Cycle 7: All About Sex

What is sex?

The biological name for the word sex is **copulation** or **intercourse**. The word 'sex' can be used in a different variety of ways:

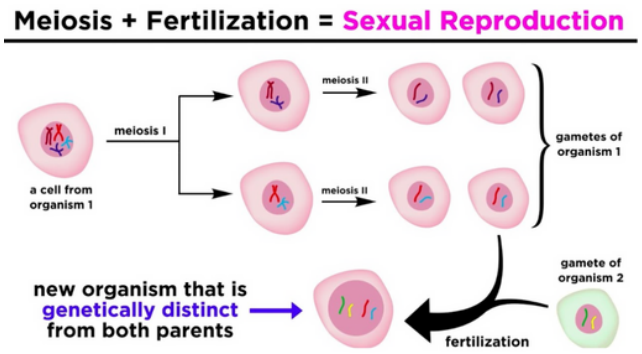
- 'Having sex' refers to intercourse
- 'Sex' can also refer to gender, based on reproductive features and function. Such as males, females and intersex

However, in this course sex is referred to as the exchange of genetic material. Specifically, sex is the mixing of genetic variation that results in offspring with new genotypes and phenotypes.

- Animals, plants, eukaryotes: in sexual reproduction, gametes fuse to generate new combinations of alleles in the offspring
- Bacteria, archaea: in sexual reproduction, they acquire DNA from another organism or their environment

How does sexual reproduction occur?

- Sexual reproduction occurs through cell fusion, where genetic material of male and female is combined
- A haploid egg and sperm gamete will fuse to create a diploid zygote
- Sexual reproduction occurs in most eukaryotes, but it does not occur in bacteria or archaea
- Sexual reproduction ensures that the zygote has a combination of alleles that are unlike the parents
- For example, in humans, we can have more than 10 600 combinations of alleles



Sexual Reproduction produced by the Same or Different Sexes

Sexual reproduction is the fusion of gametes, typically produced by different sexes. However, there are also organisms that are both sexes and can sexually reproduce

- Dioecious animals = individuals that sexually reproduce by using gametes from two individuals
- Monoecious animals = individuals that sexually reproduce by gametes from the same individual (they are both sexes, and are also referred to as hermaphrodites)

Monoecious Animals

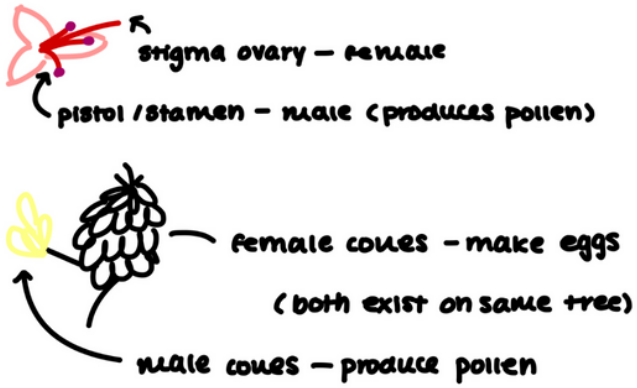
Monoecious animals are hermaphrodites and can be classified as simultaneous or sequential hermaphrodites.

Sequential hermaphrodite: The animal begins as one sex and then develops into another sex

- Ex. The blue head wrasse begins as a female and then transitions to a male. If the dominant male dies, one female will develop into a male.
- Ex. clown fish begin as males and develop into females

Simultaneous hermaphrodite: As an individual, you simultaneously have male and female reproductive organs

- Ex: earthworms have both ovaries and testes
- Ex: plants have both the pistil / stamen and the stigma ovary



How do individuals know when they should be male or female?

One question you may ask is: how do sequential hermaphrodites know when to transition between the sexes? The theory that addresses this question is the size advantage model of sex change. This theory suggests that individuals will change sex depending on which sex will ensure the greatest reproductive success at that point in time. It is found that reproductive sex will change depending on size and gender. Males tend to increase in reproductive success at a faster rate than females, resulting in male rate having a steeper slope than the female rate (see diagram)

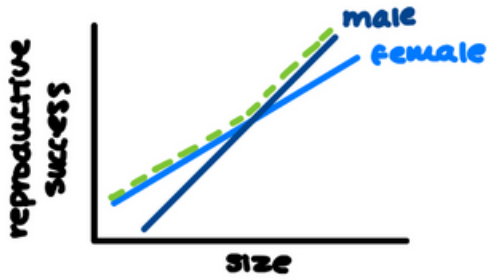
In the example of the blue head wrasse: in order for the blue head wrasse to ensure the greatest reproductive success, they will follow the green dotted line.
The blue headed wrasse will begin as a female, and transition into a male once the male sex surpasses the female sex in reproductive success.

Clownfish on the other hand will experience the opposite. The clownfish will begin as a male and then transition to a female.

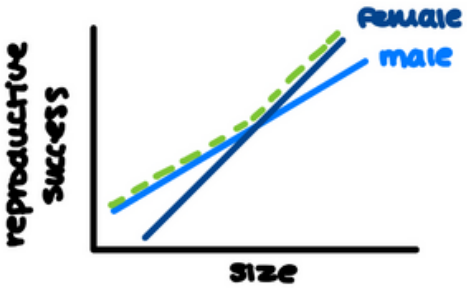
Definitions:

- Protogyny = transition from female to male
- Protandry = transition from male to female

Blue Headed Wrasse



Clownfish



How do protists sexually reproduce?

- Examples of protists are fungi and ciliates
- These organisms do not have gender, but they have more than one mating type
- These fungi / ciliates will reproduce by fusing gametes with other fungi / ciliates of a different mating type

For example

- Two fungi that have different mating types can fuse their gametes together
- Two ciliates of different mating types can reproduce

Not all reproduction is sexual and require sex

Animals

- Most animals are **obligately sexual**
- This means that they can only reproduce if they undergo sexual reproduction
- One exception to this statement is **parthenogenesis** in animals

Plants

- Most plants are **facultatively sexual**
- This means that they can reproduce sexually or asexually
- Sexually = by exchanging its own males and female gametes
- Asexually = through cloning

Bacteria and Archaea

- Most bacteria and archaea are **obligately asexual**
- This means that they can only reproduce asexually (without the fusion of gametes)
- One exception to this statement is bacterial conjunction in bacteria/archaea

	Sexually	Asexually
Animals	**Dioecious sexual reproduction:** Fusion of gametes from two different individuals	**Parthenogenesis:** Parthenogenesis is where females produce offspring asexually. The offspring will develop from an unfertilized diploid egg
Plants	**Monoecious sexual reproduction:** Fusion of gametes, both from the same individual	**Cloning:** Cloning is a form of asexual reproduction in plants. For example, potato plants have 'tubers'. If the tuber was cut into pieces and each piece was planted into the ground, a new plant will grow as a clone. Another example: in strawberries, a new strawberry plant can grow out of the parent, and plant itself into the ground. It will then grow as its own new plant, and is a clone of the parent
Bacteria and Archaea	**Bacterial conjunction:** This is when bacteria and archaea transfer plasmids from one bacteria to another. Although no two gametes fuse, this type of sex is still sexual because genetic information is exchanged	**Binary fission**: The cell will replicate and divide through binary fission. All offspring are clones

Origin and History of Sex

Life started 3.5 Billion years ago, and began with likely a protist (called last universal common ancestor). The life form asexually reproduced and likely exchanged genes. 1.2 Billion years ago, eukaryotes formed and evolved from meiosis and sexually reproduced. Now most animals must sexually reproduce (asexual animals are rare and prone to extinction).

Disadvantages of Sex

Although sexual reproduction is important to produce offspring and produce new alleles, there are some disadvantages to sex.

Disadvantages

Risky

- Finding a mate can be time consuming and will take resources
- In that search, you may expose yourself to predation
- Having sex increases susceptibility of STIs

Costly

- Sex is costly because only ½ of genetic material is inherited and is passed on
- Unlike asexual reproduction where all offspring are clones and all have same genetic material, sexual reproduction result in only half the genetic material being passed on
- Therefore, for every generation, individuals pass on 2x less genetic material than asexual reproducers

Inefficient

- Sexual reproduction that results in males will reduce reproductive output
- Since only females produce offspring, males do not add to the population
- Asexual population thus grow faster because all cells can reproduce

Advantages

Generates variation

- Sex generates variation that is not possible through asexual reproduction
- Sex causes gene recombination, shuffling genetic variation in the population
- This occurs through
  - Gene exchange
  - Independent assortment
  - Recombination
  - Fusion of material and paternal chromosomes = new allele combos

Better adaptability

- Genetic variation will produce offspring that are genetically distinct from either parents
- This variation is beneficial and outweighs costs because it leads to the population being able to adapt better to the environment
- Sexual populations that have greater diversity of offspring will have increased probability of some offspring surviving and having favourable phenotypes

1	1	1
1	1	1

Asexual

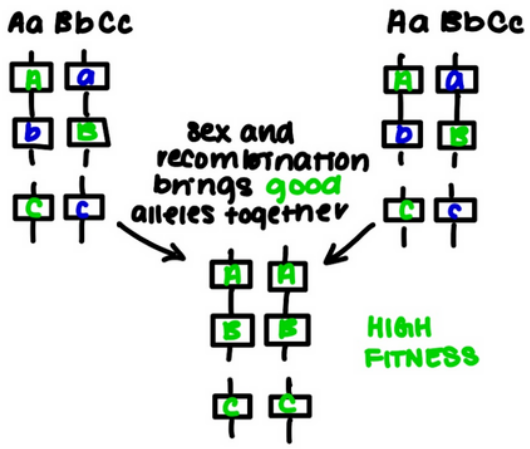
In asexual reproduction, all offspring are genetically identical to the parents, and therefore have all of the same alleles. If the environment does not change, and the offspring have a successful combination of alleles, they will survive.
However, this can also result in **clonal interference**: this is where multiple strong allele combinations compete with one another since there is no sexual recombination to incorporate bad alleles into the population

2	6	4
1	3	5

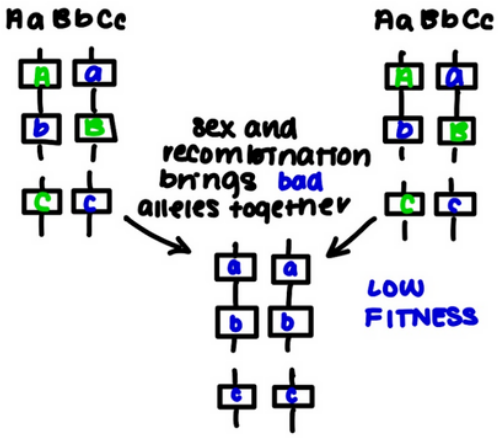
Sexual

In sexual reproduction, all of the offspring are genetically different from one another, and therefore have different combinations of alleles. In a changing environment, variation is advantageous. These individuals will confer a better chance of survival because at least one will have alleles highly suited for the environment.

Summary of DNA Damage



Sex can bring beneficial alleles together. This will result in increased fitness



Sex can result in a combination of all bad alleles together. This will result in decreased fitness

What is natural selection?

Natural selection = a struggle for existence between individuals where favoured traits increase survival and fitness.

Sexual Selection in Animals

Sexual selection in animals is a struggle for males. In animals, traits that are favoured in the environment are those that increase mating success and individual fitness. There are two types of sexual selection:

1. Intersexual selection = *one sex chooses their mate of choice*

In intersexual selection, females choose mates based on the displays and physical traits of the male. This includes courtship displays, calls, ornamentation, or through males competing for females. For example: peacocks evolved to have elaborate feathers; male bowerbirds make elaborate nests to attract females. In intersexual selection, it is normally the female that chooses its mating partner.

2. Intrasexual selection = *individuals of one sex compete amongst themselves for a member of the other sex*

Intrasexual selection is where individuals are competing to gain mates of the opposite sex. The 'winner' will be able to mate with the female. Typically, males will fight and compete with one another to gain access to a female. Males will outcompete rivals to get direct control of females, and to control a resource that is important to females (such as food or territory).

Why do females choose their mating partner?

Females are able to choose their partner because females are more invested in parental care. Females contribute less to the next generation than males, and therefore they are more selective in the mates that they choose because they want to ensure the quality and survival of their offspring. For example, in humans females can only contribute to the population every 9 months at most. However, males can contribute to the population as much as possible. Since females are selective, this results in males competing for a female's mate.

Sperm competition: male competition may not always be super obvious

Other forms of male competition include:

1. Swimming speed = the fastest sperm gets to the egg
2. Using scrapers = males have features on their body that enable them to scrape out the sperm deposited by other male in the female, and then will deposit their own

Mating plugs = after mating, males can leave a plug to prevent other males from mating with the same female

Potential Fitness

Potential fitness refers to how much a sex can contribute to the next generation of offspring. Individual fitness varies widely from male to male. Males are able to have very high potential fitness because they can contribute to the population as much or as little as desired. However, females have a smaller number of gametes and must spend time growing offspring (e.g. one egg per month). They need to choose wisely to get the best mate for their offspring. Their fitness is normally closer to the mean, because they can only contribute to the population so often.

Why be choosey?

1. Direct benefits of being selective

- Attractive parents may be good parents
- Your mate may provide you with food and protection

2. Indirect benefits of being selective

- Attractive individuals may have good alleles which can increase survival and attractiveness of offspring
- It may give better immunity or make you more attractive

Sexual Dimorphism

Sexual dimorphism *= where two genders have a distinct difference in size and appearance.*
For example: in animals, males are often bigger and bright in colour.

The relative role in parental care affects the degree of sexual dimorphism. If the role in parental care is very different, the sexual dimorphism will be greater. For example, since female animals tend to provide more parental care than males...

1. It makes them unavailable for reproduction
2. It makes male competition for females to be higher
3. It makes males be under stronger sexual selection because they must compete more strongly for females

Males and females evolved to have greater sexual dimorphism because males needed to compete for female attraction and attention.

What if both sexes invest equally in parental care?

Biparental care is where both sexes invest equally in parental care.
In biparental care:

- Males are removed from seeking additional mating opportunities
- Both sexes compete for mates, so both sexes are choosy
- Sexual selection acts on both sexes, so there is little to no dimorphism (both sexes are similar, although in humans there is some)