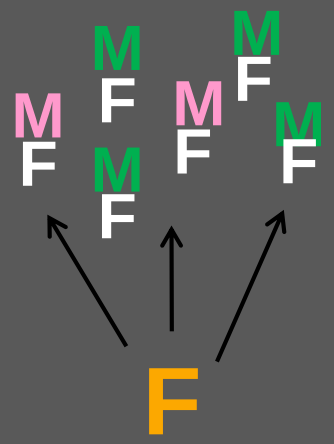


Danchin *et al.* 2018. *Science*

Why?

- Social learning is not perfect (at best 80% learn)
  - which should strongly hamper the emergence of a collective preference

- Except if females are **conformist:**
  Behave as the majority

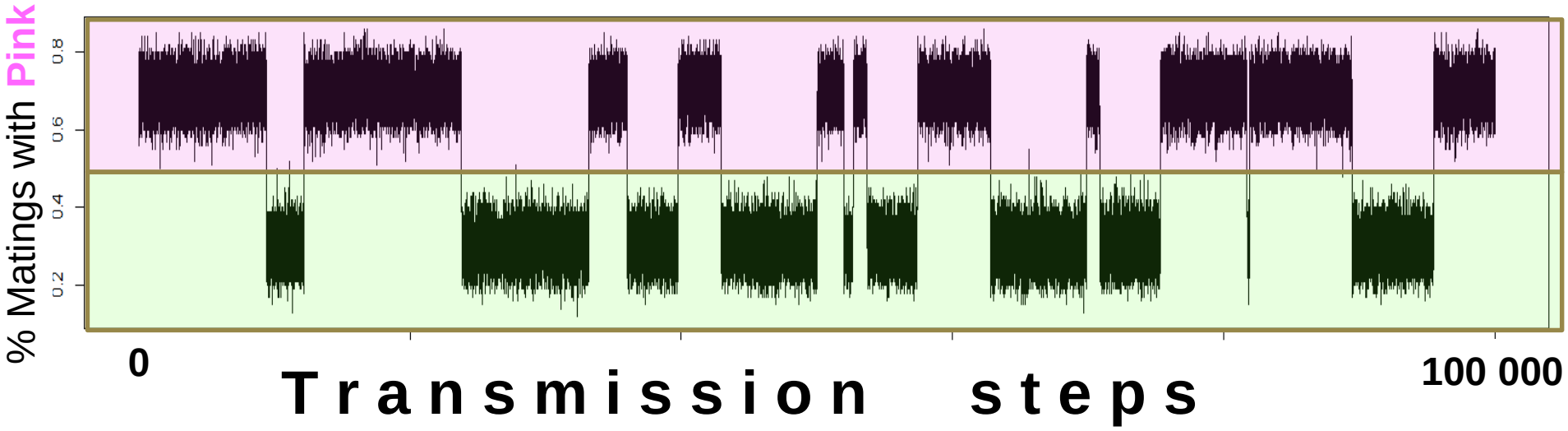


Prefer
Green

Back to modeling

- **Adding conformity** => Long periods of preferring one color (traditions). Up to 20,000 transmission steps

100,000 transmission steps, 100 observer females, MCI=0.68 + Conformity



- **Is it the case that Drosophilas' social-learning is conformist?**

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Criterion 5

ANIMALS LEARN CONFORMISTICALLY

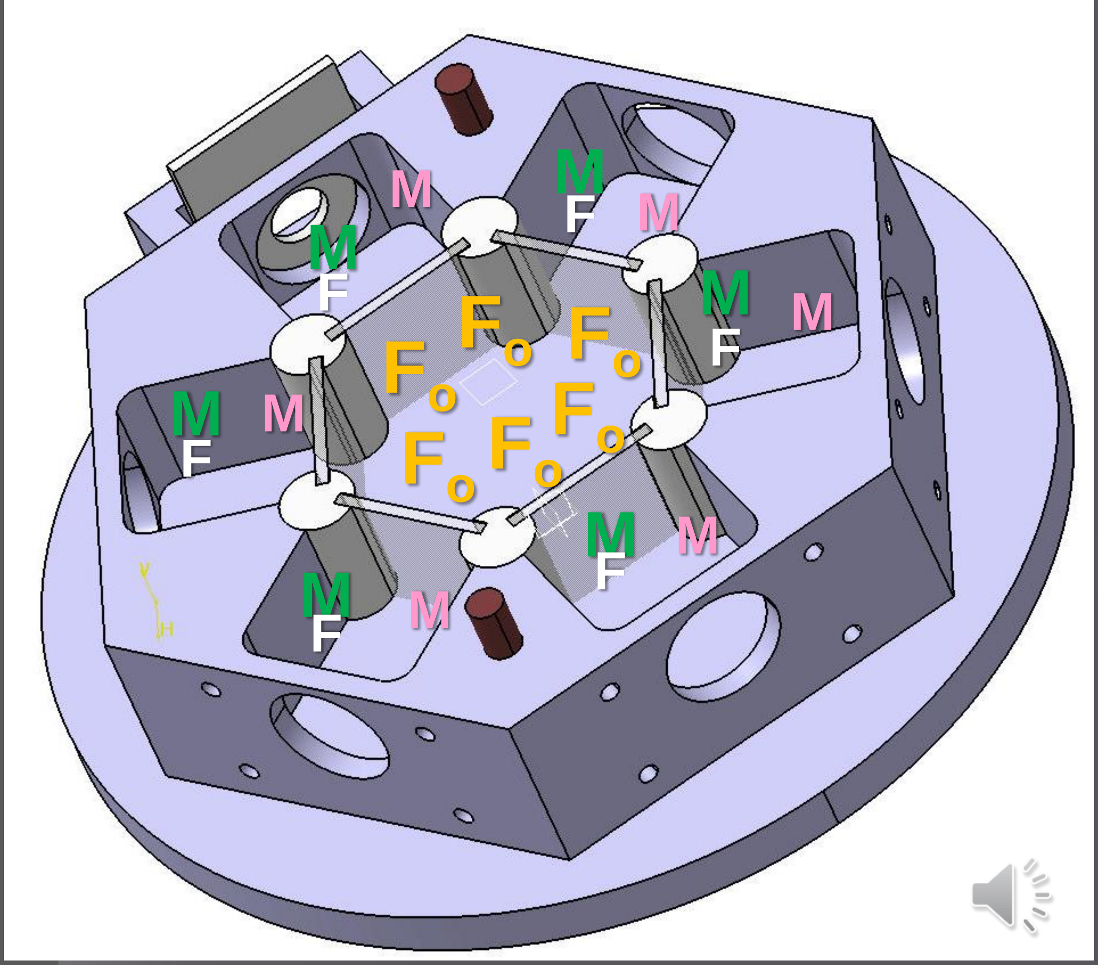
CONFORMITY FACILITATES CULTURAL TRANSMISSION

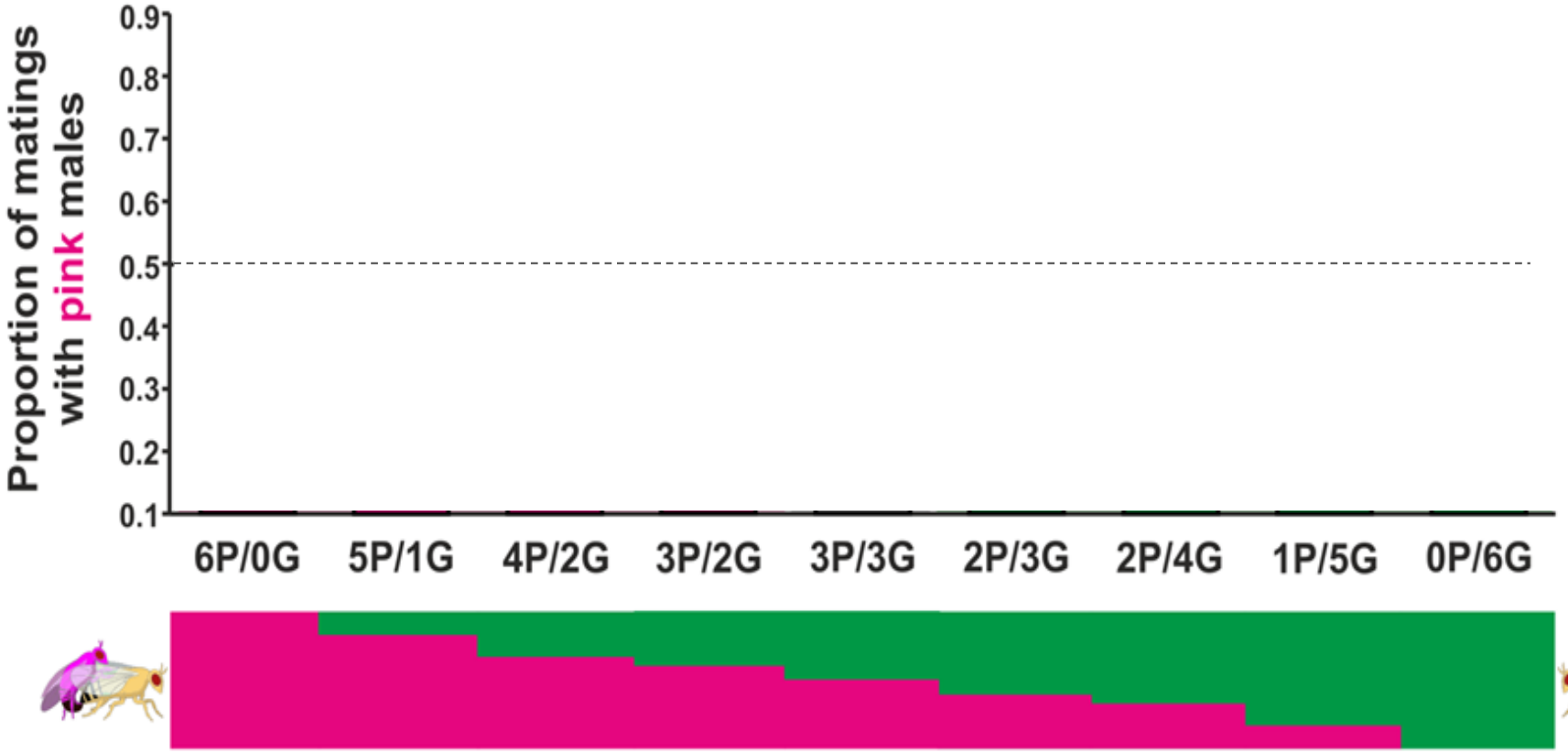
Hexagon

- Demonstrations (9 Possibilities)

	Majority	
0G,6P	100%	More Pink
1G,5P	83%	
2G,4P	67%	
2G,3P	60%	
3G,3P	-------	Control
3G,2P	60%	More Green
4G,2P	67%	
5G,1P	83%	
6G,0P	100%	

All Green demonstrations





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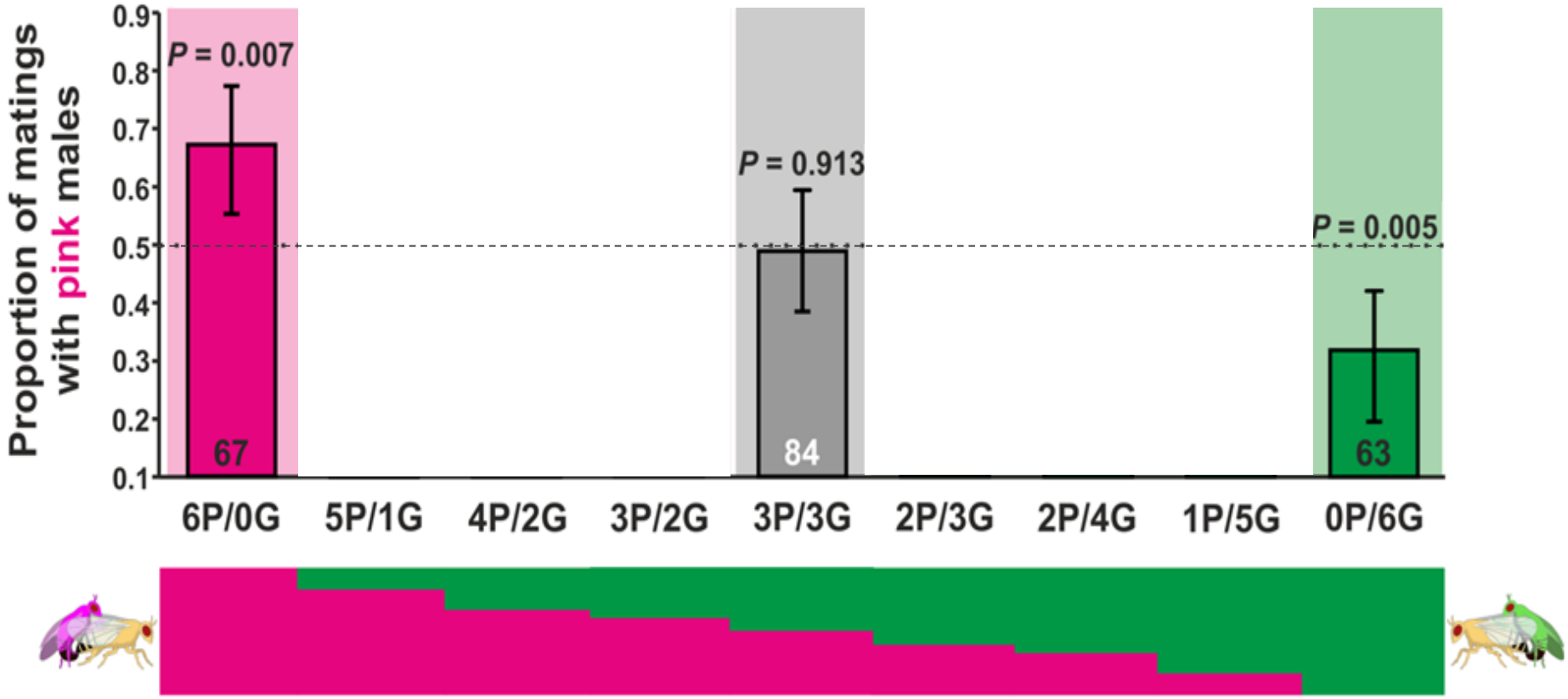

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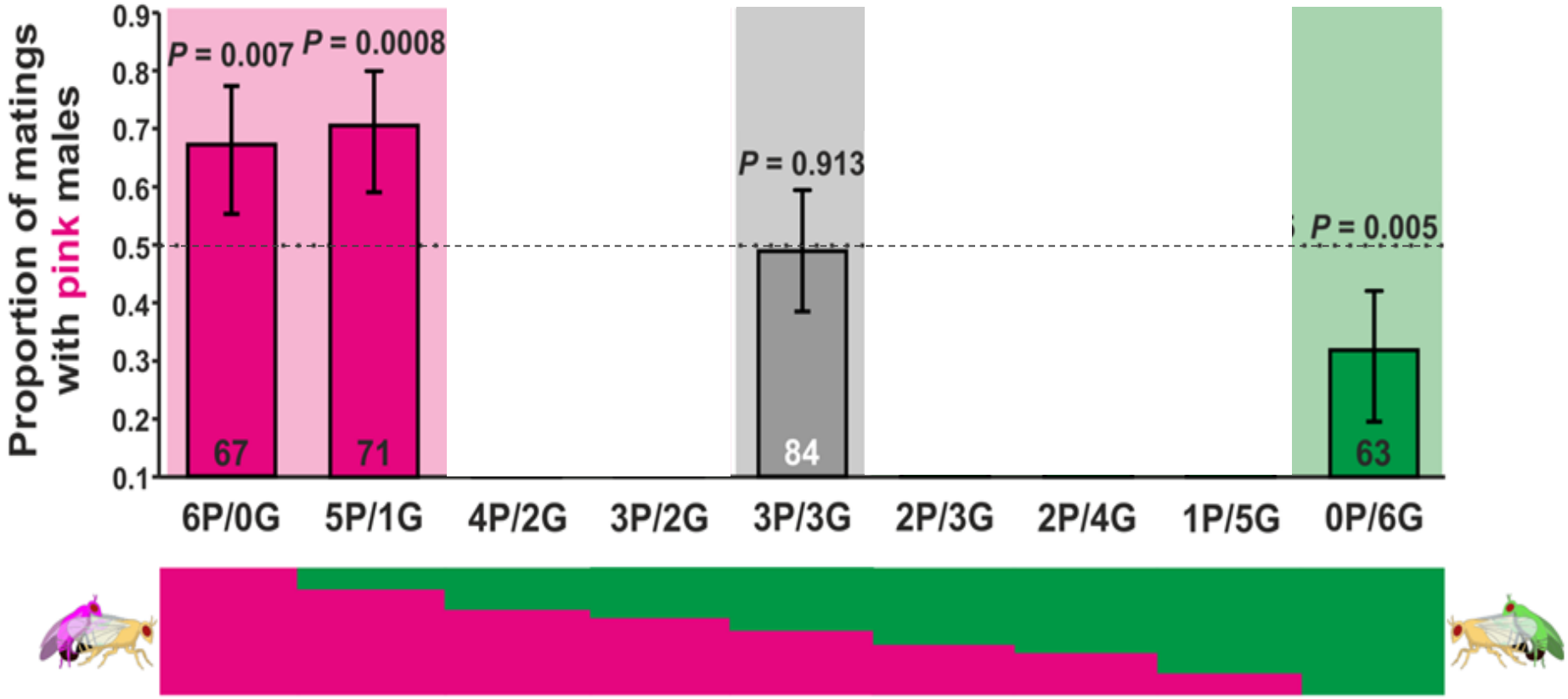

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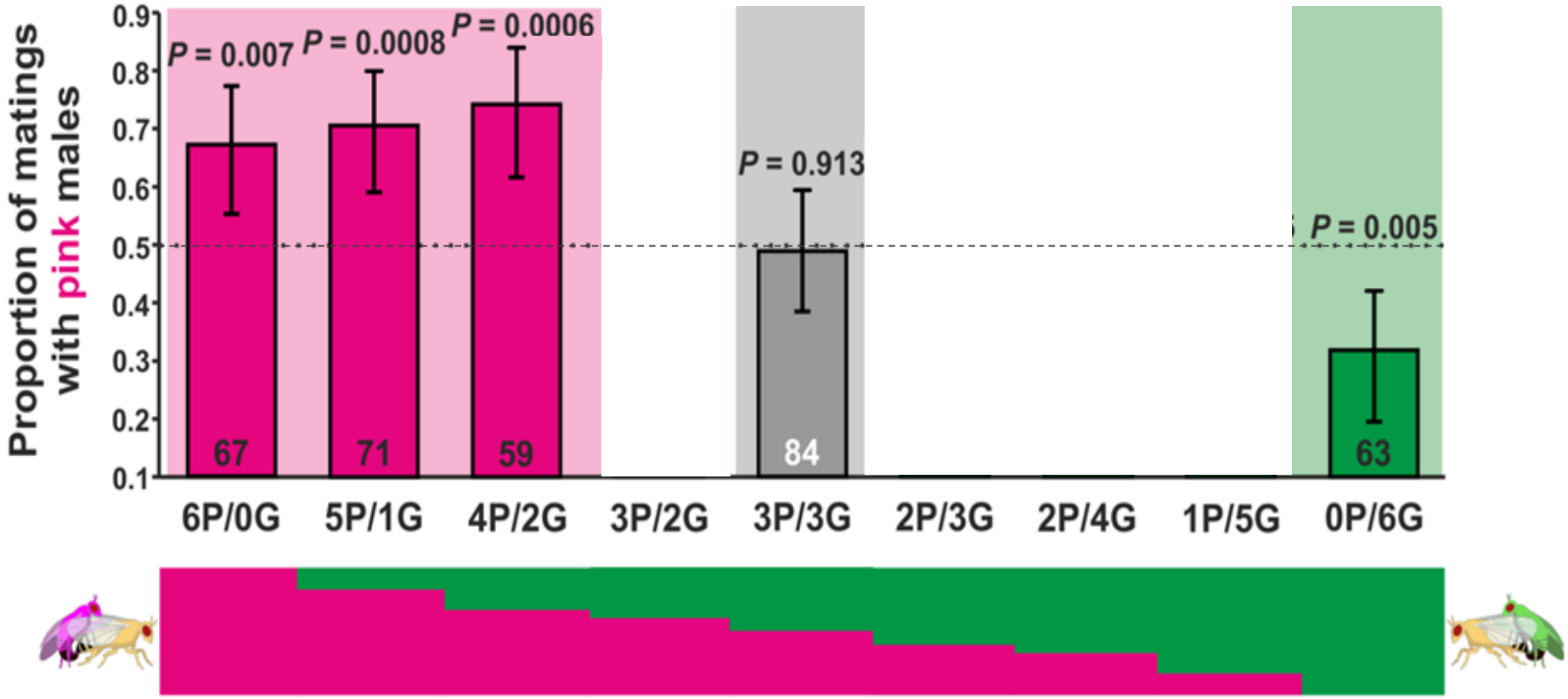

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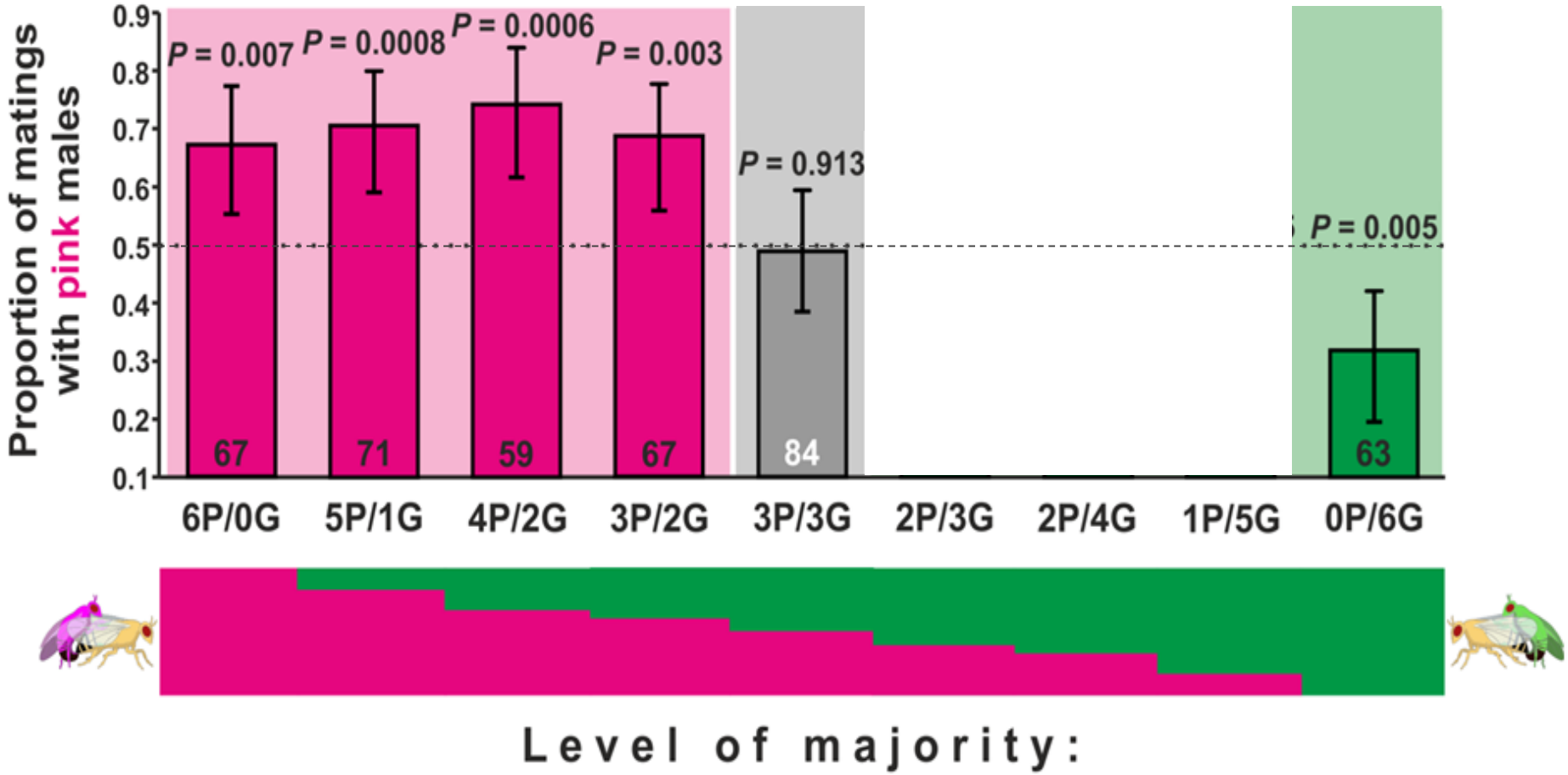

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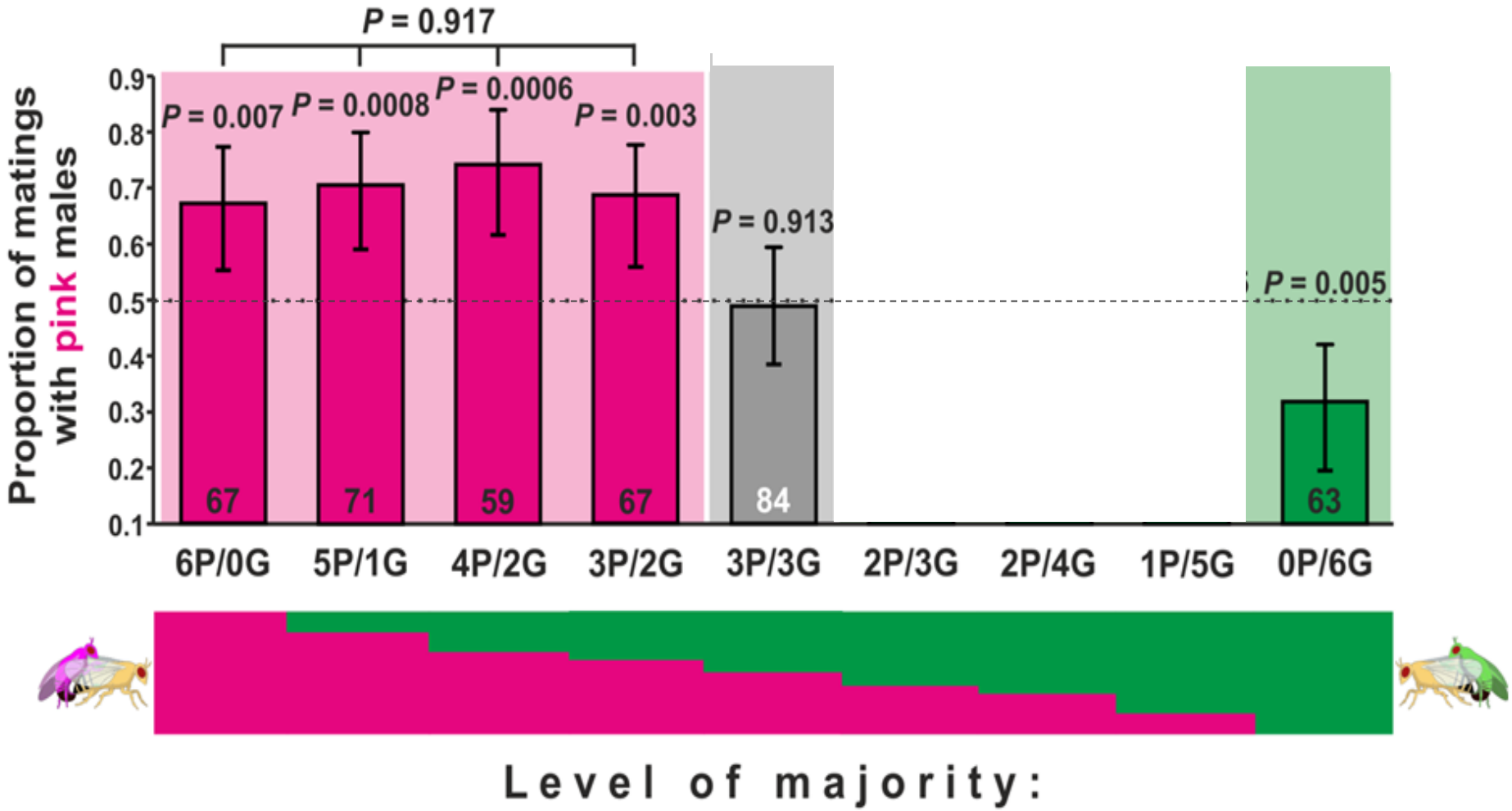

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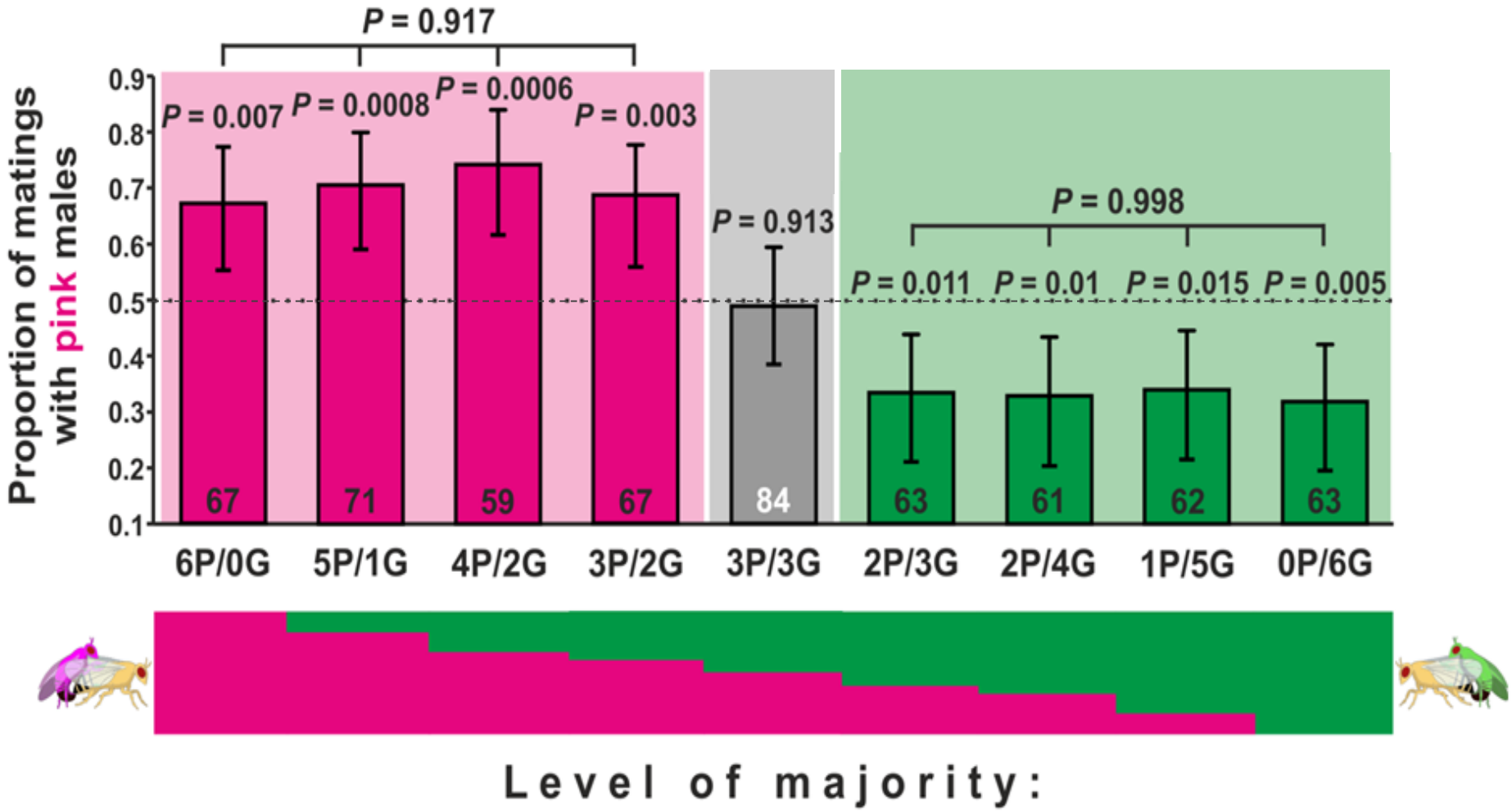
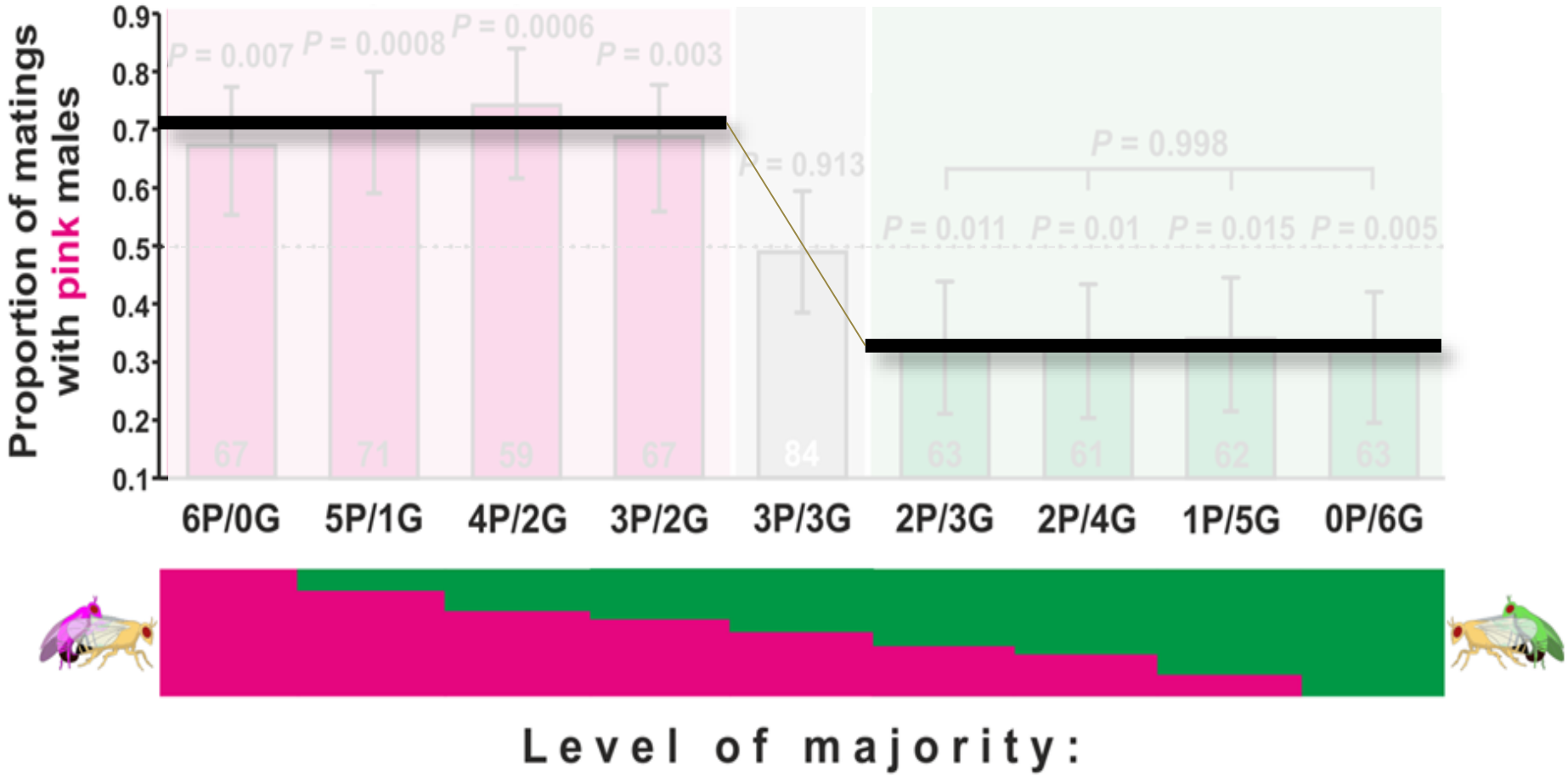


Danchin *et al.* 2018. *Science*

=>Females learned to prefer the most commonly chosen male phenotype equally well, independently from the level of majority (down to 60%)



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Criterion 5

ANIMALS LEARN CONFORMISTICALLY

CONFORMITY CORRECTS TRANSMISSION ERRORS

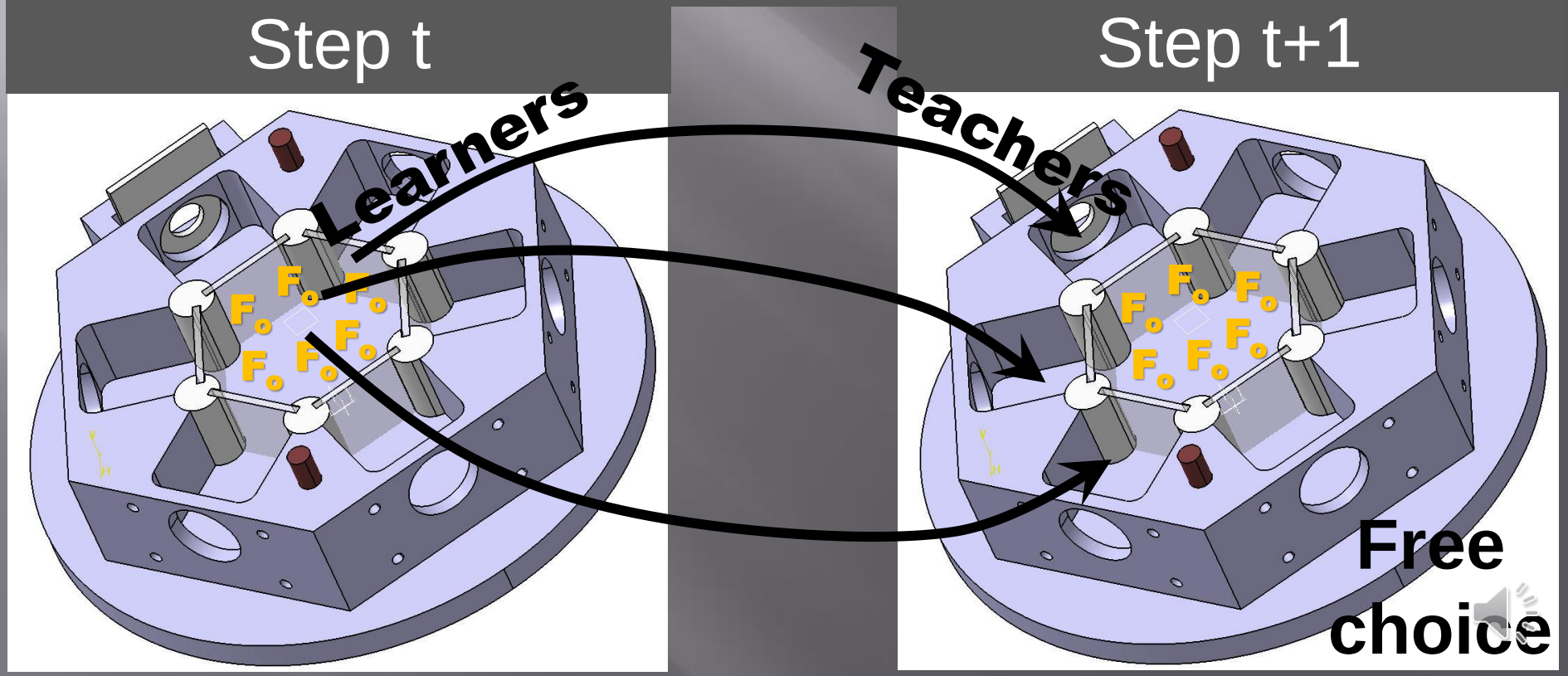
6- Traditions?

CAN DOCUMENTED COGNITION FOSTER TRADITIONS?

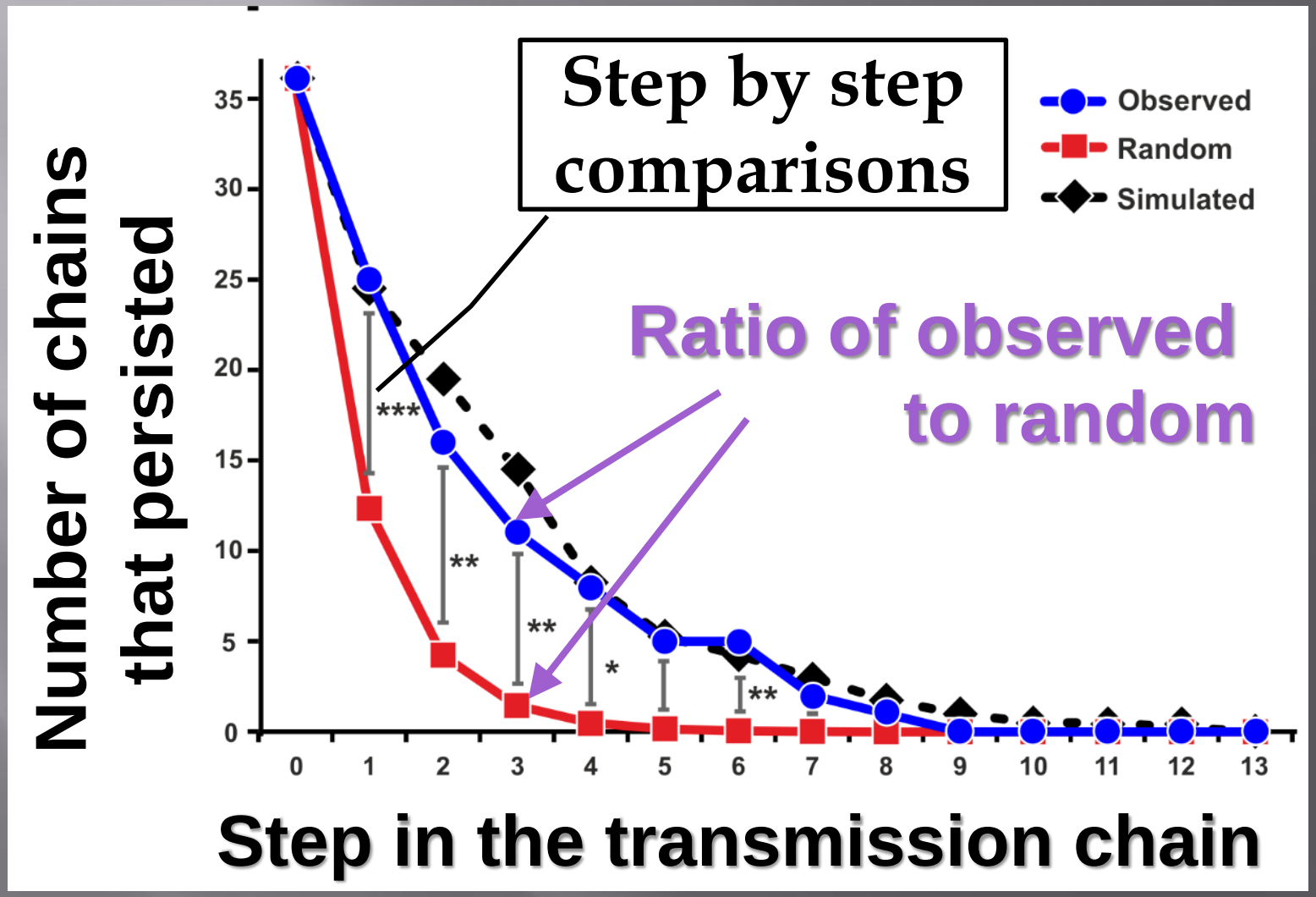
PERSISTENCE IN A TRANSMISSION CHAIN EXPERIMENT

Transmission chain

- **Transmission chain in which learners of step *t* become the demonstrators of step *t+1***
- Starts with 100% for one color. Then Free choice
- Stops when gets to 50% or less
- **36 such trials**



36 transmission chains



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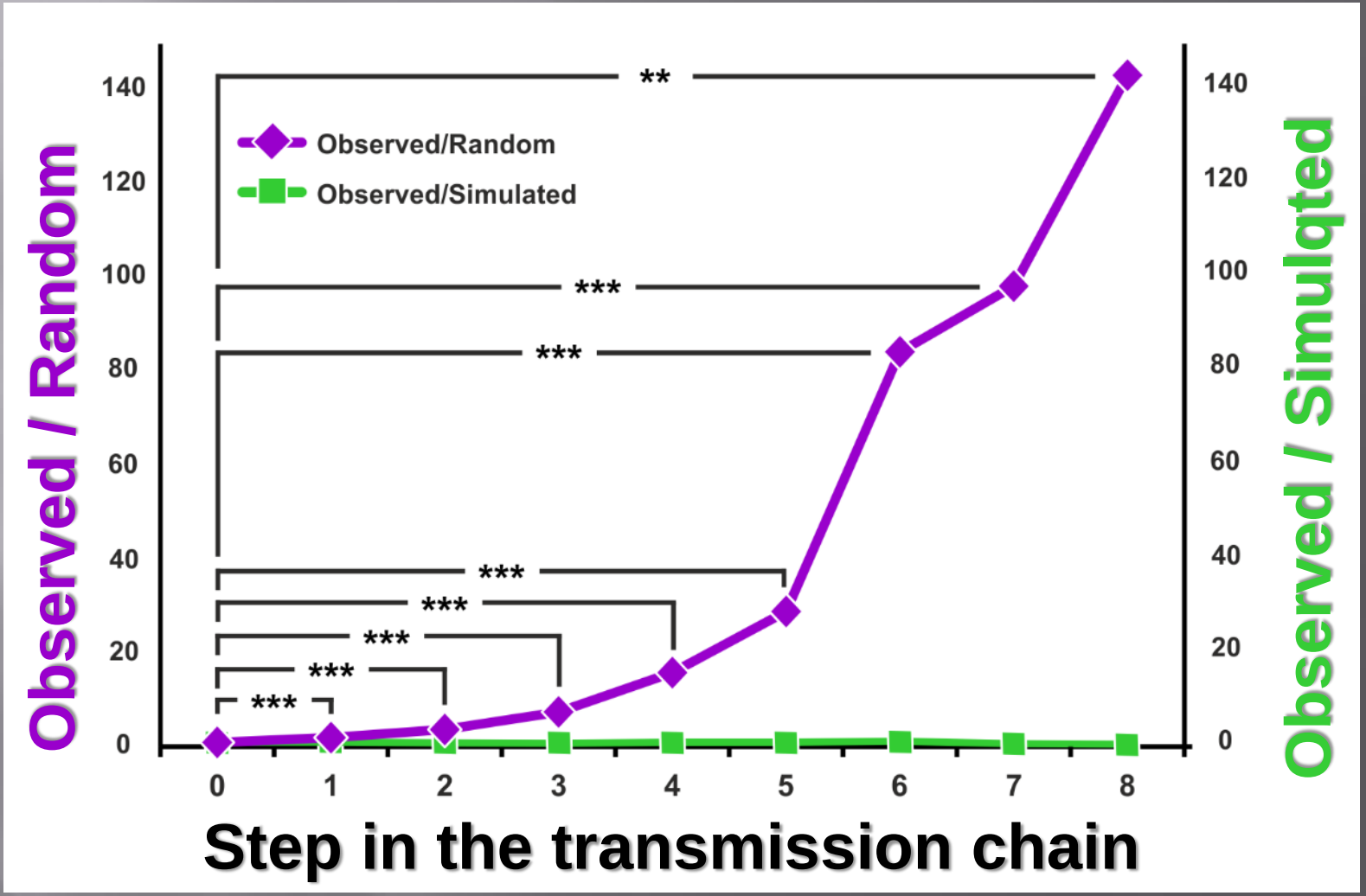
36 transmission chains



- Chains lasted much longer than expected by chance
- Model validated

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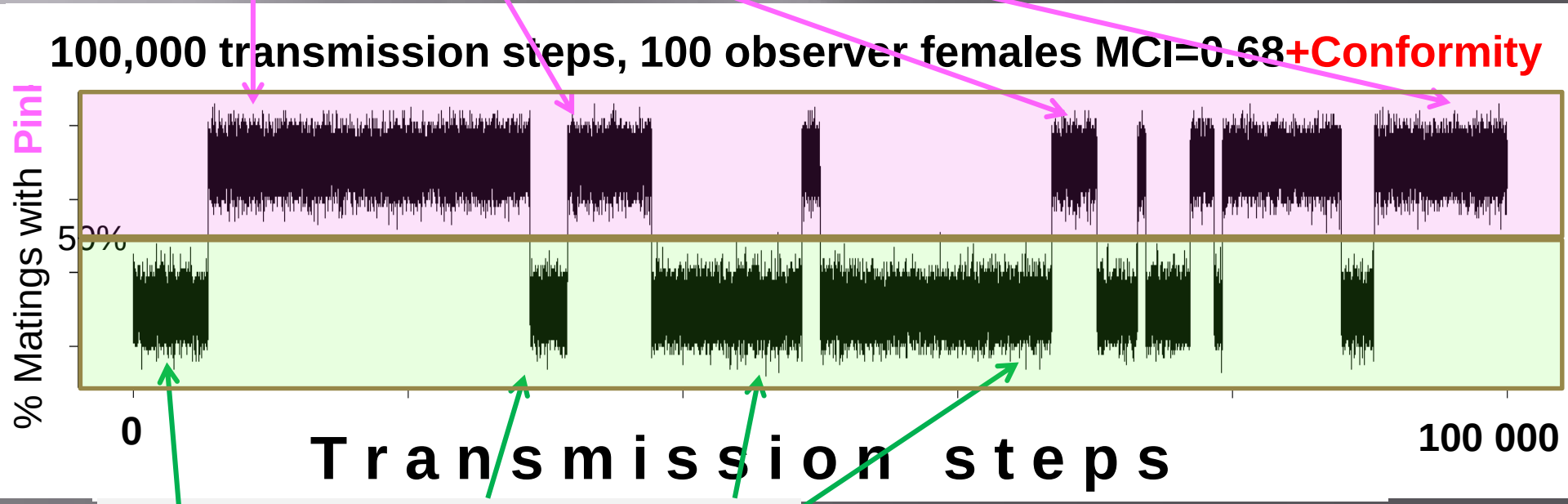
=> long-lasting traditions

Traditions up to 25,000 transmission steps
~ 2000 generations

Traditions for Pink



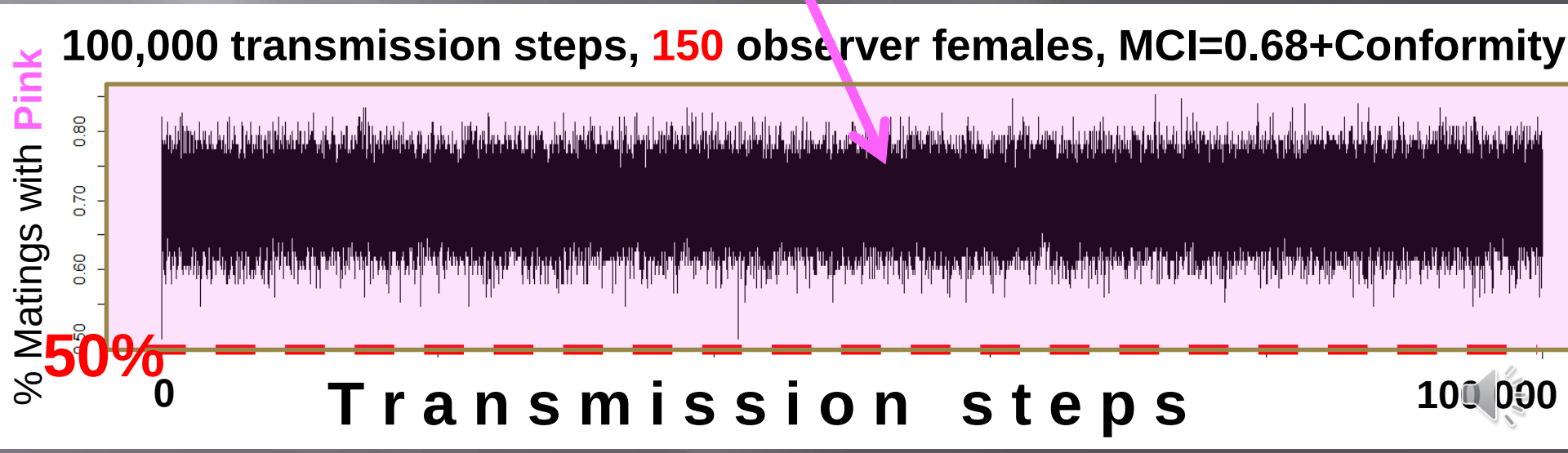
Traditions for Green

Danchin et al. 2018. Science

Danchin *et al.* 2018. *Science*

- With 150 observer flies
- 100,000 days: > 274 years i.e. >9,000 generations

Single tradition for Pink lasting quasi forever



- *Drosophila melanogaster* females have all the **cognitive capacities** to transfer their **mating preferences** culturally, **potentially** creating long lasting local traditions of preferring a given male phenotype => **speciation**

- **Considerably expands the taxonomic range of cultural processes: incorporates invertebrates**

Danchin *et al.* 2018. *Science*

General conclusion

New tractable definition: culture / cultural transmission

- The **part of** phenotypic variation inherited through:
- 1) a form of
- 2) occurs **ac**
- 3) **memoriz**
- 4) **trait-base**
- 5) incorpora
  (conformity,
  learning imp
- 6) five condi
  local traditi

Mechanistic definition
=
An 'experimental toolbox'
transposable
to many organisms
&
Connected to previous definitions

Final remarks

- Current insect examples => Insects **CAN transmit behavior culturally**, but **Not that they actually DO SO in nature**.
- Such evidence is still lacking in insects
- In vertebrates, although we know that persistent traditions exist in nature, usually we only have suspicion that these are produced by social learning
- While in insect we have better knowledge on transmission mechanisms
- These taxa are thus complementary

Challenges for the future

- Run **experiments** on animal culture
- The only way to study **mechanisms/causality**
- Apply these to **many species**
- Seek evidence for insect culture in nature
- Integrate **culture** into **biology**

Cited references

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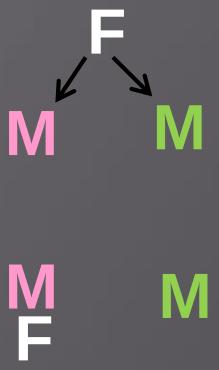
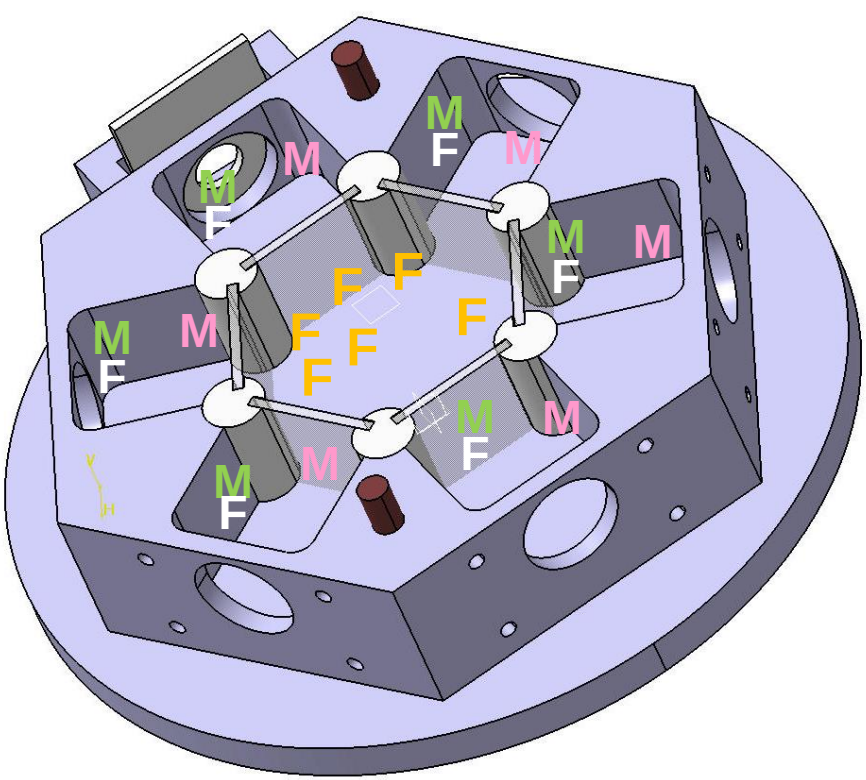
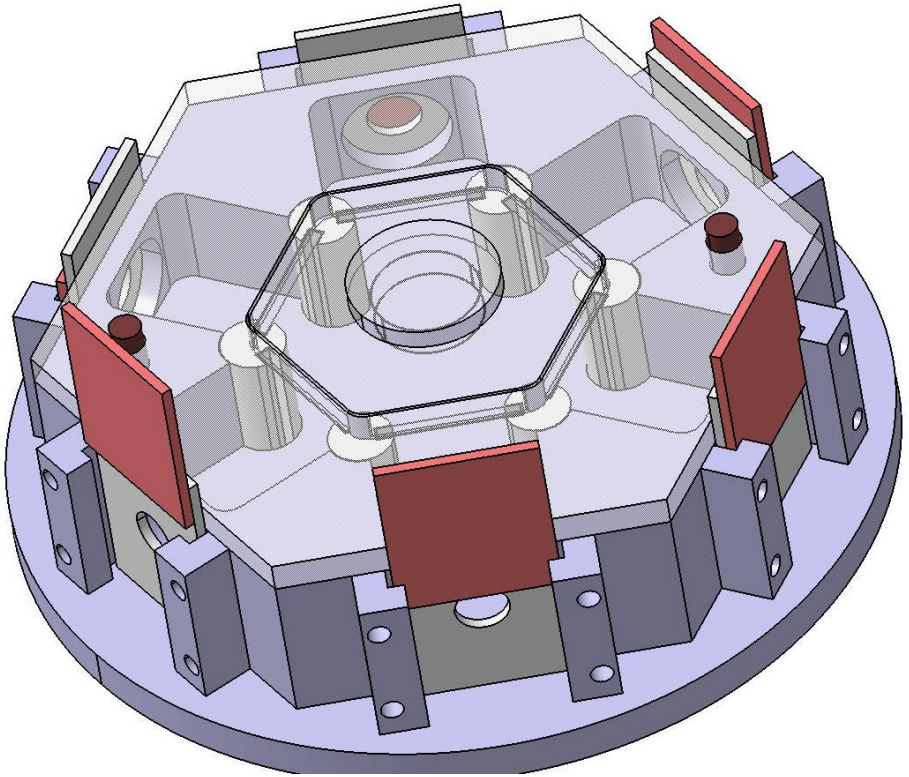
- Brooks 1998. The importance of mate copying and cultural inheritance of mating preferences. ***Trends in Ecology and Evolution.***
- Danchin *et al.* 2011. Beyond DNA: integrating inclusive inheritance into an extended theory of evolution. ***Nature Reviews Genetics.***
- ***Plus references therein***

New design: "Inverted Peep Show"

- Live demonstration of a F choosing between **M** and **M** => no control on demonstration
- => Transfer copulating pairs of the desired color + Male of the other color







Chapters 4 and 20