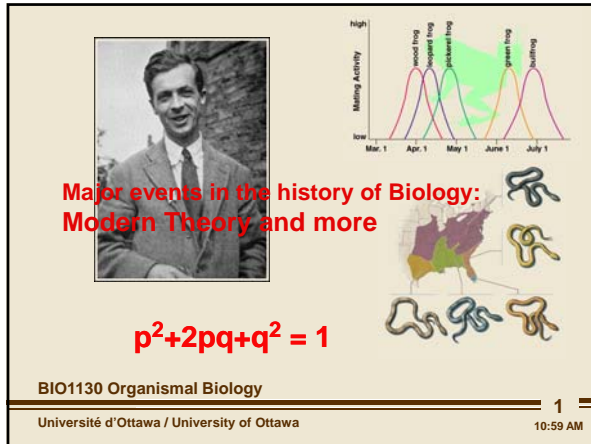


Modern theory and more

**Major events in the history of Biology:
Modern Theory and more**



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

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In this lecture topic

- How can Mendelian genetics be use to explain natural selection in populations?
- Allele frequencies and evolution – Hardy-Weinberg.
- Sources of variations in alleles.
- What is a species and how do new species arise?
- The importance of systematics?

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biology still does not have a proper definition of species yet.

Darwin's five theories

- No constancy of species
- Common ancestry
- Gradual changes
- **Natural selection (microevolution)**
- Multiplication of species



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Modern theory and more

Important stages in the history of Biology
Modern theory and more

- **Synthetic (Modern) theory of evolution**
 - Population genetics and natural selection based on Mendelian genetics



Huxley
(1887-1975)

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they still didn't know what the heritable material was, but they knew that it was transferred from generation to generation in pairs.

Microevolution

- **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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allelic frequencies can also come about through chromosomal abnormalities and many other things. if there is one generation with one allelic frequency, and the next generation has the same allelic frequency, microevolution has not occurred.

Some basic terms for microevolution

- **Allele**
- **Phenotype**
- **Genotype**
- _____
- _____
- **Dominant and recessive**

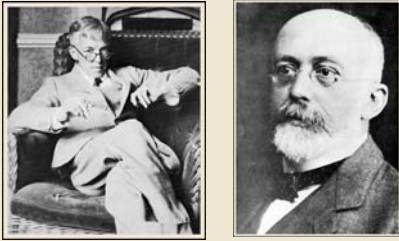
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Modern theory and more

Important stages in the history of Biology
Modern theory and more



Hardy
 (1877-1947)

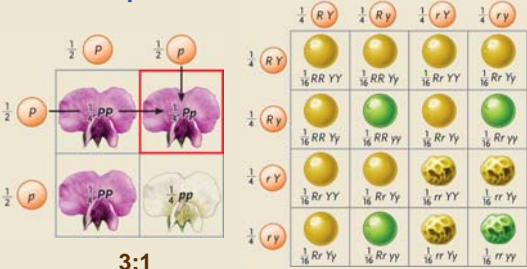
Weinberg
 (1862-1937)

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how do we predict what the frequency will be in the next generation

Punnett squares



3:1

9:3:3:1

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Incomplete dominance – snap dragons

P - parental

$C^R C^R$ Red

X

$C^W C^W$ White

F₁ - Generation 1

$C^R C^W$ Pink

F₂ - Generation 2

$C^R C^R = 25\%$

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

$C^W C^W = 25\%$

Figure 11.13




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incomplete dominance: red + white = pink.





Modern theory and more

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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Using the Hardy-Weinberg Principle

p² + 2pq + q²	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

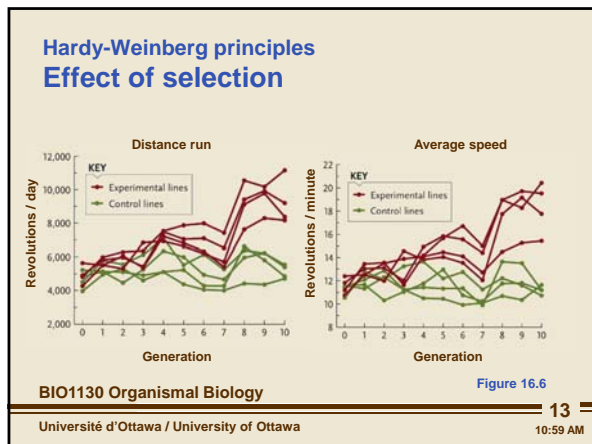
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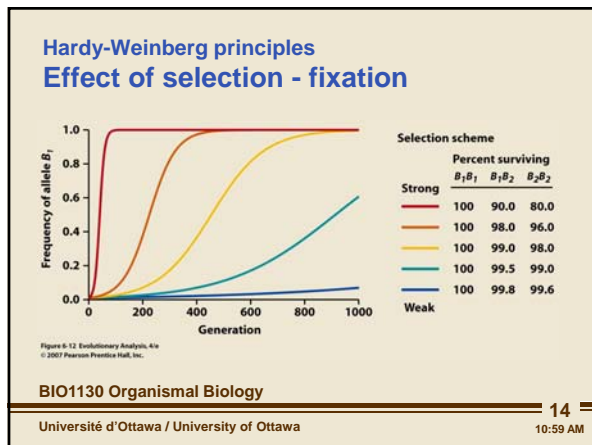
- Hardy-Weinberg principle's assumptions**
- No natural selection
 - Random mating
 - No mutation
 - No genetic drift – population is large
 - Gene flow
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if you dont get back the answer you were expecting, it means the allele frequency change due to an influence.

Modern theory and more

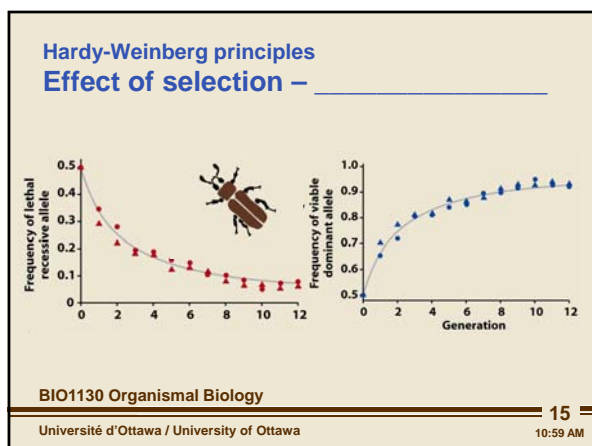


although it can be very very long before a group evolves, but it can be very quick as well. they took mice that like to run and bred them together and mice that didn't like and bred them together. after about 10 generations they were able to breed different strains of mice that liked to constantly run, and one that would just sit around and not do much physical activity. To generations is very fast.



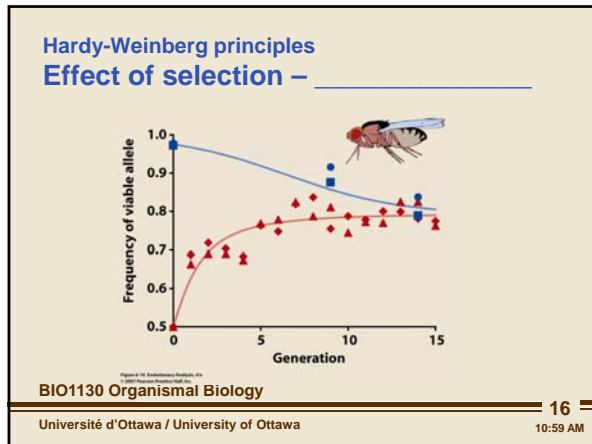
this shows us that very slowly over time, the B_1 allele will slowly increase in its population. if you go to the 4%, the pressure is so strong that the allelic frequency is changing and slowly disappearing from the population. this is called being "fixed"

this tells us that under low slow selective pressure you don't really lose genetic variability. under extreme selective pressure, alleles are able to actually disappear rather quickly.

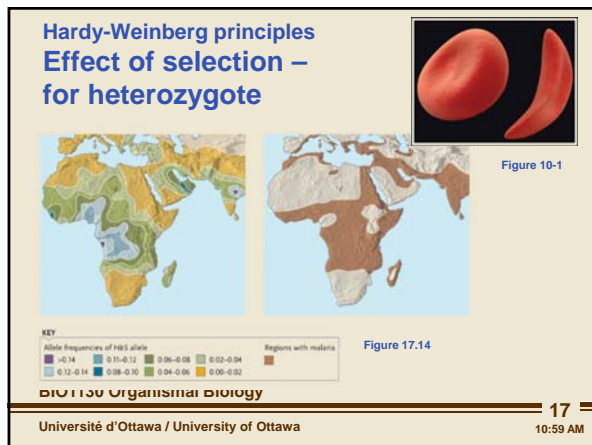


this experiment has been done twice and the numbers matched up perfectly, as well as the mathematic prediction for the occurrence.

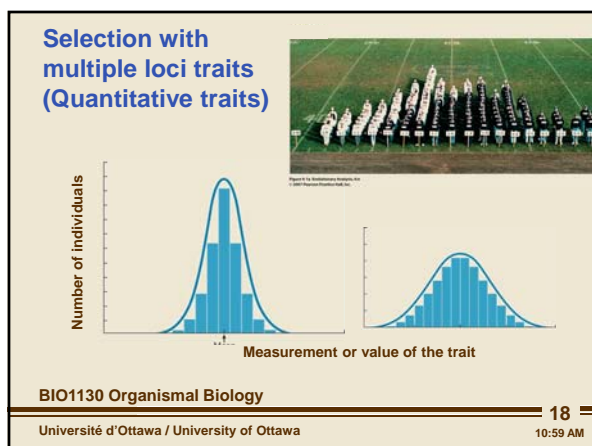
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in this example, being a heterozygote has an advantage. this is because there are a lot more genetic variances

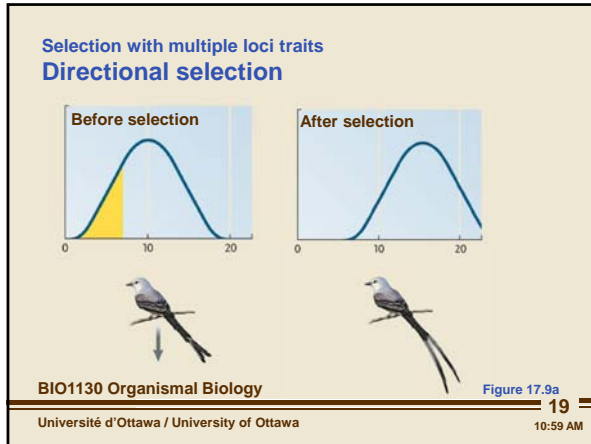


one of the consequences of sickle cell anemia, the cell cannot carry as much oxygen. if you are a heterozygote, you will be tired and slow.. but when you look at it, in a certain part of the world it has an abnormal allele frequency. they realized that if you look at where malaria, it overlaps the areas with sickle cell anemia. the advantage for the heterozygote cell. the malaria parasite is still able to get inside a sickle cell. the human body recognises a sickle cell, so the liver will remove the cell from the body. this is where the advantage comes from. the certain number of sickle cells that have malaria will be removed. but if the cell is normal the liver will not remove the cell.

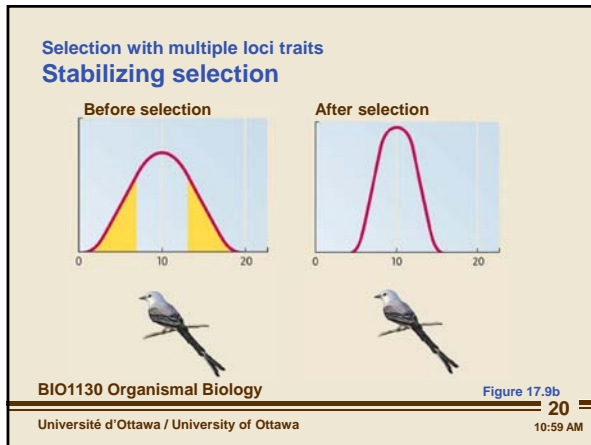


the spread of the curve is 95% of the population (standard deviation). The mean value is the value in the middle when the numbers are in order high to low. behavioural ecologists go out and collect data in order to make a distribution curve and then characterize it.

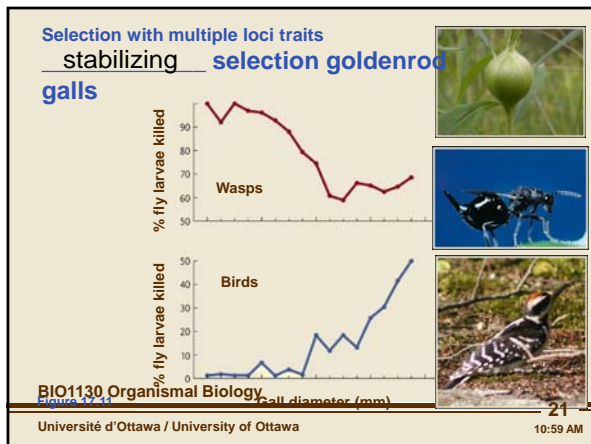
Modern theory and more



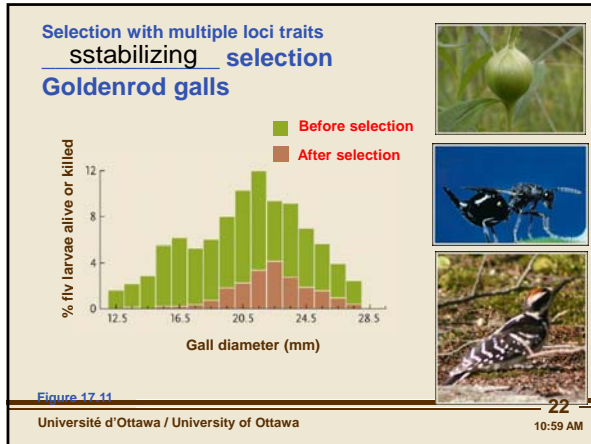
due to the selection, eventually the mixture of genes are not going to translate to the next generation. The mean has shifted in this curve (directional selection). Selection that takes the curve and moves it forward.

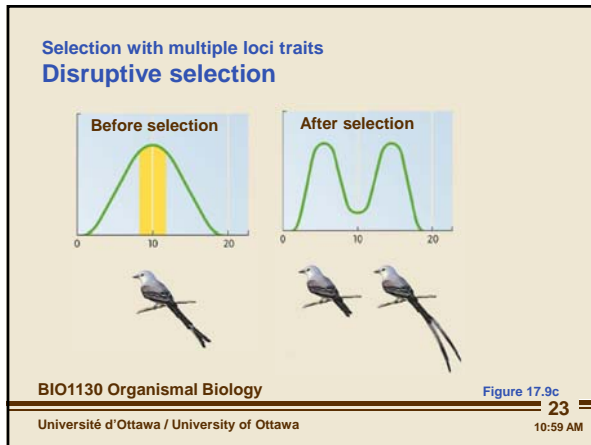


When there is selection at both ends, there is still the same mean but the standard deviation has narrowed.

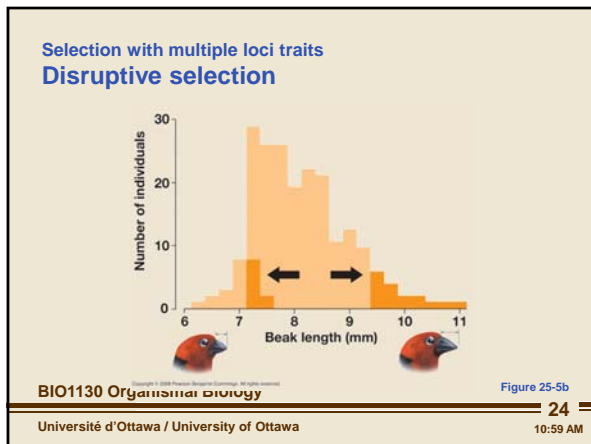


Modern theory and more





Unlikely to pass genetics to the next generation.
Causes loss of the genetics in the middle. This could potentially become 2 different species.



During a drought in the Galapagose islands, the plants that produced middle sized seeds when dormant in order to survive. Within a couple of generations, the birds with a middle beak size began to die out. The population was then split between large and small beaks. Within a period of about 7 years the drought ended, seeds came back and the middle sized beaks came back.

Modern theory and more

Hardy-Weinberg principle's assumptions

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

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We can see mathematically or with the curves.

Hardy-Weinberg principles
Nonrandom mating - Inbreeding

Figure 25-10 26
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Inbreeding is when individuals breed with very genetically similar individuals. If you have a population, when the mating occurs in the closed environment, everytime the heterozygous individual crosses you get 25% homozygous for those traits. then when they mate again it will be another 25%. they end up creating a situation where the homozygous conditions begin to take over. This is not micro-evolution because it happened within a closed system.

Hardy-Weinberg principles
Nonrandom mating - Sexual dimorphism

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Within the animal world there are many animals where the males and females differ in appearance. 2 The female always only has a limited number of eggs to create offspring. They invest a large amount of effort in producing an egg with her genetic material. She then wants to find a male that is healthy and the best for her egg. The male spends much less effort on his sperm and just wants to distribute his sperm to as many females as possible. The colouration, size, song and many other signals are used by the male to attract the female. The male has so much extra energy it is able to do more things to attract more females.

Modern theory and more

Hardy-Weinberg principles
Nonrandom mating - sexual selection

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

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Hardy-Weinberg principles
Sexual selection
female choice

riflebird
Tail feathers

Tail Length	Mean number of mates/male
Shortened	~0.5
Normal	~0.8
Lengthened	~1.8

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behavioural ecologists captured a bunch of males with long tails and cut them short. They then attached the tail to males with shorter tails. This showed that the females were selecting males purely based on the size of the tail.

Hardy-Weinberg principles
Sexual selection
Male competition - combat


Lifetime reproductive success: Number of offspring weaned	Percentage of males born
0	~90
1-10	~5
11-20	~2
41-50	~1
81-100	~1

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elephant seal males are male selection. usually there is one male controlling a population.

Modern theory and more

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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sperm competition means that they want to be sure that it is only his sperm that fertilizing the female. dragon flies stay stuck together because the male pulls ou the sperm fromn any other males and then puts his own in. he then stays attached to her until his sperm is able to move far enough up the reproductive tract to not be able to be pulled out

Hardy-Weinberg principles
Sexual selection
Male competition – infanticide



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Lions have a single dominant male which mates and defends those females. If the dominant male loses a battle and a new dominant male comes in, he kills off all of the previous cubs in order to kill off the other genes and create his own.

Modern theory and more

Hardy-Weinberg principle's assumptions

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

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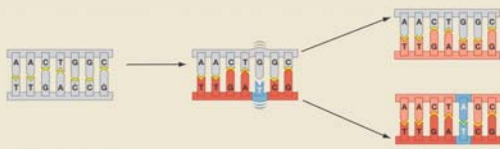
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Hardy-Weinberg principles Mutation

- Beneficial
- Neutral
- Deleterious



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Figure 16-20

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a point mutation is very rare and often has very minimal effect

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	U C A G
C	CUU Leu CUC CUA CUG	CCU Pro CCC CCA CCG	CAU His CAC CAA CAG	CGU Arg CGC CGA CGG	U C A G
A	AUU Ile AUC AUA AUG Met	ACU Thr ACC ACA ACG	AAU Asn AAC AAA AAG	AGU Ser AGC AGA AGG	U C A G
G	GUU Val GUC GUA GUG	GCU Ala GCC GCA GCG	GAU Asp GAC GAA GAG	GGU Gly GGC GGA GGG	U C A G

KEY
 Ala = alanine
 Arg = arginine
 Asn = asparagine
 Asp = aspartic acid
 Cys = cysteine
 Glu = 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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Figure 14-5

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chances are a mutation in the 3rd position isn't gonna do much to the codon.

Modern theory and more

Hardy-Weinberg principles Mutation

- Point mutations
 - Silent
 - Missense
 - Nonsense
 - Frame shift
- Chromosomal mutations

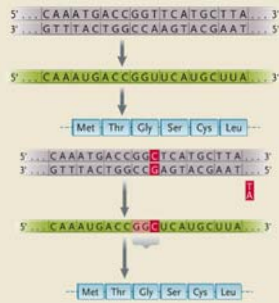
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Silent



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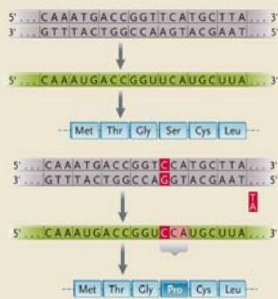
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Normal - the one big fly had one red eye

Missense

- Normal:
the one big fly
had one red eye
- Missense:
thr one big fly
had one red eye.



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Modern theory and more

Hardy-Weinberg principles
Mutation – sickle cell

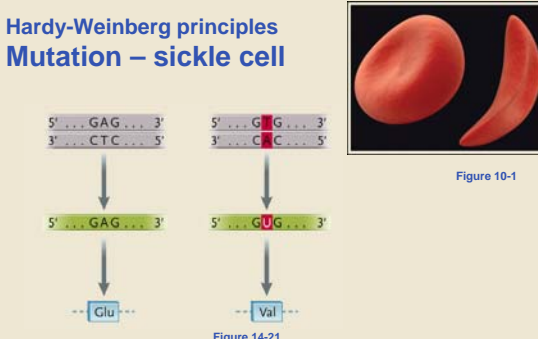


Figure 10-1

Figure 14-21

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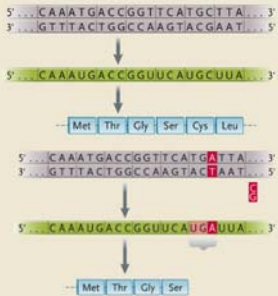
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Nonsense

- Normal:
the one big fly had one red eye
- Nonsense:
the one big



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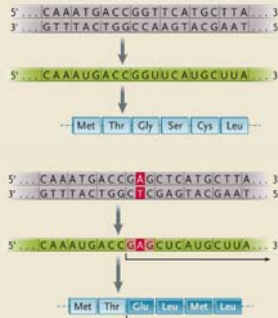
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Frame shift

- Normal:
the one big fly had one red eye
- Frame shift:
the one rbi gfl yha don ere dey



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Modern theory and more

Hardy-Weinberg principles
Mutation

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

Figure 12-11

Inversion

Translocation

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Chromosomal mutations are much more common.

Hardy-Weinberg principles
Mutation

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

Figure 12-11

Deletion

Duplication

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Hardy-Weinberg principles
Chromosomal mutations – crossing over

Figure 10-14

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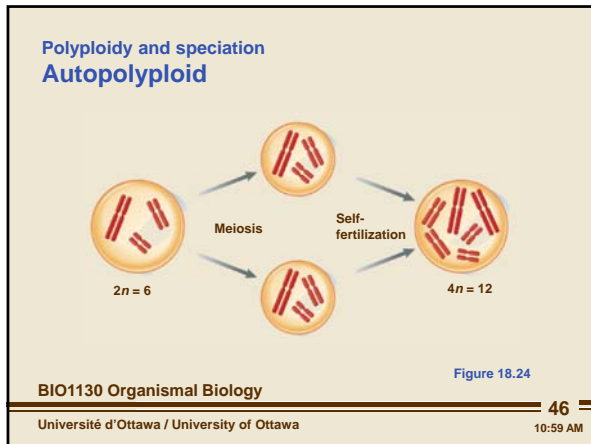
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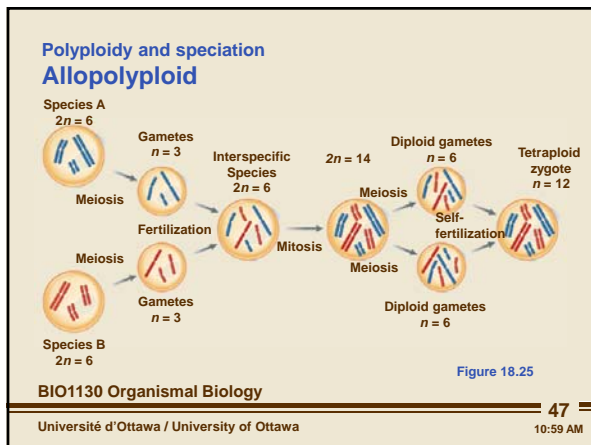
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biggest source of genetic mutation

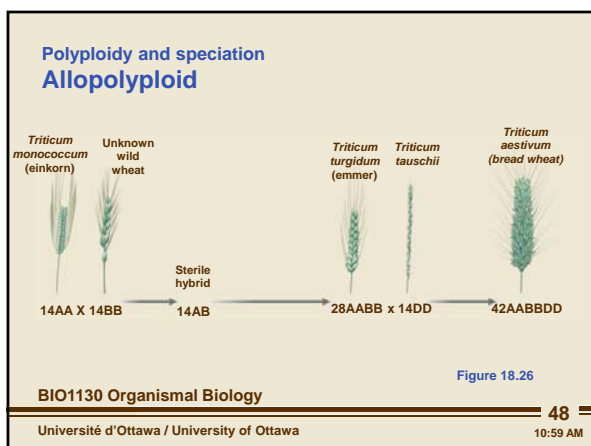
Modern theory and more



in miosis sometimes the chromosomes dont seperate properly. this doubles the chromosome numbers in the gametes. when you combine the 2 gametes you get double the chromosomes of the parents. this will be very bad in animals. In plants it will do this on purpose to self fertilize.



when there is a different species involved. Chromosomal compliments from 2 different species end up combining.



Modern theory and more

Hardy-Weinberg principle's assumptions

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

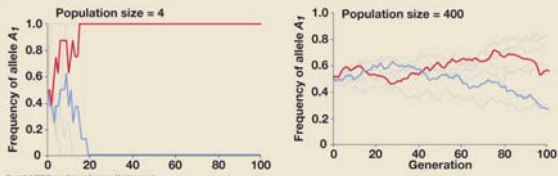
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Hardy-Weinberg principles Genetic drift



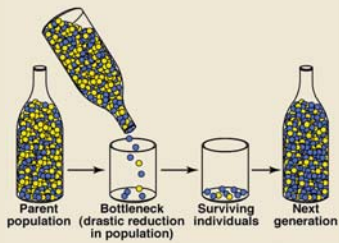
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Hardy-Weinberg principles Genetic drift – _____



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Modern theory and more

Hardy-Weinberg principles
Genetic drift – Founder effect



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Hardy-Weinberg principle's assumptions

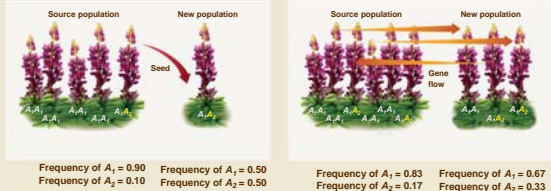
- No natural selection
- Random mating
- No mutation
- No genetic drift – population is large
- Gene flow

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Hardy-Weinberg principles
Gene flow - _____



Frequency of $A_1 = 0.90$
Frequency of $A_2 = 0.10$

Frequency of $A_1 = 0.50$
Frequency of $A_2 = 0.50$

Frequency of $A_1 = 0.83$
Frequency of $A_2 = 0.17$

Frequency of $A_1 = 0.67$
Frequency of $A_2 = 0.33$

Figure 25-8b

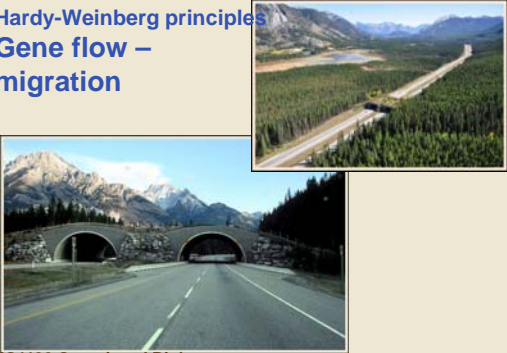
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Modern theory and more

Hardy-Weinberg principles
Gene flow – migration



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Darwin's five theories

- No constancy of species
- Common ancestry
- Gradual changes
- Natural selection (microevolution)
- Multiplication of species




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EXAM

Speciation



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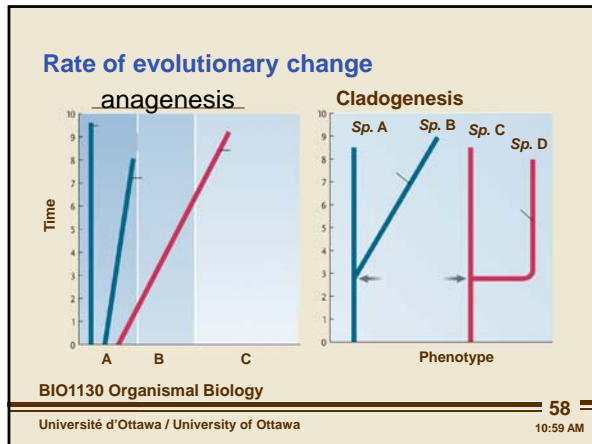
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The study of identifying species. Species give us a measure of diversity and the fundementale unit in a population.

Species concept: 10-12 different concepts in order to define a species. Biologists have never come up with a real hard definition of a species.

Modern theory and more



evolutionary change can be slow and gradual in relation to its environment in anagenesis in cladogenesis, a certain population of a species changes over time, while some original populations remain.

Species concepts – what is a species?

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

Species are groups of actually or potentially interbreeding populations, which are reproductively isolated from other such groups.

Ernst Mayer (1942)

Mayer (1904-2005)

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BIOLOGICAL SPECIES CONCEPT

If there is a species in a location that is isolated from each other species and unable to reproduce than they are not the same species.

ISSUES

- We have to prove reproductive isolation. This restricts us because we are unable to demonstrate if fossils are reproductively isolated.

- It requires sexual reproduction. There is a major group on the planet that does not engage in sexual reproduction (bacteria). They reproduce by binary fission and inherit genetic variability from something else.

ECOLOGICAL SPECIES CONCEPT

Organisms that are uniquely adapted to an environment within their niche, making them considered to be a species

Species concepts

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

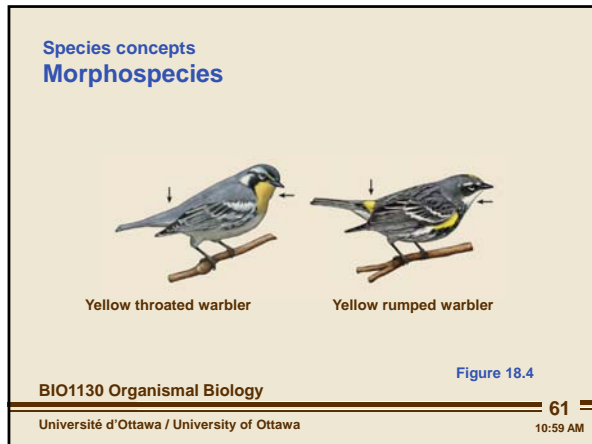
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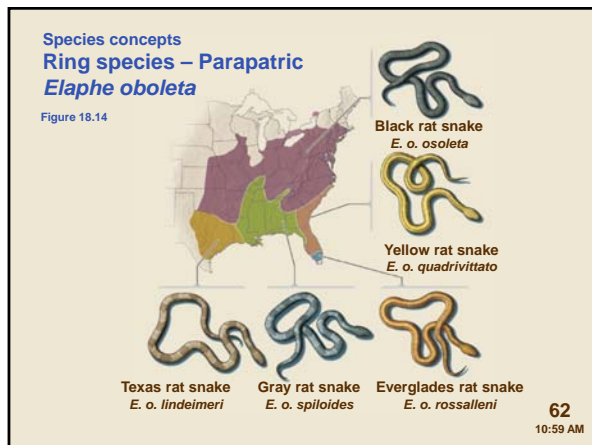
Modern theory and more



Differences in appearance can be used to differentiate between species. Birds are so dramatically different that they deserve to be in their own category. When looking at their genetic makeup, we saw that things such as feathers and flight were not actually unique at all. We ended up seeing that birds and reptiles should be placed in the same group.

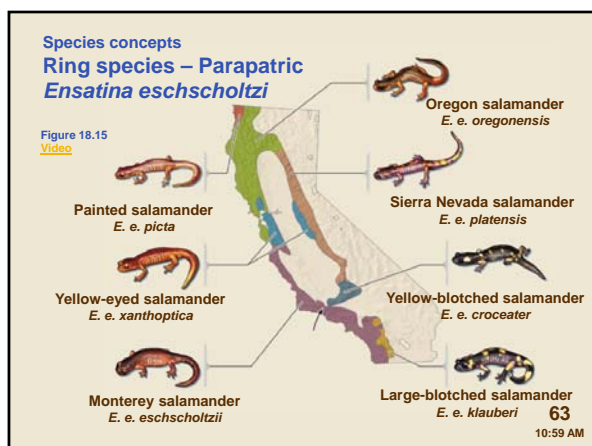
Up until about 10 years ago the dog was called *Canus Familiaris*. An example of the morphospecies concept since the dog had been domesticated and changed enough to be considered different from wolves. Also, if dogs get free into the wild they are still able to reproduce with wolves, meaning that we created artificial isolation.

The dog has become a subspecies of wolves called *canus lupus familiaris*



"how do we get new species"

Parapatric means that new species are created but are slightly isolated from each other. They are still able to interact and interbreed with each other. All of these populations could possibly merge into one species, or isolation could become complete creating a bunch of completely different species.



Developed an adaptive strategy of blending into the surroundings that they were living in. They developed the yellow spots to mimic the sun spots on the forest floor. On the other side the salamander adapted the bright colors of a poisonous newt in order to mimic it and look poisonous. Eventually the species met again and were able to still mate. This caused a hybrid that is unable to hide as well and is probably not gonna last

Modern theory and more

Second contact – Hybridization outcomes

- Fusion of the populations
- Reinforcement
- Hybrid zone formation
- Extinction of one population
- Creation of a new species

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Allopatric Speciation - Vicariance

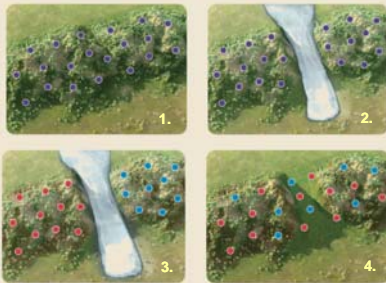


Figure 18.18

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Vicariance.. A uniform population gets split and over a very long time the two now separate populations become very different. Then if that thing disappears the populations are able to come back together and breed again

Allopatric Speciation - Dispersal

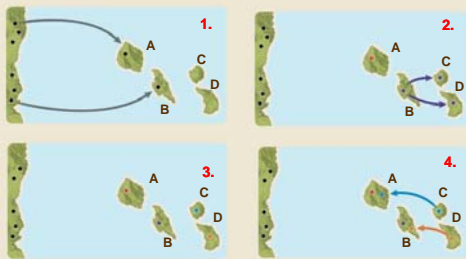


Figure 18.18

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When organisms move uncharacteristically long distances and inhabit this new area.

Modern theory and more

Grylloblattid – Ice age vicariance

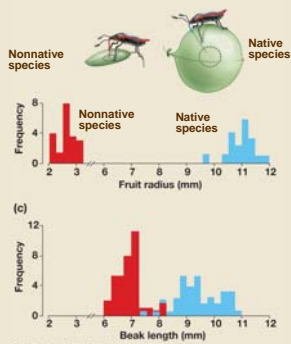


Video

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developed an antifreeze system to enable itself to survive in freezing temperatures. In the winter it was able to remain dormant but not die. As the ice age ended and the ice melted away, it had speciated into one separate species. Due to the ice they were separated from each other for so long that there are now many different species of this cricket. If it warms about 5 degrees it will die, since it is so adapted to the cold.

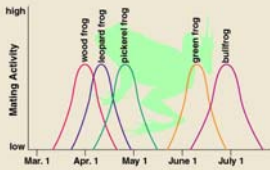
Sympatric speciation



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Biological species
Reproductive isolation

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



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Ecological species are species that are completely isolated from each other

Temporal isolation means that the species mate in different points of the year, season, or day

Behavioural isolation is when the male of a species sends signals to the female in order to catch attention to mate


Mechanical isolation means that the male and female sex organs do not fit together causing a physical barrier. also isolation between coevolved species.

Gametic isolation is when a species has no internal reproductive systems and just leave their eggs and sperm outside or in water. If the sperm from another species tries to penetrate the membrane of the egg it will not work.

Modern theory and more

Biological species
Reproductive isolation

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



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<input type="checkbox"/> P. canadensis	<input type="checkbox"/> P. albicollis	<input type="checkbox"/> P. ignita
<input type="checkbox"/> P. leucogaster	<input type="checkbox"/> P. magister	<input type="checkbox"/> P. pyralis
<input type="checkbox"/> P. carolinensis	<input type="checkbox"/> P. canadensis	<input type="checkbox"/> P. grandis

Biological species
Reproductive isolation

- Prezygotic isolation
 - Habitat
 - Temporal
 - Behaviour
 - _____ [comit orchid](#)
 - Gametic
- Postzygotic isolation



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Biological species
Reproductive isolation

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



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Modern theory and more

Biological species
Reproductive isolation

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



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A mule is an example of hybrid sterility.

Important stages in the history of Biology
20th century: Modern biology


- Cellular respiration, ATP and mitochondria (1930-1950)
- Ecology (1940's)
- DNA is the genetic materials (1943)
- DNA structure (1953)
- Gene regulation (1961)
- Genetic code (1960's)
- Recombinant DNA experiments (1970's)
- Cloning of a mammal (1997)
- Human genome sequence (2000)

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Types of taxonomies

- Folk
- Artificial
- Mechanical
- Natural (Evolutionary)
- Cladistic (Phylogenetic)



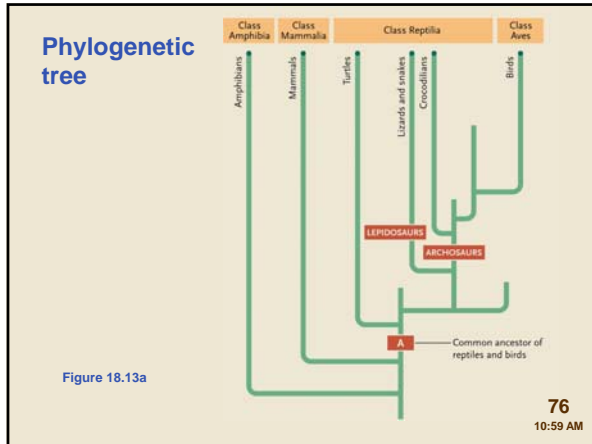
Hennig
(1913-1976)

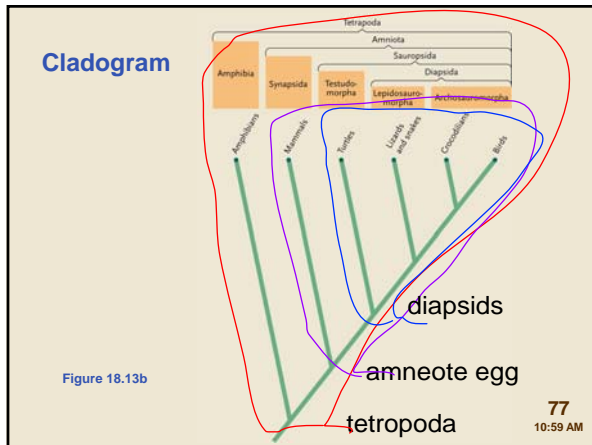
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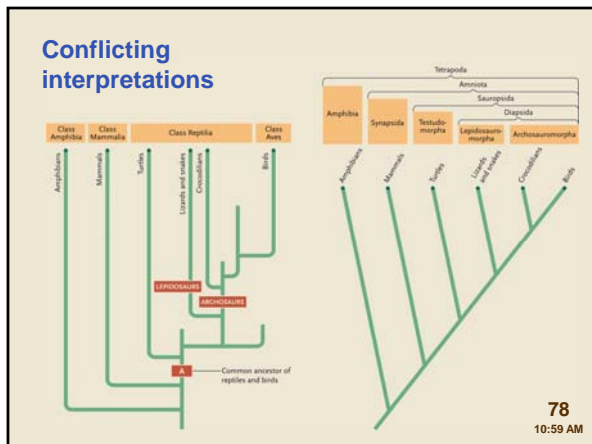
Hennig gave us cladistic (phylogenetic) taxonomy. Morphology was still driving the evolution of organisms. He wanted to try and find a way to remove the subjectivity when comparing traits

Modern theory and more

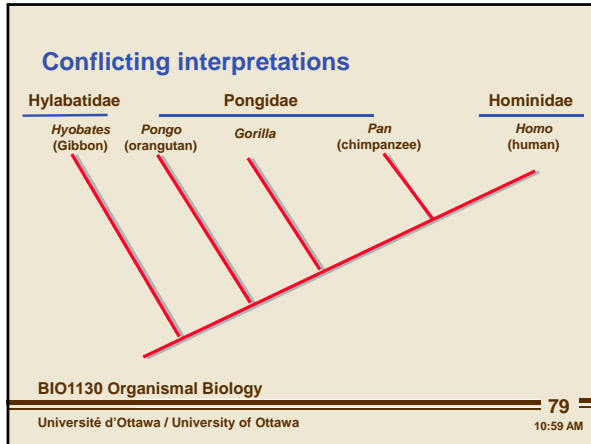




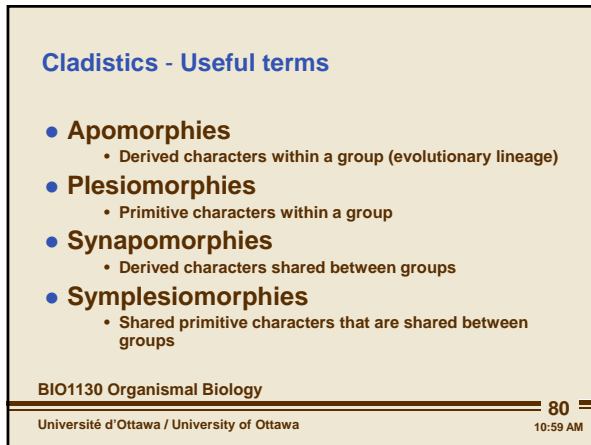
every species that descends from a branch descends from each other.

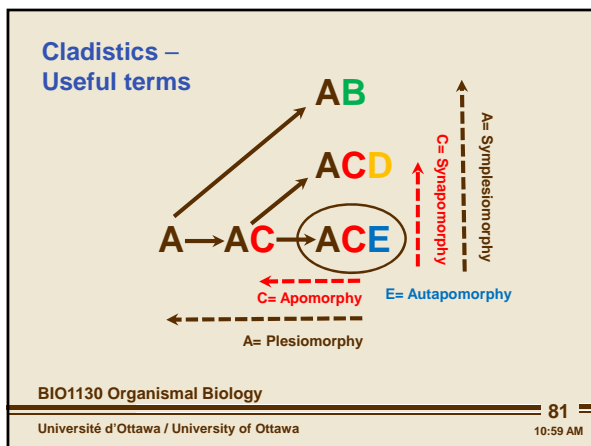


Modern theory and more

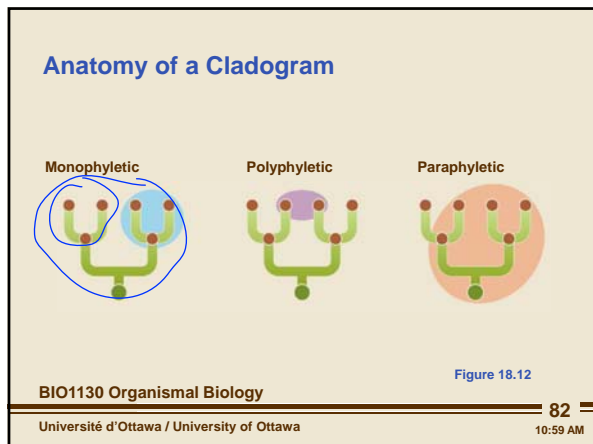


Found the transition fossile between chimpansees and humans





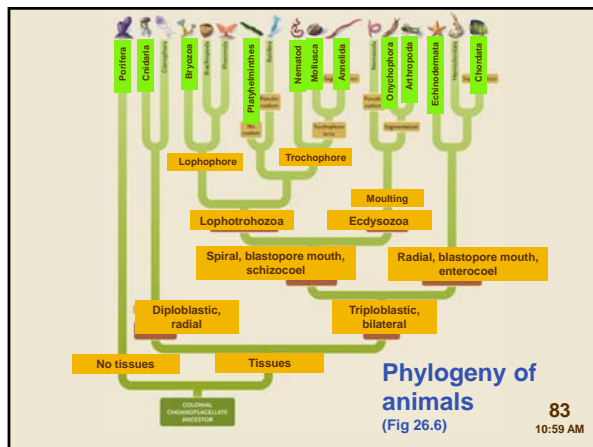
Modern theory and more

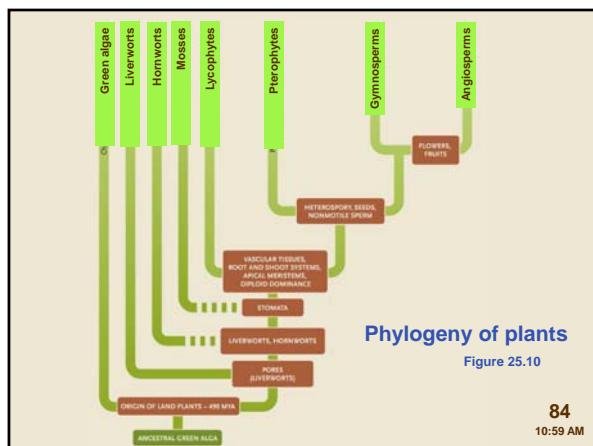


Monophyletic: descendant and all of the ancestors. we do not want any one left out. When cladograms are put together that look monophyletic, as people build new cladograms and continue research we change these cladograms and ruin them.

Polyphyletic: Some of the descendants without the ancestor


Paraphyletic: A descendant and only some of their ancestors. Example: birds vs. reptiles. Once all of the research has been done we found out that birds are actually reptiles that have been evolved for flight.





Modern theory and more

Cladogram construction



outgroup



	Springtail	Silver fish	Dragon fly	Cockroach	Beetle	Fly
0						
0	o					
0	o					
0	o	o				
0	o	o				

- Double jointed mandible
- Two pairs of wings
- Folding wing mechanism
- Metamorphosis
- Reduction of wings to haltere

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score them a 0 or 1 based on whether or not they have a trait

Cladogram construction







	Springtail	Silver fish	Dragon fly	Cockroach	Beetle	Fly
0	1					
0	0					
0	0					
0	0					
0	0					

- Double jointed mandible
- Two pairs of wings
- Folding wing mechanism
- Metamorphosis
- Reduction of wings to haltere

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Cladogram construction



	Springtail	Silver fish	Cockroach
0	1	1	
0	0	1	
0	0	1	
0	0	0	
0	0	0	

- Double jointed mandible
- Two pairs of wings
- Folding wing mechanism
- Metamorphosis
- Reduction of wings to haltere

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Modern theory and more

Cladogram construction

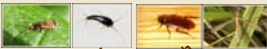
0	1	1	1		
0	0	1	1		
0	0	1	1		
0	0	0	1		
0	0	0	1		

- Double jointed mandible
- Two pairs of wings
- Folding wing mechanism
- Metamorphosis
- Reduction of wings to haltere

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Cladogram construction






0	1	1	1	1	
0	0	1	1	1	
0	0	1	1	0	
0	0	0	1	0	
0	0	0	1	0	

- Double jointed mandible
- Two pairs of wings
- Folding wing mechanism
- Metamorphosis
- Reduction of wings to haltere

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Cladogram construction

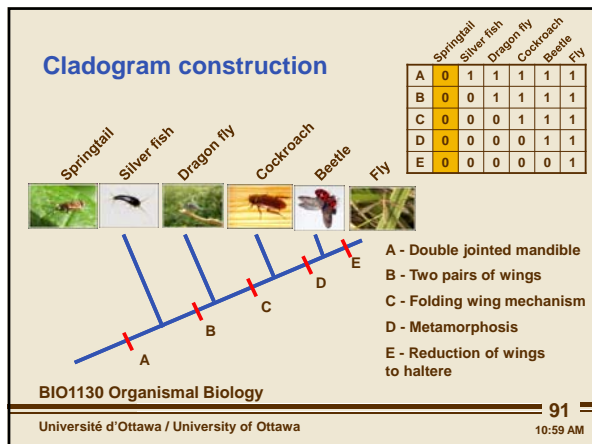
0	1	1	1	1	1
0	0	1	1	1	1
0	0	1	1	0	1
0	0	0	1	0	1
0	0	0	1	0	0

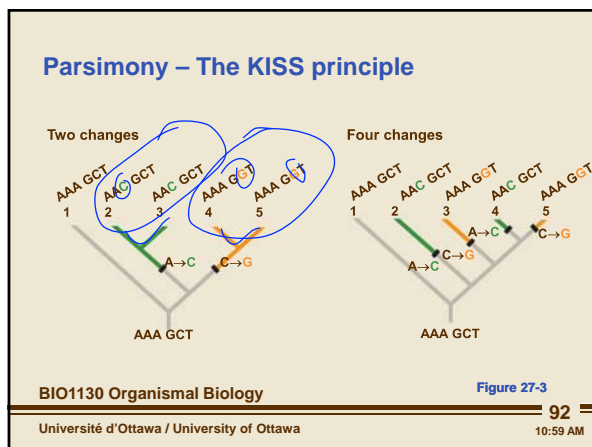
- Double jointed mandible
- Two pairs of wings
- Folding wing mechanism
- Metamorphosis
- Reduction of wings to haltere

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Modern theory and more



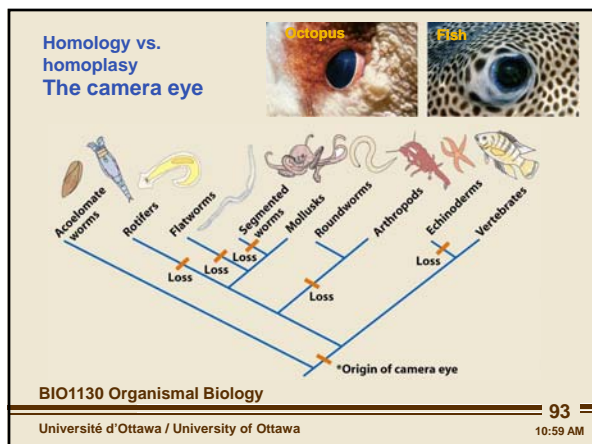


Keep it simple, stupid. You want to have the least number of evolutionary changes possible, in other words, the simplest cladogram possible.

The first codon changed and spun a group off, then the second codon changed and spun another group off. Then we went back to the first codon and changed it again and so forth with the second codon.

this actually ends up creating 4 changes.

You really want to create the most parsimonious statement.



The camera eye consists of a lens with a small opening, where light goes through and gets inverted. This is then projected onto the surface like a camera. Light surfaces could only see light differences. Through evolution, the light sensors were put in a cup allowing for orientation. After time the hole gets smaller and smaller and eventually becomes a pin hole which projects the image to the back of the eye where the sensors then interpret the image.

there are 7 events to explain the loss of the camera eye in the animal kingdom.

Modern theory and more

Homology vs. homoplasy
The camera eye

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A more parsimonious way to explain the camera eye is to simply state that instead of being lost 7 times, it arose twice through evolution.

Convergent evolution because we can see that the way these eyes work are very very different from how human or other eyes work

Species concepts – what is a species?

- Biological species
- Ecological species
- Morphospecies
- Phylogenetic species

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