

Microevolution



Microevolution & Speciation

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In this lecture topic

- What is microevolution?
- Allele frequencies and evolution – Hardy-Weinberg.
- Sources of genetic variation in alleles.
- What is a species?

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to understand where new species come from we need to understand microevolution. most of the time the hardy-weinberg principle cant we will look at where it all comes from. how do we define a species within a biological system.

Important stages in the history of Biology

20th century

- Synthetic theory of evolution
 - Population genetics and natural selection based on Mendelian genetics



Huxley
(1887-1975)

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huxley was the one that combined the concept mendel gave us to be able to understand heredity. mendel showed us that heritable traits were packaged. huxley took this concept of mathematical predicatibility and turned it around and applied it to living organisms.

Microevolution

Microevolution the phenotype can also change on based upon the arrangemnt of the genes of the chromosomes. we can get variation a lot of other ways.

- Evolutionary changes that result from changes in allele frequencies in a population, or in chromosome structure or numbers due to mutation and recombination.

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Incomplete dominance – snap dragons

P - parental F₁ – Generation1 F₂ – Generation2




$C^R C^R$ Red
 X
 $C^W C^W$ White

→ $C^R C^W$ Pink

→ $C^R C^R = 25\%$
 $C^R C^W = 50\%$
 $C^W C^W = 25\%$

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Genotype and allele frequencies





Phenotype	Genotype	Number	Genotype frequency	Total C ^R alleles	Total C ^W alleles
	C ^R C ^R	450	450/1000 = 0.45	2x450 = 900	0x450 = 0
	C ^R C ^W	500	500/1000 = 0.50	1x500 = 500	1x500 = 500
	C ^W C ^W	50	50/1000 = 0.05	0x50 = 0	2x50 = 100
	Total	1000	0.45 + 0.50 + 0.05 = 1.0	1400 p = 0.7	600 q = 0.3

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Microevolution

Using the Hardy-Weinberg Principle

$p^2 + 2pq + q^2 = 1$

	C ^R frequency p=0.7	C ^W frequency p=0.3
C ^R frequency p=0.7	 C ^R C ^R = p ²	 C ^R C ^W = pq
C ^W frequency p=0.3	 C ^W C ^R = pq	 C ^W C ^W = q ²

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you could use to see if the allelic frequencies change or not in a population. Biology historically was basically based on desc But now we have a mathematical way to determine if there is allele frequency.

Allele frequencies in populations
(Each of the 20 adults produces 10 gametes)

If each adult supplies the same number of gametes to the next generation we have a stable allelic frequency and we have no microevolution.

Initial allele frequencies in gametes	A: 0.6	a: 0.4
---------------------------------------	--------	--------

• A: $2 \times 36 + 48 = 120/200 = 0.6$
 • a: $48 + 2 \times 16 = 80/200 = 0.4$
 • Final = Initial frequency

Final allele frequencies	A: 0.6	a: 0.4
--------------------------	--------	--------

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Hardy-Weinberg principle's assumptions

- No natural selection
- No mutation
- No genetic drift – population is large
- Gene flow
- Random mating

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this principle describes when something isnt happening. it is saying that there is no microevolution. when theres a change in allelic frequency then the question becomes what caused the change.

Microevolution

Hardy-Weinberg principles
Effect of selection

Initial allele frequencies in gametes	
A	a
0.6	0.4

• A: $2 \times 36 + 36 = 108/160 = 0.675$
 • a: $36 + 2 \times 8 = 52/160 = 0.325$
 • Final \neq Initial frequency

Final allele frequencies	
A	a
0.675	0.325

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Hardy-Weinberg principles
Effect of selection

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Hardy-Weinberg principles
Effect of selection - fixation

Under severe selection alleles or traits that are not favoured will disappear from the population.
Under mild selection the frequencies will shift a bit but we will never lose them. Under certain circumstances Natural selection will not eliminate a certain allele.

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Microevolution

Hardy-Weinberg principles
Effect of selection – against recessive

Initial allele frequencies in gametes	
A	a
0.6	0.4

A: $2 \times 36 + 48 = 120/168 = 0.714$
a: $48 + 0 = 48/168 = 0.286$
Final \neq Initial frequency

Final allele frequencies	
A	a
0.714	0.286

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Hardy-Weinberg principles
Effect of selection – against recessive

even when we kill the ones that are recessive and homozygous the allele is still never lost from the population, it is still there in small numbers. You have to start with heterozygotes to get the 50% frequency. Natural selection will not on its own remove a detrimental gene, it will push it down but it will still be there in small numbers. Even though we select against a recessive we wont completely lose it.

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Hardy-Weinberg principles
Effect of selection – for heterozygote

the good gene instead going to 0.9 plateaus at 0.7. we didnt get up to the level purity as the homozygous. the heterozygous advantage. life was great with GG life sucked with bb life was better with Gb. this gave the concept that heterozgosity can sometimes be advantageuos.

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Microevolution

Hardy-Weinberg principles
Mutation – sickle cell

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sickle celled sufferers have a mechanism to remove sickled cells. if you are heterozygote for sickle cell anemia the body will recognize that these cells are not correct and the liver will get rid of the cells.

Hardy-Weinberg principles
Effect of selection – for heterozygote

KEY
Allele frequencies of HbS allele: <math>< 0.14</math>, 0.15-0.12, 0.06-0.04, 0.02-0.04, 0.12-0.14, 0.08-0.10, 0.04-0.06, 0.00-0.02
Regions with malaria

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the malaria will enter sickle celled blood cells and the normal cells. the person with sickled cel anemia have a mechanism that will get rid of the malaria because it gets rid of the sickled blood cells that contained malaria.

Quantitative variation

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most of the traits that we would look at in a population aren't controlled by single alleles. we cant go in and do the hardy-weinberg principle. biologists have another way to determine variation within a population thats not based on allelic variation. if its polygenic or polyallelic it is a normal distribution. the measurement of spread through STDEV is way to describe gene variation.

Microevolution

Selection with multiple loci traits

- Directional selection
- Stabilizing selection
- Disruptive selection

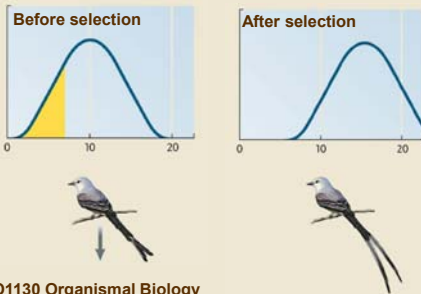


Figure 16.9 for Evolutionary Analysis, 4th ed.
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Selection with multiple loci traits Directional selection



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Figure 16.9a

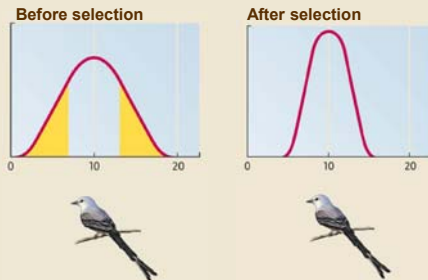
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we can watch for changes within a population.
female birds tend to mate with males with longer tails.
the short tailed males never find a mate and never have any viable offspring.

Selection with multiple loci traits Stabilizing selection



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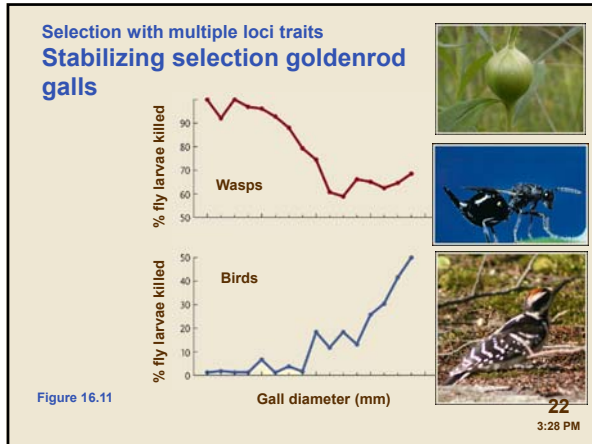
Figure 16.9b

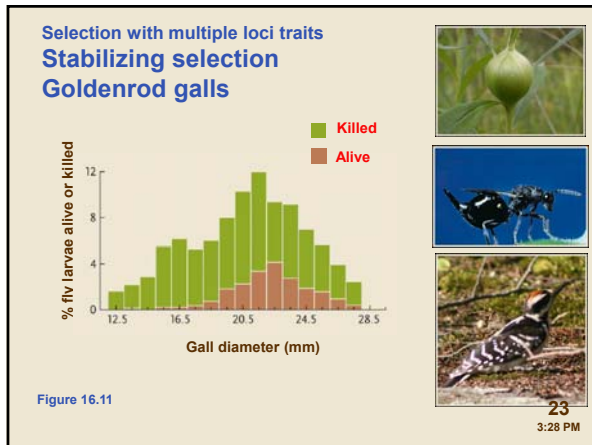
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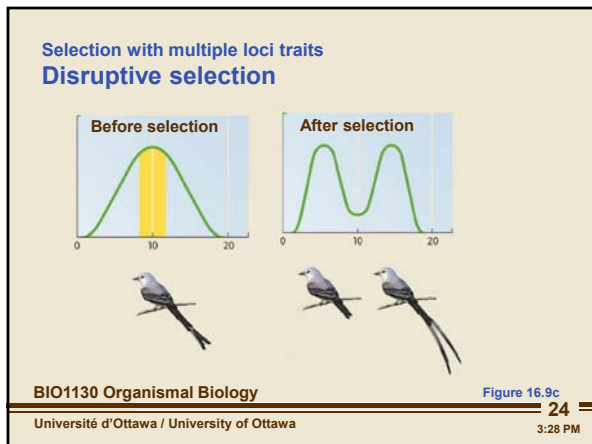
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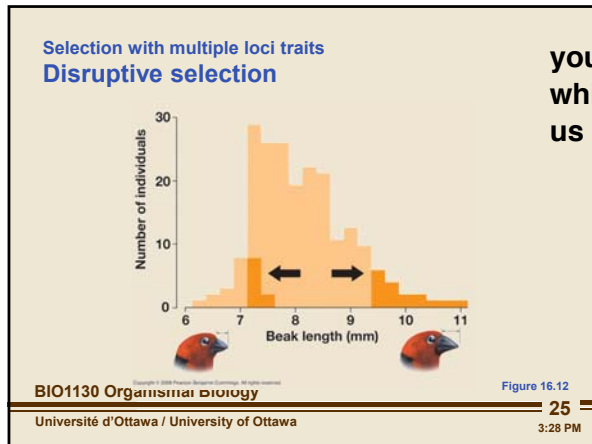
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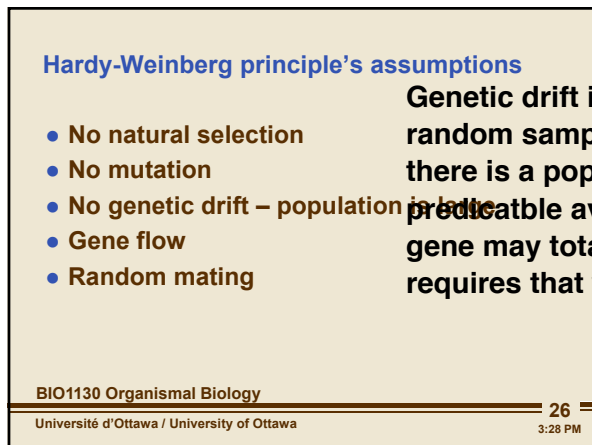


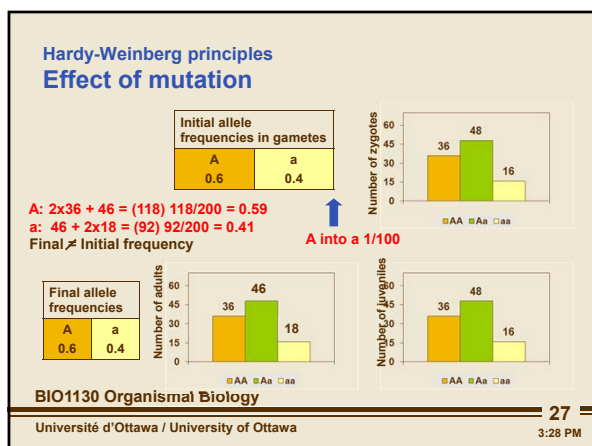


Microevolution



you're starting to differentiate between two species which gives us new species. Disruptive selection gives us new species.





Microevolution

Hardy-Weinberg principles
Mutation

- Beneficial
- Neutral
- Deleterious

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Mutation in eukaryotes have little to no effect. Every organism in their life time will have 2 mutations. the DNA system is fine tuned to have no mutation. there is a lot of correcting going on. If there is a mutation they are very often neutral and have no effect. Even if it is deleterious its only in one of the alleles, and there is a back up allele to perform its function. Its very rare.

Genetic code

	U	C	A	G
U	UUU Phe UUC UUA Leu UUG	UCU Ser UCC UCA UCG	UAU Tyr UAC UAA UAG	UGU Cys UGC UGA UGG Trp
C	CUU Leu CUC CUA CUG	CCU Pro CCC CCA CCG	CAU His CAC CAA CAG	CGU Arg CGC CGA CGG
A	AUU Ile AUC AUA AUG Met	ACU Thr ACC ACA ACG	AAU Asn AAC AAA AAG	AGU Ser AGC AGA AGG
G	GUU Val GUC GUA GUG	GCU Ala GCC GCA GAG	GAU Asp GAC GAA GAG	GGU Gly GGC GGA GGG

KEY:
Ala = alanine
Arg = arginine
Asn = asparagine
Asp = aspartic acid
Cys = cysteine
Gln = glutamine
Glu = glutamic acid
Gly = glycine
His = histidine
Ile = isoleucine
Leu = leucine
Lys = lysine
Met = methionine
Phe = phenylalanine
Pro = proline
Ser = serine
Thr = threonine
Trp = tryptophan
Tyr = tyrosine
Val = valine

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if there is a mutation that changes the 3rd triplet it will not change the protein and will have a neutral effect.

Hardy-Weinberg principles
Mutation

- Point mutations (the red big fly had one red eye)
 - Silent
 - Missense (thr one big fly had one red eye)
 - Nonsense (the one big)
 - Frame shift (the one rbi gfl yha don ere dey)
- Chromosomal mutations

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Microevolution

Hardy-Weinberg principles
Mutation

- Point mutations
- Chromosomal mutations
 - Inversions
 - Translocation
 - Deletion
 - Duplication
 - Crossing over
 - Polyploidy
 - Genome duplication

Figure 11-11

Inversion

Translocation

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Hardy-Weinberg principles
Mutation

- Point mutations
- Chromosomal mutations
 - Inversions
 - Translocation
 - Duplication
 - Deletion
 - Crossing over
 - Polyploidy
 - Genome duplication

Figure 11-11

Deletion

Duplication

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Hardy-Weinberg principles
Chromosomal mutations – crossing over

Figure 10-14

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when the chromosomes align during meiosis, they break while they are being pulled together, they switch between homologs. this is very common. this is another way we mix genes.

Microevolution

Hardy-Weinberg principles
Chromosomal mutations – polyploidy

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plants self-fertilize. meiosis fails instead of gametes that are haploid you get gametes that are diploid. You get what is called a tetrapod cell. this is viable in plants. Polyploid in plants generates new organism. Polyploid plants have mutiple gene copies and grow faster and produce bigger seeds.

Hardy-Weinberg principles
Chromosomal mutations – polyploidy

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2 different species can fuse their gamete which creates a new organism.

Hardy-Weinberg principle's assumptions

- No natural selection
- No mutation
- No genetic drift – population is large
- Gene flow
- Random mating

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Microevolution

Hardy-Weinberg principles
Genetic drift

Initial allele frequencies in gametes

A	a
0.6	0.4

Drift

Number of zygotes

AA	Aa	aa
31	49	20

- A: $2 \times 31 + 49 = 111/200 = 0.555$
- a: $49 + 2 \times 20 = 89/200 = 0.445$
- Final \neq Initial frequency

Final allele frequencies

A	a
.555	.445

Number of adults

AA	Aa	aa
31	49	20

Number of juveniles

AA	Aa	aa
31	49	20

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Hardy-Weinberg principles
Genetic drift

Population size = 4

Population size = 400

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Hardy-Weinberg principles
Genetic drift – bottle neck affect

Parent population

Bottleneck (drastic reduction in population)

Surviving individuals

Next generation

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a large population that undergoes a very sudden reduction in the population. when we took the small sample we get a different allelic frequency. the population crashes to a few individuals and we try to repopulate with these few individuals it means we have lost a whole lot of genetic variability. ~~The Buffalo were flooded with them with prairies. the buffalo population crashed to 750 bisen. those 750 have been used as the repopulation stock.~~ there are alerady heritable gene problems.

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Hardy-Weinberg principles
Genetic drift – Founder effect



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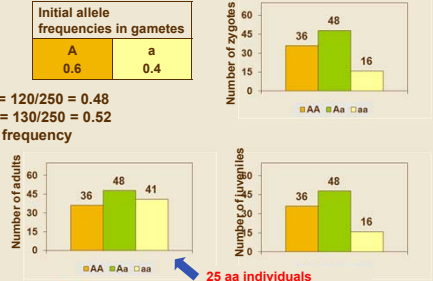
Founder effect is when a population moves into an area where they never been before and sets up a brand new population.

Hardy-Weinberg principles
Gene flow - migration

Initial allele frequencies in gametes	
A	a
0.6	0.4

- A: $2 \times 36 + 48 = 120/250 = 0.48$
- a: $48 + 2 \times 41 = 130/250 = 0.52$
- Final \neq Initial frequency

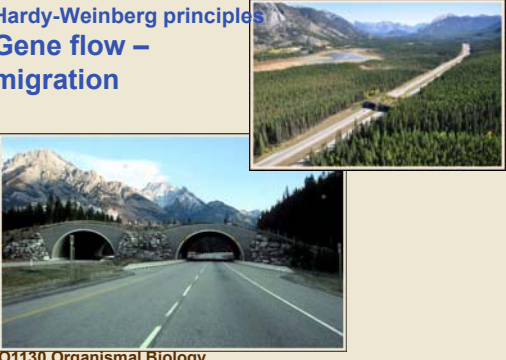
Final allele frequencies	
A	a
0.48	0.52



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extra genes come flowing in the population. this will change the gene frequency. Migration between isolated populations can do this. This ties with bottle neck effect and founder effect. This will increase the genomic variability.

Hardy-Weinberg principles
Gene flow – migration



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Hardy-Weinberg principle's assumptions

- No natural selection
- No mutation
- No genetic drift – population is large
- Gene flow
- Random mating

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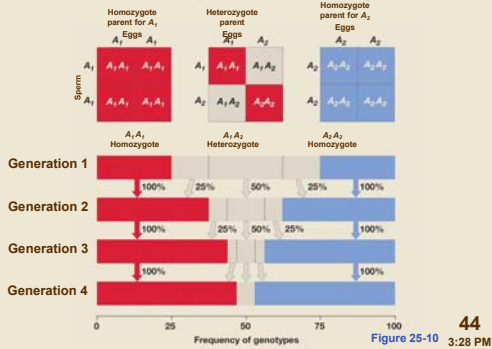
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all individual in the population have an ewual chance to mate with each other

Hardy-Weinberg principles Nonrandom mating - Inbreeding



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when one generation mates with the progeny of the next generation. Hemophilia early royalty of Europe. Chanigni the degree of homozygosity in a population. It will take one portion of the group. We decrease the heterozygosity of the population. If there is a homozygous condition that is detrimental it will become much more prominent.

Hardy-Weinberg principles Nonrandom mating - Sexual dimorphism



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where one of the species has a different appearance of another. The female is the individual of the pair that will have a limited reproductive eggs, she wants to make sure that the sperm to fertilize the eggs is the best, the female is being picky, trying to pick the most healthy male. The male is not limited to how much sperm is being created and is trying to distribute as much sperm as possible.

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Hardy-Weinberg principles Nonrandom mating - sexual selection

- Sexual selection
 - On males – female choice
 - On males – competition
 - Combat
 - Sperm competition
 - Infanticide

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the female makes a selection amongst the males
and the males are being competitive amongst the males.

Hardy-Weinberg principles Sexual selection female choice

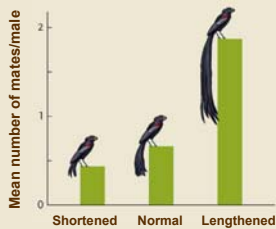


Figure 16-13

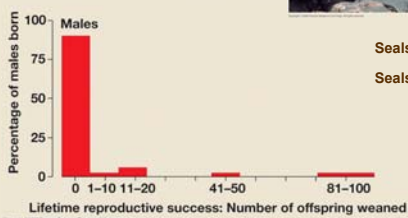
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Hardy-Weinberg principles Sexual selection Male competition - combat



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Hardy-Weinberg principles
Sexual selection
Male competition - combat




Percentage of females born

Lifetime reproductive success: Number of offspring weaned	Percentage of females born
0	75
1-10	40
11-20	25
41-50	10
81-100	5

Lifetime reproductive success: Number of offspring weaned

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Hardy-Weinberg principles
Sexual selection
Male competition – sperm competition



Copulatory wheel

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they dont just compete in aggression
the males are competing to get their sperm to the female egg. For dragonflies the male scrapes out the other males sperm first and wait until the sperm has fertilized the egg.

Hardy-Weinberg principles
Sexual selection
Male competition – infanticide



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lion groups are composed of mostly females, when the male is replaced by another aggressive male the male kills the small lion cubs because of the male he just beat. Males will kill the offspring of other males

Microevolution

Speciation



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how do we know when we have a new species?

how do we identify that we for sure have a new species?

1.3 million named species.

8.7 organisms on the earth.

Species concepts – what is a species?

- **Biological species**
- **Phylogenetic species**
- **Ecological species**
- **Morphospecies**

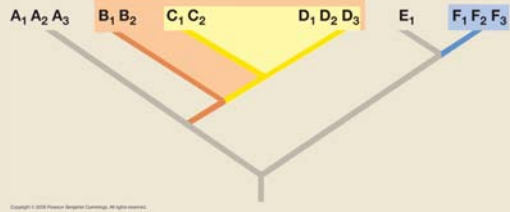
Species are groups of actually or potentially interbreeding populations, which are reproductively isolated from other such groups.
Ernst Mayer (1942)

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a species is a set of interbreeding populations reproductively isolated from other groups. Bacteria, archaea and prokaryotes do not sexually reproduce therefore you cannot refer to them as species names, that's why you see them named as proteins and biological features. This concept does not work with fossils.

Species concepts
Phylogenetic species




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The phylogenetic concept is trying to get rid of the isolation way. If you brought in species from different parts of the world that they would breed, they are just isolated. You could apply this to a fossil this time. You are using the synapomorphies to define the species.

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Species concepts
Morphospecies



Yellow throated warbler Yellow rumped warbler

Figure 18.4

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Morphospecies is when two organisms have separate distinguished morphologies. This does not really work because birds are reptiles for example.

Species concepts

- Biological species
- Phylogenetic species
- Ecological species*
- Morphospecies

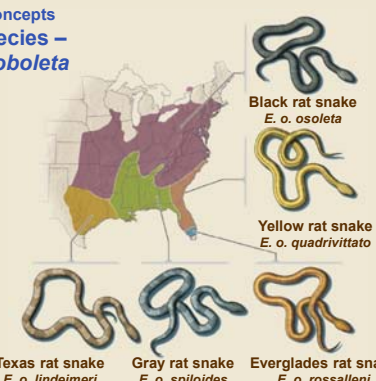
Many things that were considered to be species are now called subspecies. Ex: *Canis lupis*, there are wolves all over the world and when molecular, biological and anatomical work was done, it was found that the different species could breed. So they are now considered to be all *Canis lupis*. *Canis familiaris* means friendly dog, but now it is called *Canis lupis familiaris* it is the friendly wolf. Dogs are subspecies.

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Many things that were considered to be species are now called subspecies. Ex: *Canis lupis*, there are wolves all over the world and when molecular, biological and anatomical work was done, it was found that the different species could breed. So they are now considered to be all *Canis lupis*. *Canis familiaris* means friendly dog, but now it is called *Canis lupis familiaris* it is the friendly wolf. Dogs are subspecies.

Species concepts
Ring species – *Elaphe oboleta*

Figure 19.12



Black rat snake
E. o. osoleta

Yellow rat snake
E. o. quadrivittata

Texas rat snake Gray rat snake Everglades rat snake
E. o. lindeimeri *E. o. spiloides* *E. o. rossalleni*

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there are 4 species of rat snakes. A subspecies means that the groups is diverging and potentially isolated.

Microevolution

Species concepts
Ring species –
Ensatina eschscholtzi

Figure 19.13
[Video](#)

Oregon salamander
E. e. oregonensis

Sierra Nevada salamander
E. e. platensis

Yellow-blotched salamander
E. e. croceator

Large-blotched salamander
E. e. klauberi

Monterey salamander
E. e. eschscholtzii

Yellow-eyed salamander
E. e. xanthoptica

Painted salamander
E. e. picta

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an initial species has diversified.

Biological species
Reproductive isolation

- Prezygotic isolation
 - Ecological
 - Temporal
 - Behaviour
 - Mechanical
 - Gametic
- Postzygotic isolation

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Prezygotic isolation is when the sperm never gets the chance to fertilize. If we have 2 separate species, they never get the chance to fertilize. Postzygotic isolation is when prezygotic isolation fails the next next-generation of that species is not able to reproduce. In prezygotic isolation we can isolate organisms ecologically where 2 organisms are ecologically separated. Temporally can be based on time. One organism may be mating later, or may be in later reproductive stage. Behavioural is like song, dance, a routine.

Biological species
Reproductive isolation

- Prezygotic isolation
 - Habitat
 - Temporal
 - Behaviour
 - Mechanical
 - Gametic
- Postzygotic isolation

Figure 19.14

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Biological species
Reproductive isolation

- Prezygotic isolation
 - Habitat
 - Temporal
 - Behaviour
 - **Mechanical** comit orchid
 - Gametic
- Postzygotic isolation




Figure 19.15


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The genitalia of the male and female insects. When they mate they have only one way to physically to get the sperm to the egg.

Biological species
Reproductive isolation

- Prezygotic isolation
 - Habitat
 - Temporal
 - Behaviour
 - Mechanical
 - **Gametic**
- Postzygotic isolation



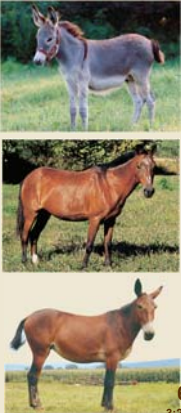
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marine invertebrates when everyone is spewing sperm into the water. The egg membrane will not be penetrated by the sperm of a different species.

Biological species
Reproductive isolation

- Prezygotic isolation
- Postzygotic isolation
 - Hybrid inviability
 - Hybrid sterility
 - Hybrid breakdown



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Hybrid inviability, the egg may become fertilized the initiation of embryo genesis may start but it will fail. Hybrid sterility cross a donkey and a horse the mule will not be able to reproduce any young. Hybrid breakdown the organism is viable but is not able to survive and does not have the necessary genes.

Microevolution

Allopatric Speciation - Vicariance

BIO1130 Organismal Biology Figure 19.16

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A reference to the fact that there is going to be some sort of barrier in between. The two species will diverge and when the two species are successfully diverged and the barrier is gone, the species are still sustained. Think about continental drift. The environment gets divided and organisms become reproductively isolated.

Allopatric Speciation - Dispersal

BIO1130 Organismal Biology Figure 19.18

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This would be for example the founder effect, we have a population of finches on the mainland and they move out to the gallapagos, one species that has big beaks goes one way the other species with small beaks goes the other way. Is occurring within the environment across a barrier. This case we have dispersal and everyone moves, the last case everyone stayed put.

Grylloblattid – Ice age vicariance

Video

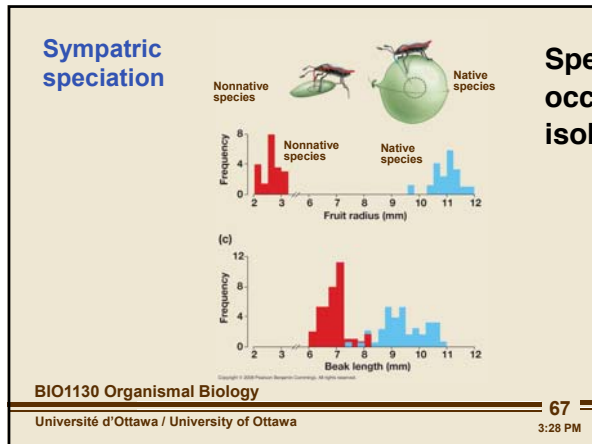
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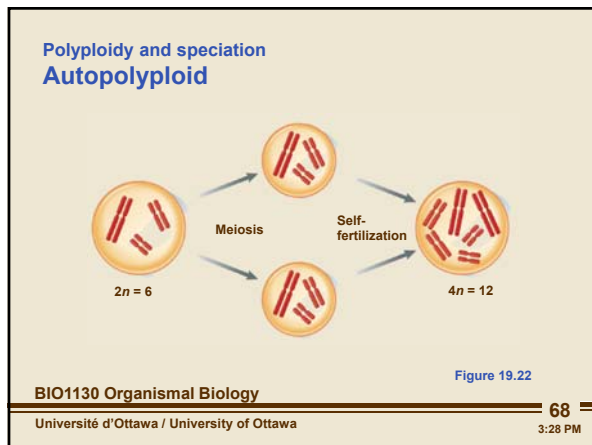
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If you heat this cricket up to 7-8 degrees it will die.

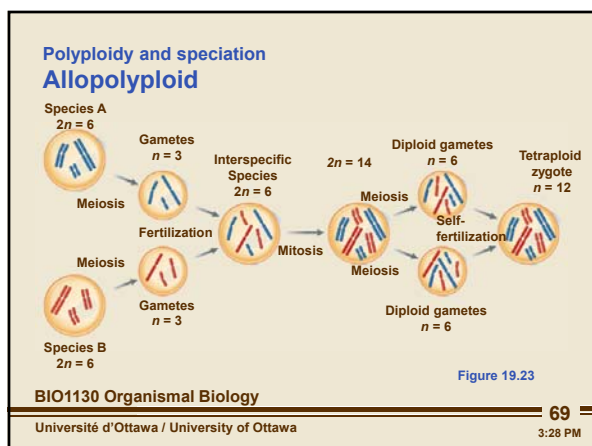
Microevolution



Speciation isn't occurring separate environments its occurring in the same environment. they become reproductively isolated.

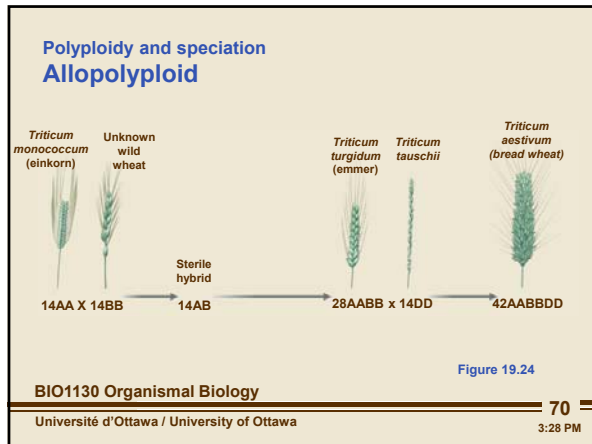


Meiosis fails and the homologs do not separate. the product of this meiotic event of the ploidy plant could not mate with the one that was correctly divided. So now they are considered to be 2 separate species.



This is when 2 species of plants mate. This usually happens when there are the same number of chromosomes in the plants. There should be equal number of chromosomes in the species. A mix of 2 genomes.

Microevolution



**Wheat today is a polyploid from
3 different wheat plants.**
