

# **Evolution of SEX, SEXES AND SEX-DETERMINATION SYSTEMS**

Bart Nieuwenhuis

# 13 SEMINAR SESSIONS

- Thursday 16:00 – 18:00
  - Not:** 1 November and 13 December
- Biozentrum - room E 02.023
- 2 people present shortly on the topic
- Credits: 3 ECTS, 2 SWS
- Everyone discusses the paper(s)
- Grade is based on presentation *and* participation

# Topics

25/10/18	The many costs of sexual reproduction
08/11/18	Benefits of recombination
15/11/18	Frequency of sexual reproduction
22/11/18	Evolution of sexual asymmetries: mating types
29/11/18	Evolution of sexual asymmetries: anisogamy
06/12/18	Evolution of sexual asymmetries: separate sexes
20/12/18	Diversity of sex determination systems
10/01/19	Sexes and “sex roles”
17/01/19	Sexual conflict
24/01/19	Sex chromosome evolution
31/01/19	Sex chromosome turnover
07/02/19	Cheating Mendel

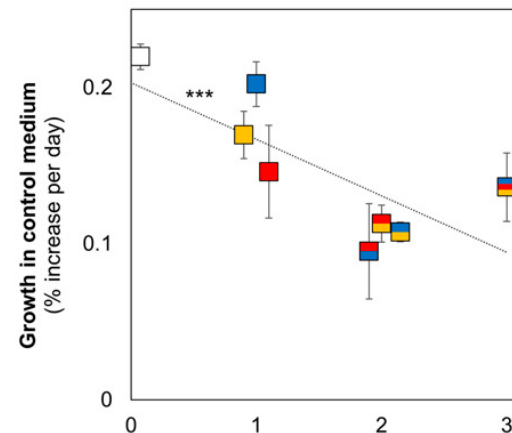
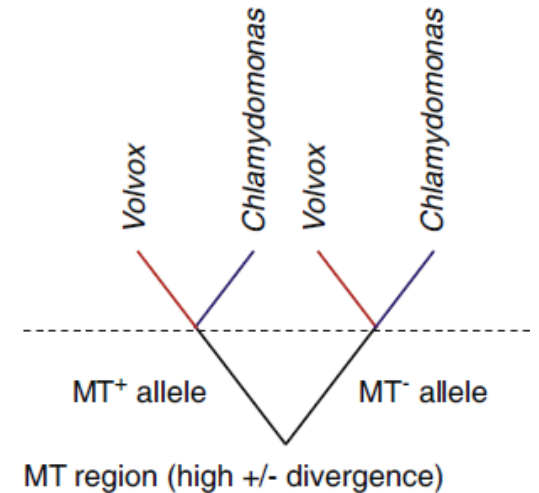
# PRESENTATION

- ~10 min
- Introduce the **topic** (not the papers)
- Give theoretical background
- Present examples from **variety** of groups:
  - Microorganisms
  - Plants
  - Algae
  - Animals

# Types of papers

- Experimental work
- Phylogenetic analyses
- Genomics
- Theoretical modelling

$$K^* = \frac{(1 + s - 2s\delta)}{(k + 2s\delta - s)} k^*$$



# CONTACT

[http://evol.bio.lmu.de/\\_teaching/Seminar\\_EvolSex/](http://evol.bio.lmu.de/_teaching/Seminar_EvolSex/)

[nieuwenhuis@bio.lmu.de](mailto:nieuwenhuis@bio.lmu.de)

Office: B01.005

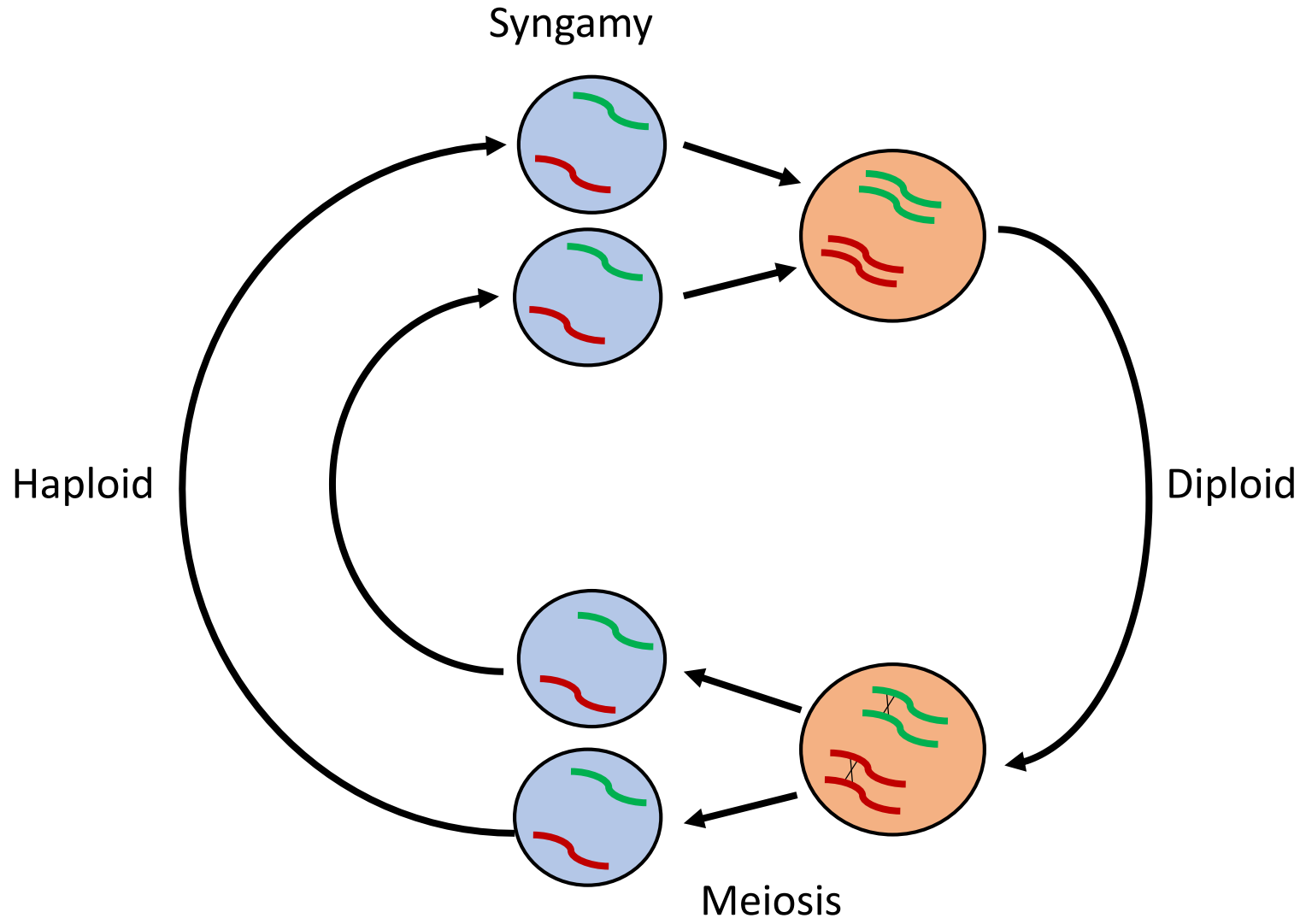
**WHAT IS SEXUAL REPRODUCTION?**

# **WHAT IS SEXUAL REPRODUCTION?**

Sex is the coming together of two  
genomes in the same individual

EVOLUTION, Barton 2007





**"Sex is the queen of problems in evolutionary biology.**

**Perhaps no other natural phenomenon**

**has aroused so much interest;**

**certainly none has sowed so much confusion."**

**- Graham Bell, 1982**



# COSTS of SEXUAL REPRODUCTION

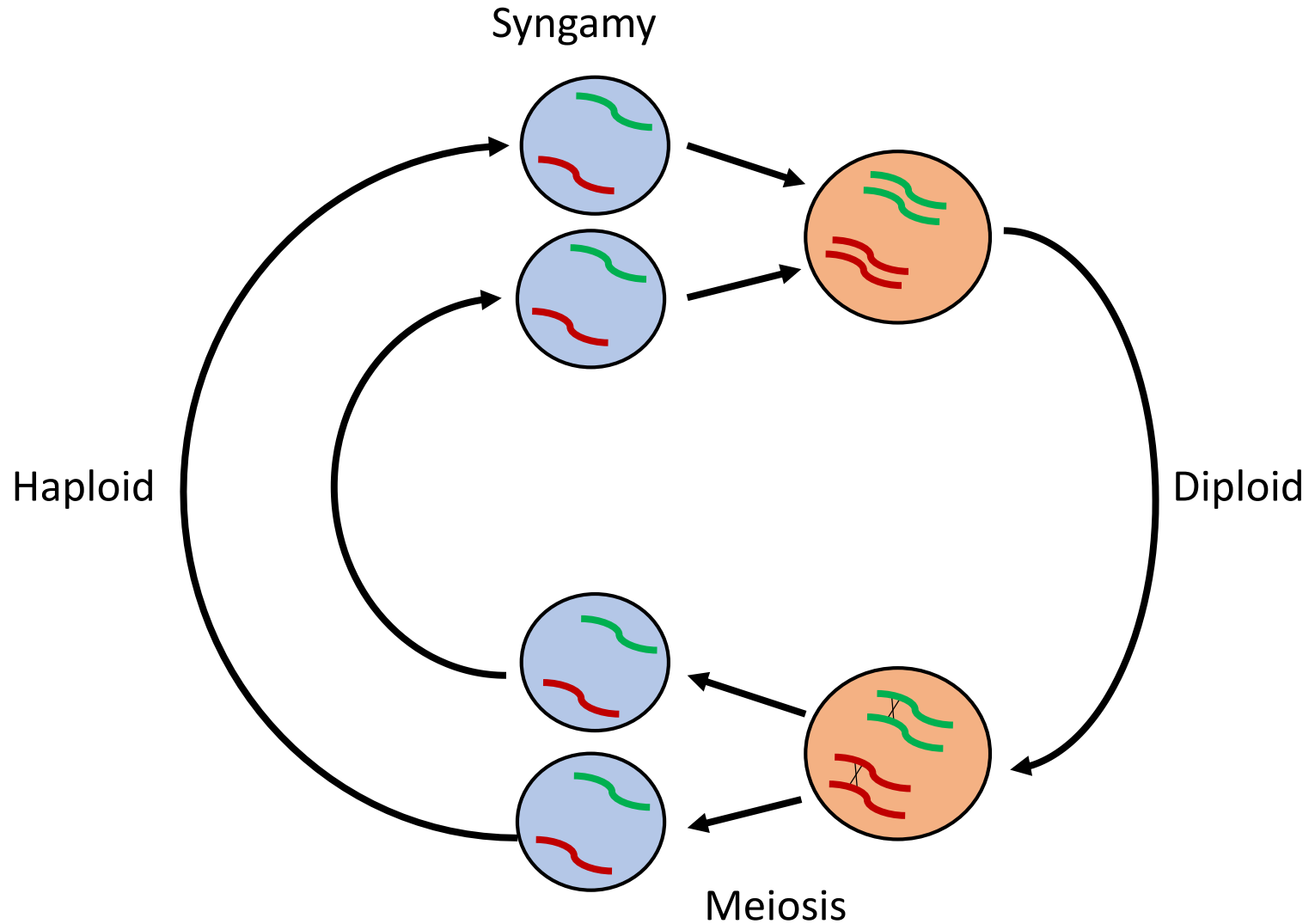
- Two-fold cost of sex
- Meiosis is complicated and takes much more time than mitosis
- Finding a mate: complicated and costly!
- Sexual selection is costly
- Recombination breaks up combinations of genes that are well adapted

>> 2x more costly than asexual reproduction

# CONCEPTS of THE SEMINAR

- Sex
- Sexes
- Sex determination systems

# SEXUAL REPRODUCTION



# SEXES

- Genders
- Males and females
- Sexes
- Mating types

# SEXES

- Genders – Social construct
- Males and females
- Sexes
- Mating types

# SEXES

- Genders – Social construct
- Males and females and hermaphrodites
- Sexes
- Mating types



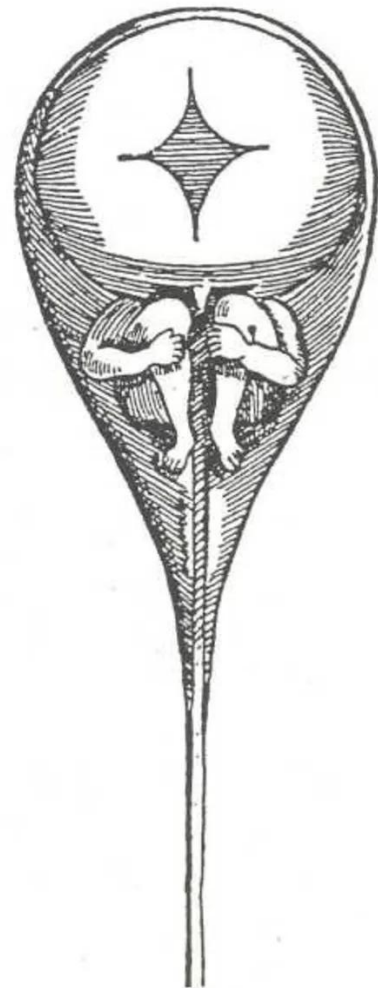
# SEXES

- Genders – Social construct
- Males and females and hermaphrodites
- Sexes – producing small or large gametes
- Mating types

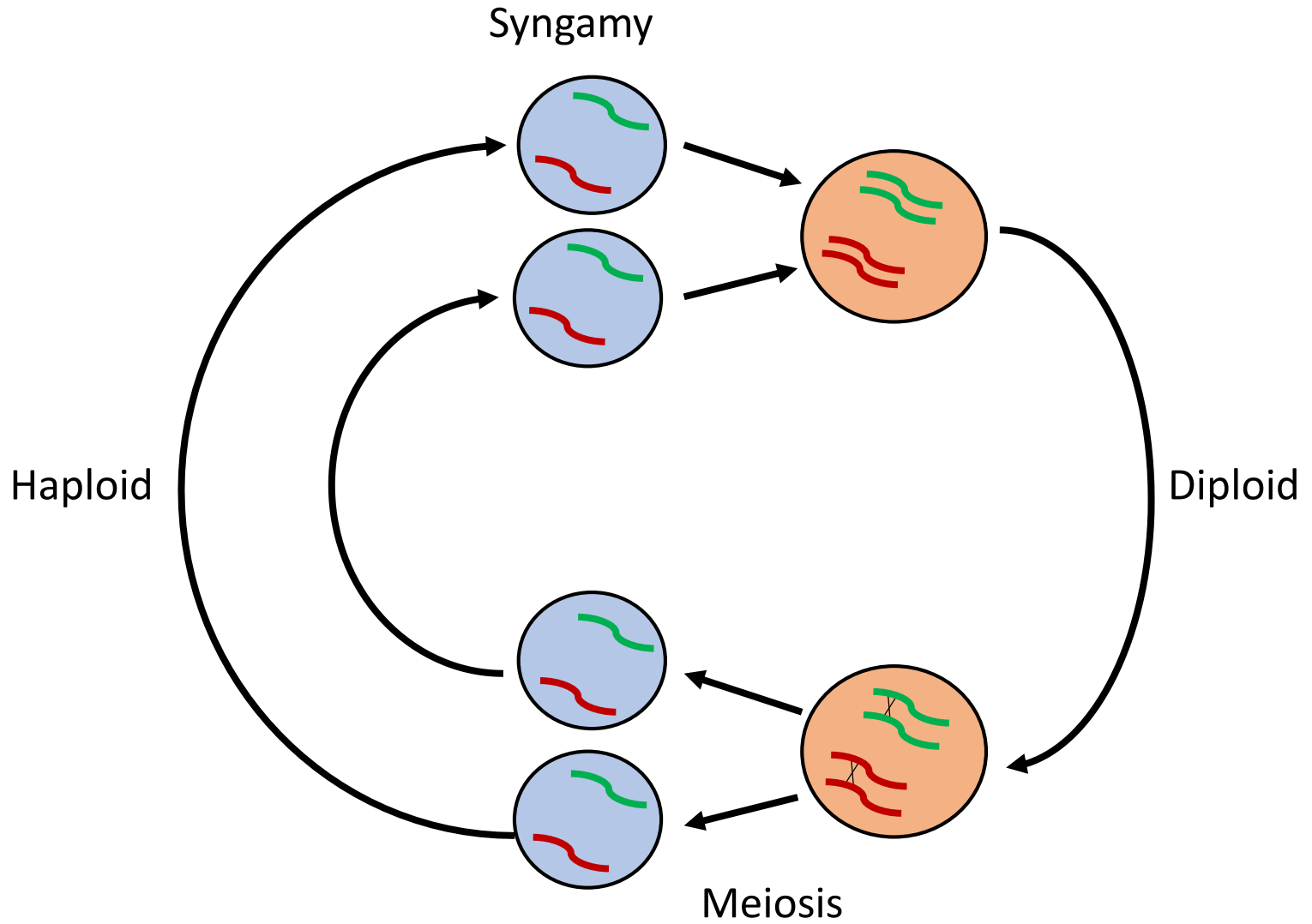
# SEXES

- Genders – Social construct
- Males and females and hermaphrodites
- Sexes – producing small or large gametes
- Mating types – gamete incompatibility

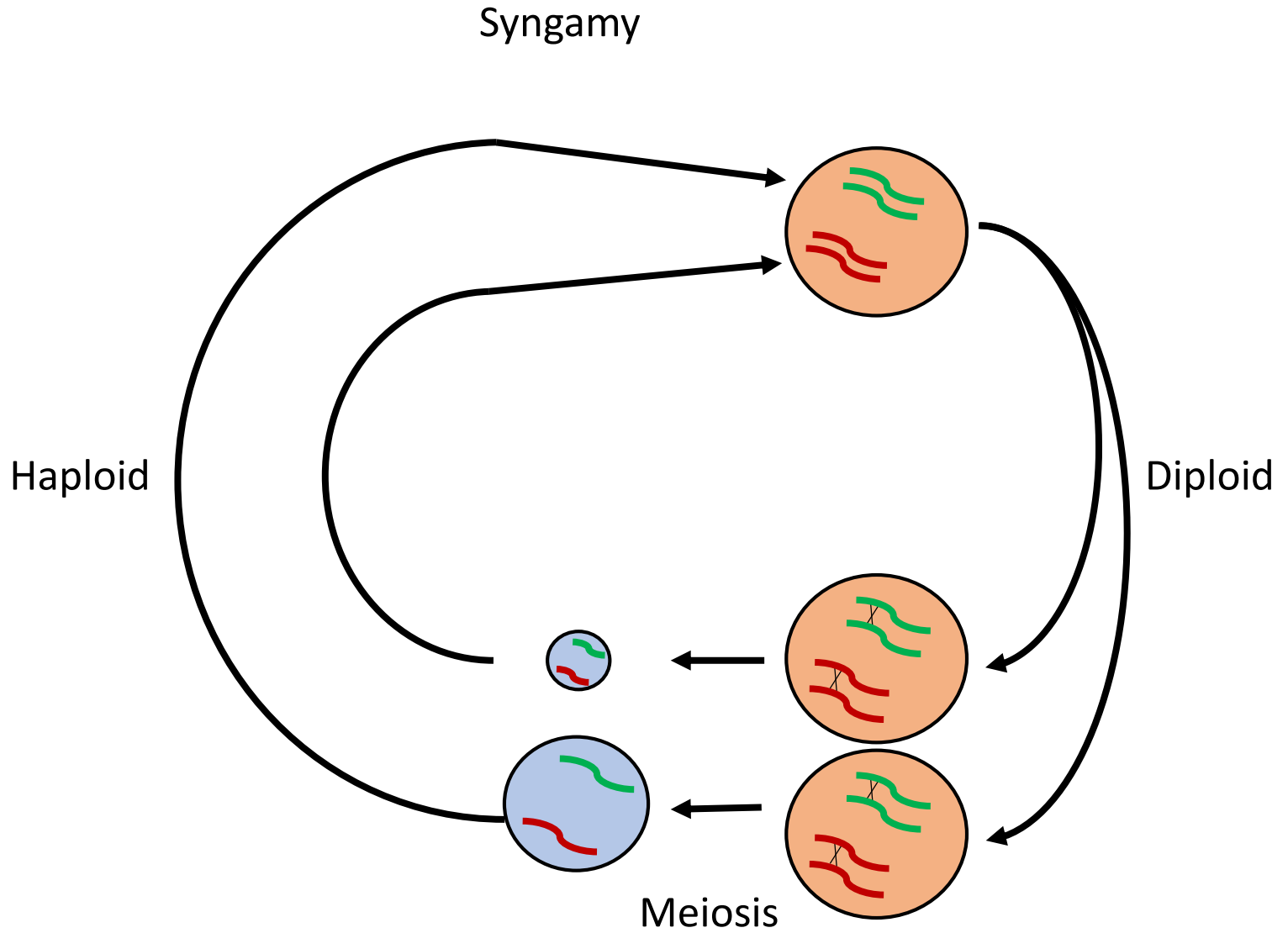
# SEXES: PRODUCING SMALL OR LARGE GAMETES



# SEXES



# SEXES



# SEPARATE SEXES

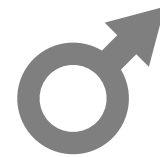


**HERMA-  
PHRODITE**

**MONO-  
OECIOUS**



**FEMALE**

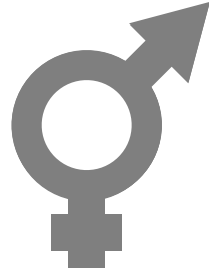


**MALE**



**DIOECIOUS (PLANTS)  
GONOGORIC (ANIMALS)**

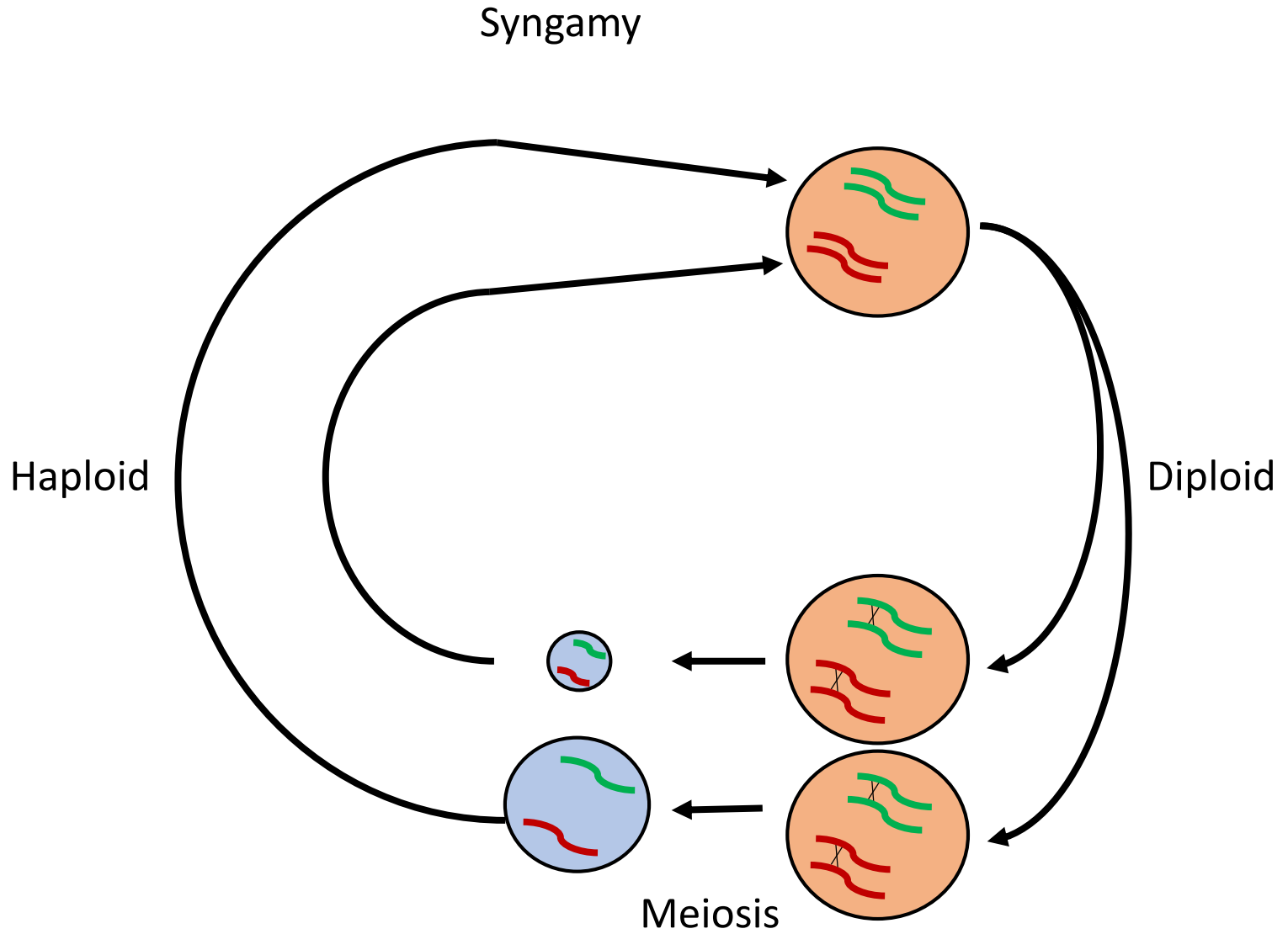
# HERMAPHRODITES



**SEPARATE SEXES**

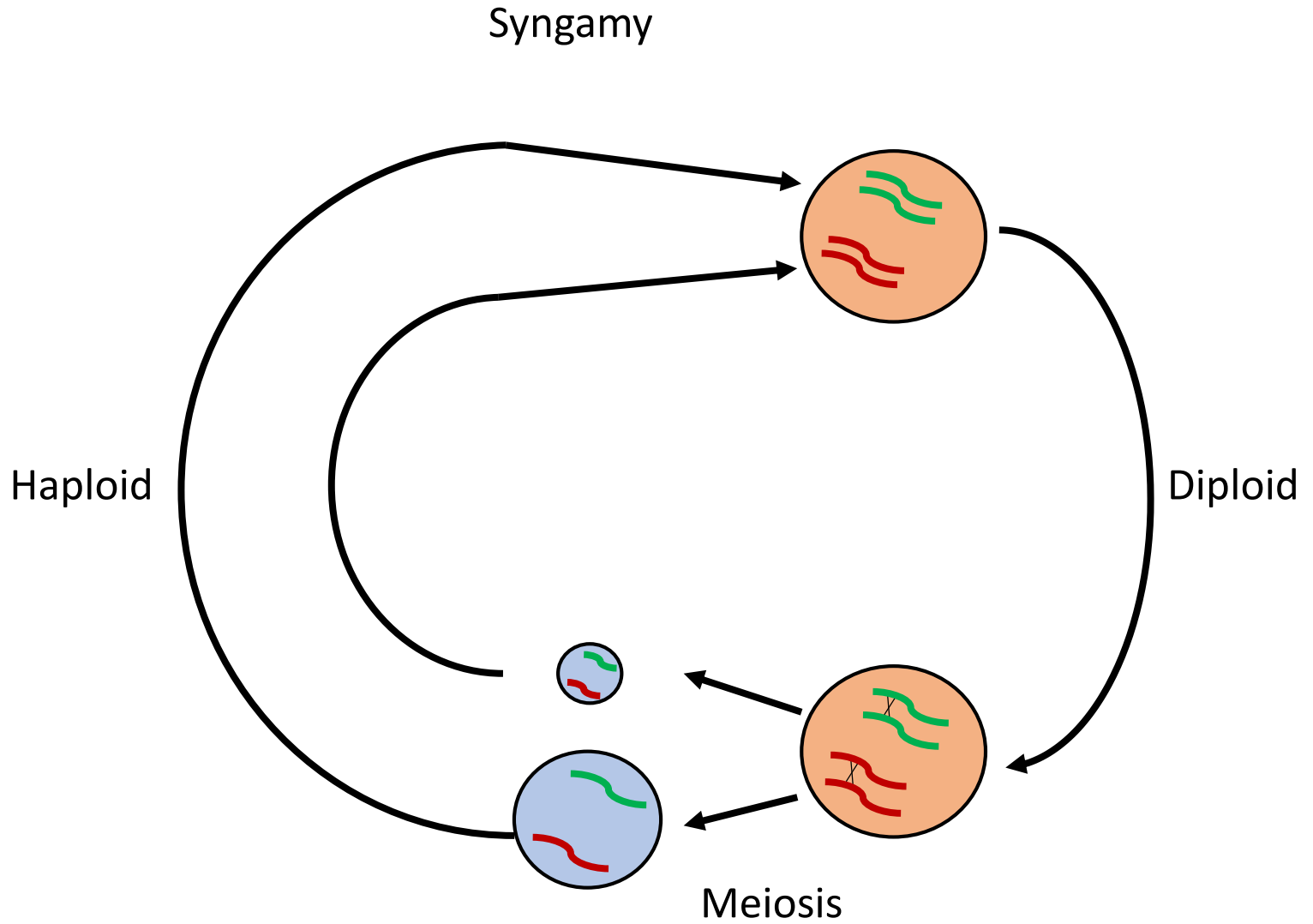
**Symposium - PLATO (c. 385-370 BC)**

# SEXES

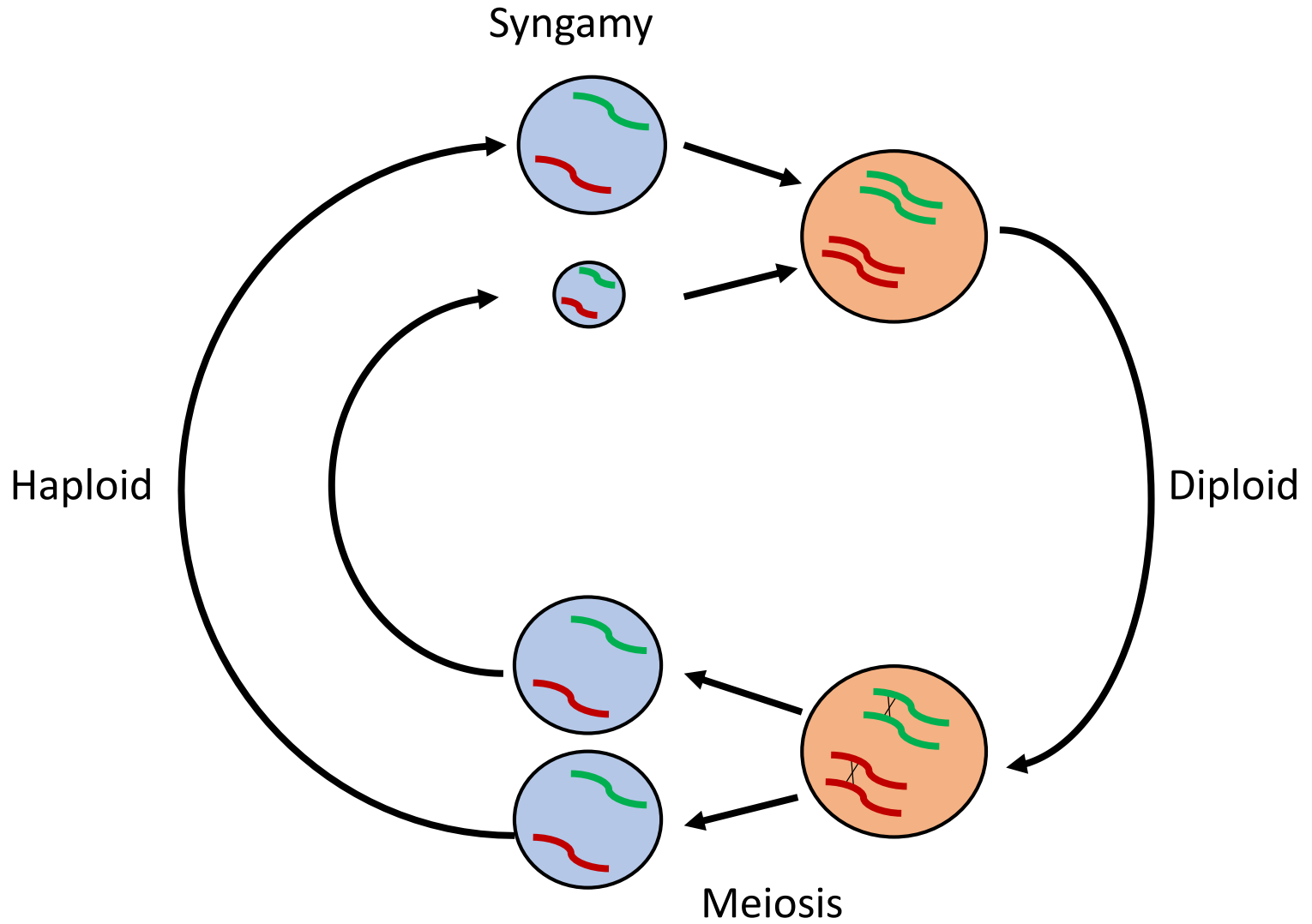




# SEXES



# SEXES



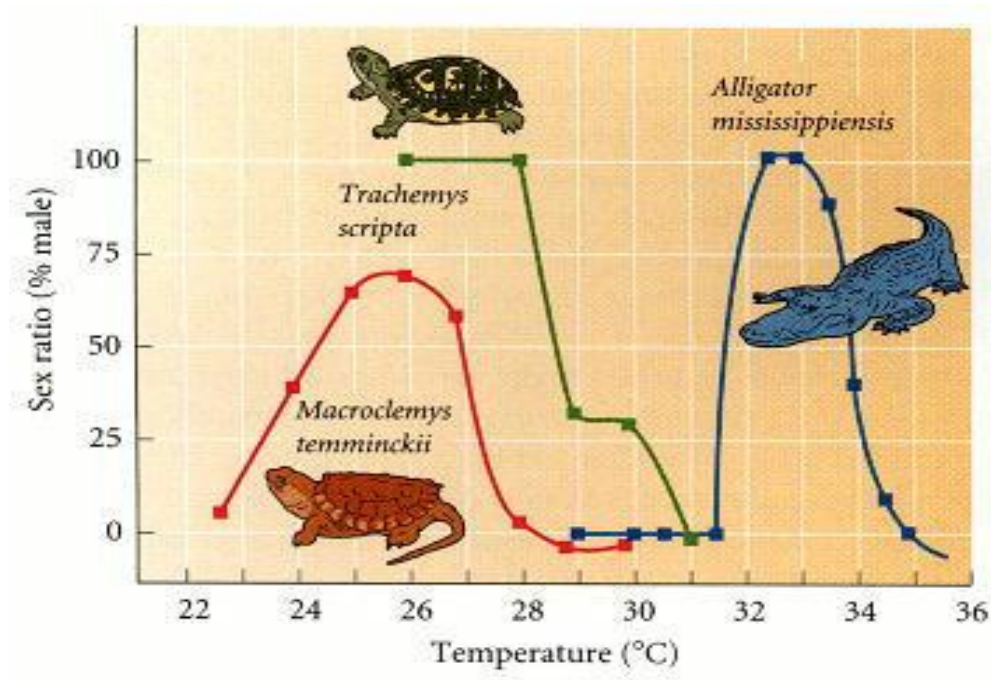
# **Modes of REPRODUCTION**

# **Modes of REPRODUCTION**

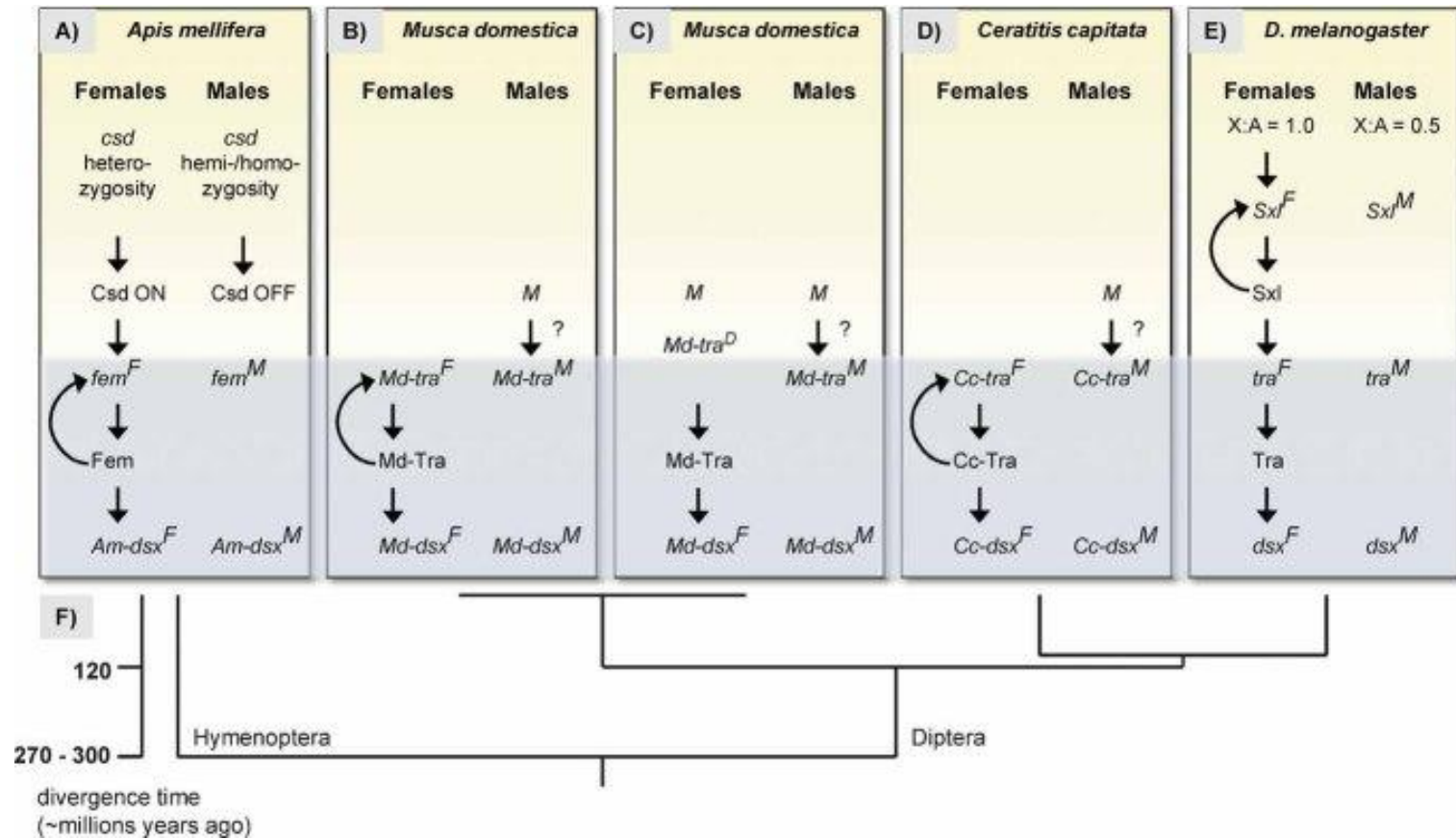
- Sexual or asexual
- Obligate or facultative sexual
- Self-fertilizing or outcrossing
- Separate sexes or hermaphrodites

# SEX dETERMINATION

# ENVIRONMENTAL SEX DETERMINATION



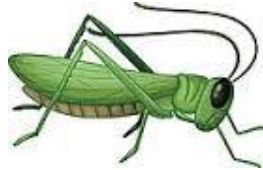
# GENETIC SEX DETERMINATION



# CHROMOSOMAL SEX DETERMINATION



Homo-/hemizyosity



XX

X0

Haplo-/Diploidy



2n

n

Male heterogamety



XX

XY

Female heterogamety



XY (ZW)

XX (ZZ)



# Insects

## Sex determination

X0 Male heterogamety

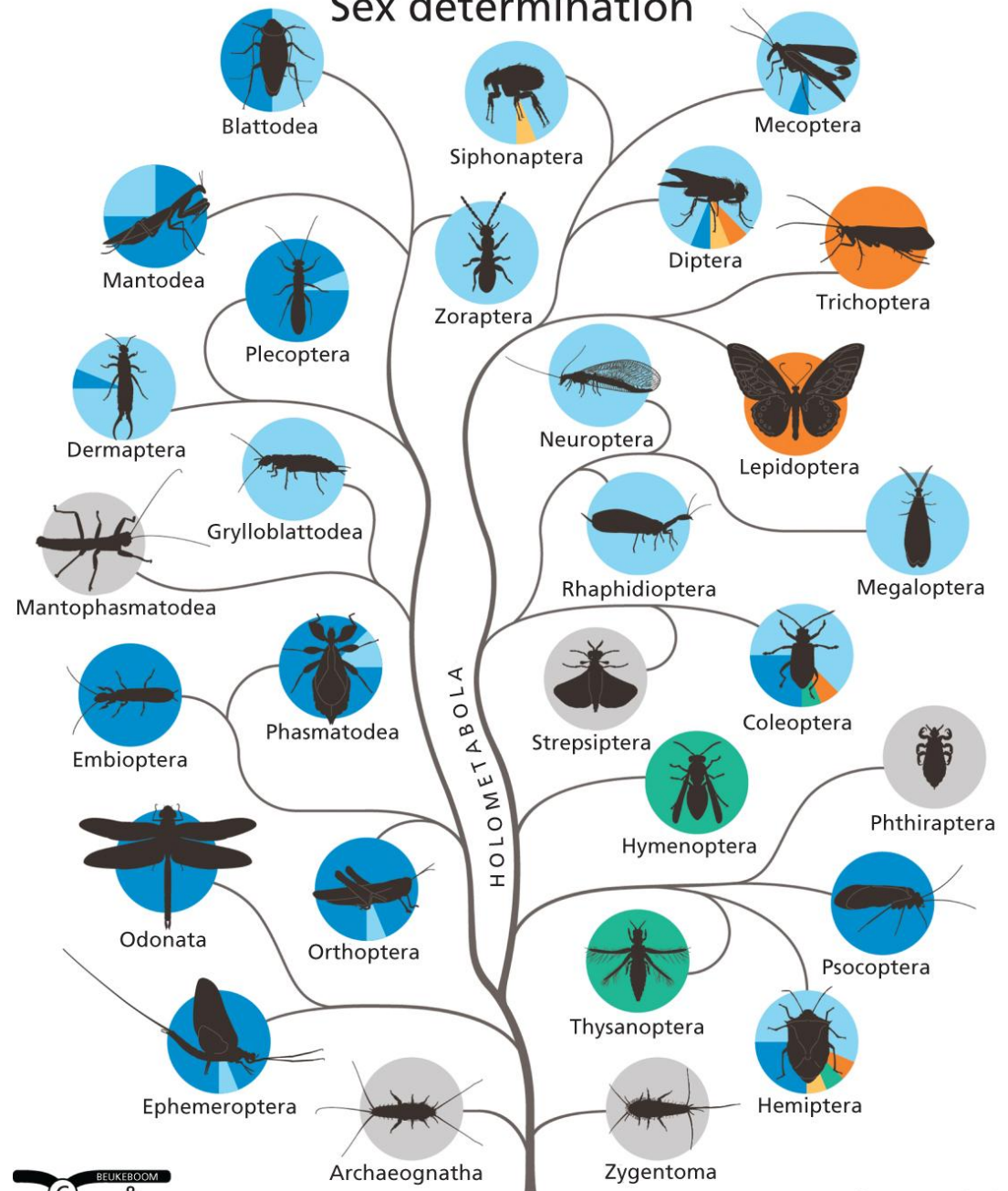
Haplodiploidy

XY Male heterogamety

ZW/Z0 Female heterogamety

Miscellaneous

Unknown



Beukeboom & Perrin (2014)



# A GENERAL SCENARIO FOR SEX CHROMOSOME EVOLUTION

