Genetics

Everything mostly from Campbell's Bio

Presentation by Laurie, Slides by Slidesgo

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Mendelian Genetics

Background

- Mendel bred pea plants in a monastery ~1857
- Why peas are cool:
  - Different varieties (white, purple)
    - **Character** – something that can be inherited (flower color)
    - **Trait** – a version of the character (purple or white)
  - Breeding can be controlled
    - Pollen can be manually moved to carpels to avoid **self-breeding**
    - **True-breeding** – a plant that makes the same offspring through many generations (by self-breeding)
    - **Hybridization** – crossing 2 true-breeding organisms
  - Short generation times and lots of offspring
    - **P generation** – true-breeding parents
    - **F_1 generation** – hybrid offspring
    - **F_2 generation** – offspring of F_1

Vocab

- **Gene** – a sequence of nucleotides – passed on parent to offspring
- **Allele** – alternative versions of a gene
    - Comes from different DNA at the gene’s locus
    - An organism gets one allele from each parent
- **Dominant allele** – determines appearance
- **Recessive allele** – doesn’t visibly affect appearance

When you have 2 alleles:

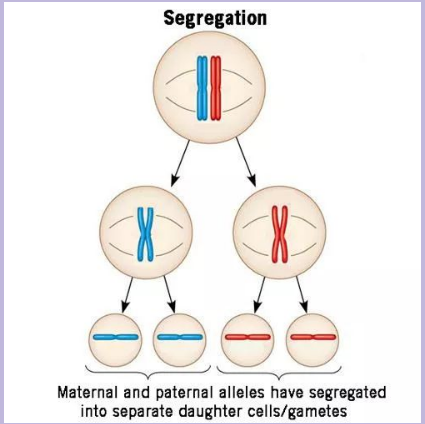
- **Homozygous** – 2 alleles are the same
- **Heterozygous** – 2 alleles are different – not true-breeding

- **Phenotype** – observable traits
- **Genotype** – genetic makeup

Mendel's Laws

Law of Segregation:

The alleles segregate in meiosis and go into different gametes.



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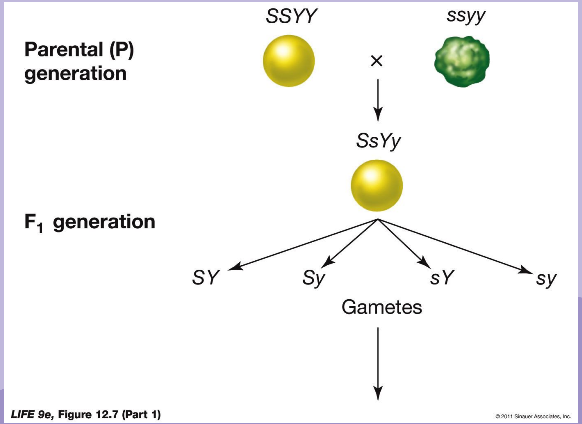
Law of Independent Assortment:

The way one allele pair segregates doesn't affect the way other allele pairs segregate.

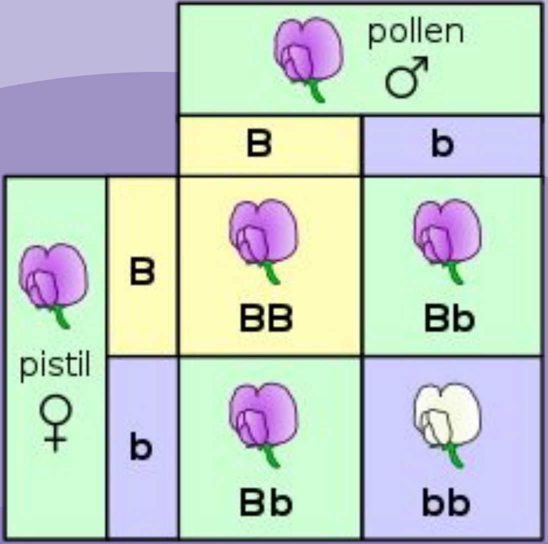


https://biology-forums.com/gallery/18099_29_04_12_1_39_50.jpeg

Punnett Squares

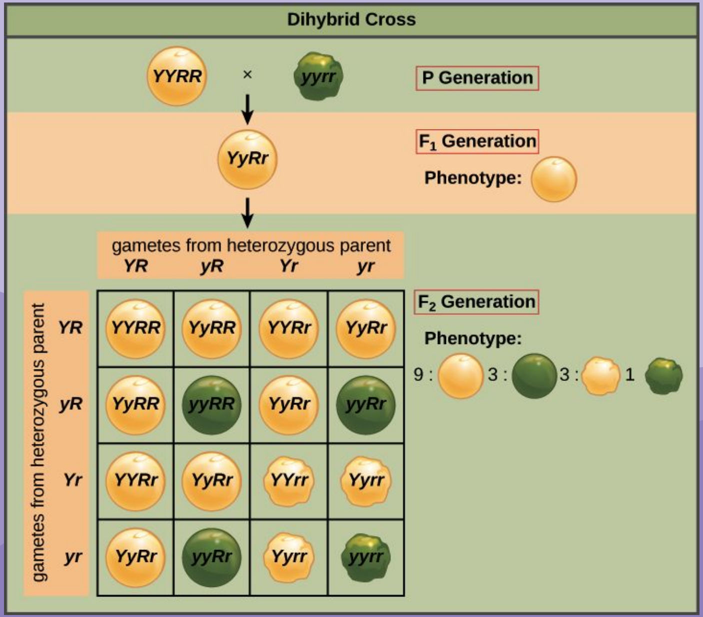
- Predict offspring genotypes

Monohybrid Cross



https://upload.wikimedia.org/wikipedia/commons/thumb/1/17/Punnett_square_mendel_flowers.svg/240px-Punnett_square_mendel_flowers.svg.png

Dihybrid Cross



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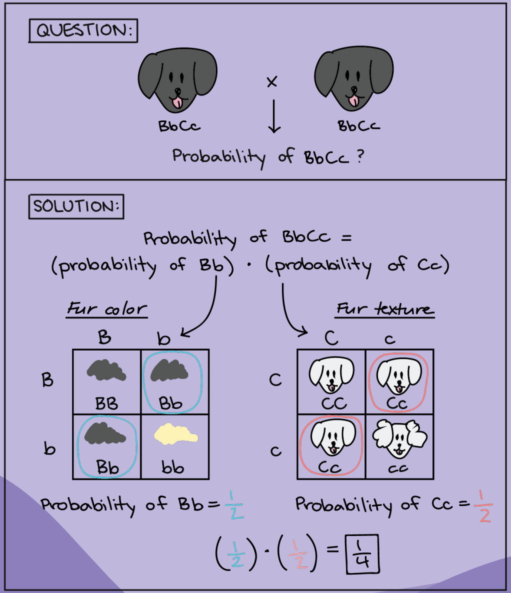
✨ Math ✨

Multiplication Rule:

- P(A and B) = P(A) x P(B)



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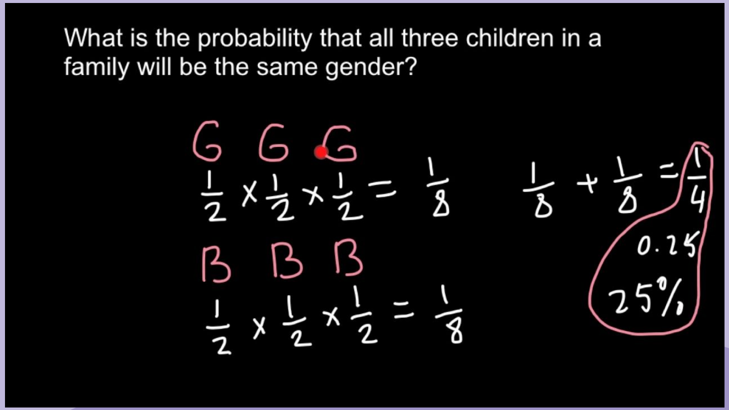
Addition Rule:

- P(A or B) = P(A) + P(B) - P(A and B)



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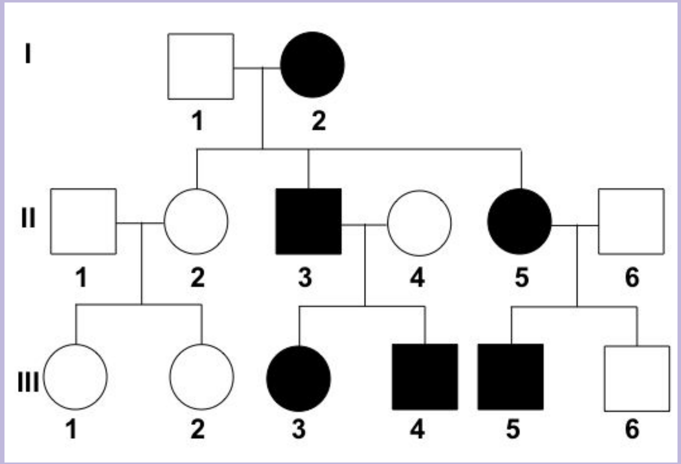
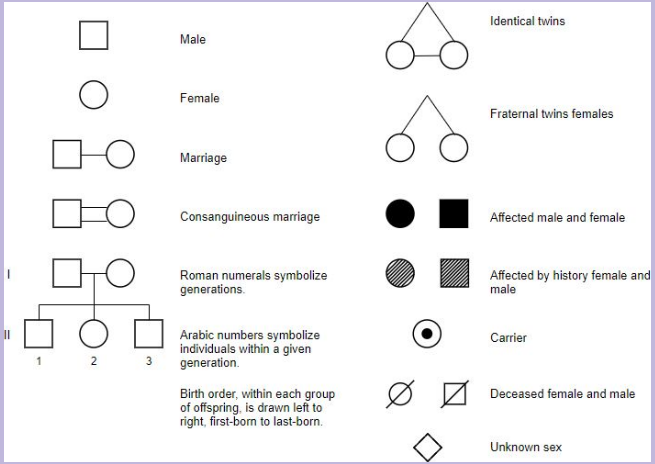
Pedigrees





Tips:

- Autosomal dominant never skips a generation
- X-linked tends to be more common in males

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https://online.visual-paradigm.com/servlet/editor-content/knowledge/organizational-chart/what-is-pedigree-chart/sites/7/2020/03/pedigree-chart-symbols.png

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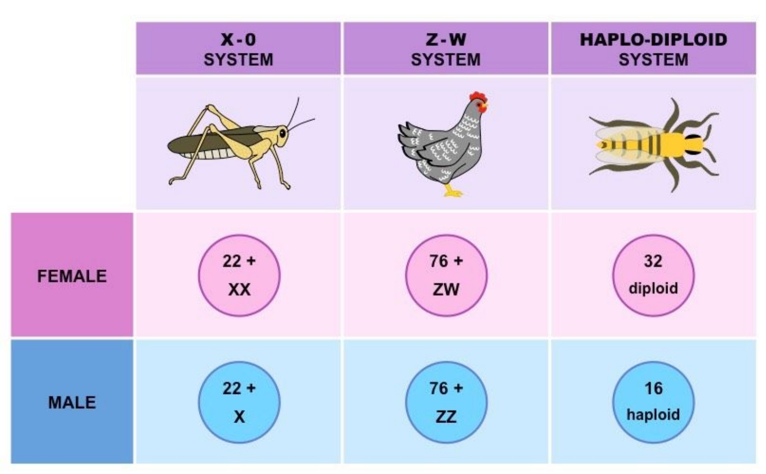
Non-Mendelian Genetics

How Sex Chromosomes Work

	X	X
X	XX	XX
Y	XY	XY



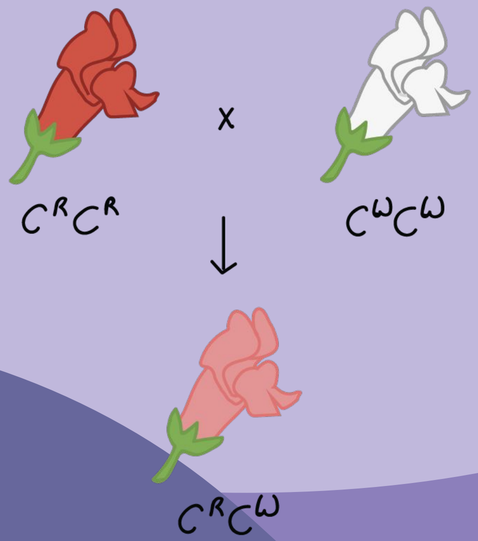
- ★ Human males are more susceptible to X-linked recessive diseases

http://www.discoveryandinnovation.com/BIOL202/notes/images/Punnett1.jpg

https://ib.bioninja.com.au/_Media/sex-determination-systems_med.jpeg

Incomplete Dominance

- Both alleles are expressed partially in the heterozygote
- Example: Snapdragons



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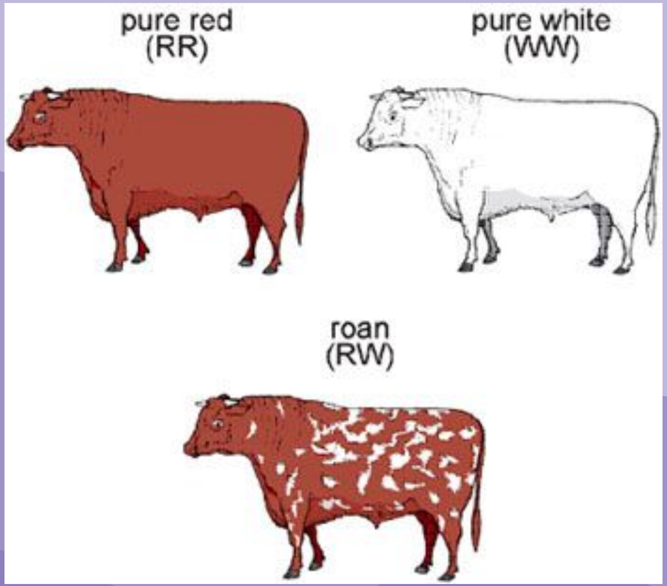
https://sakataornamentals.com/wp-content/uploads/sites/13/2022/02/Cast-Bloom-Plants-2018_44A6305.jpg

Codominance

- Both alleles are dominant in the heterozygote
- Example: Roan cows



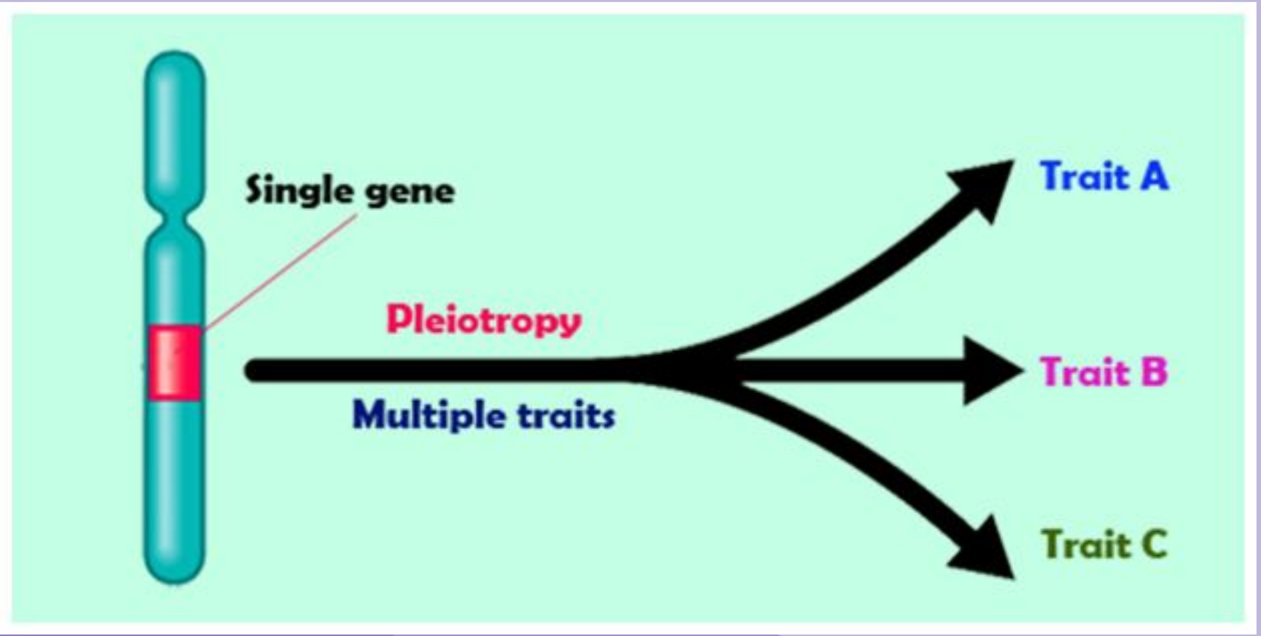
Multiple Alleles

Inheritance of the ABO Blood System in Humans

	I^A	I^B	i
I^A	$I^A I^A$ A	$I^A I^B$ AB	$I^A i$ A
I^B	$I^B I^A$ AB	$I^B I^B$ B	$I^B i$ B
i	$i\ I^A$ A	$i\ I^B$ B	$i\ i$ O

Pleiotropy

- One gene controls multiple phenotypes
- Example: Pea flowers and seed coats



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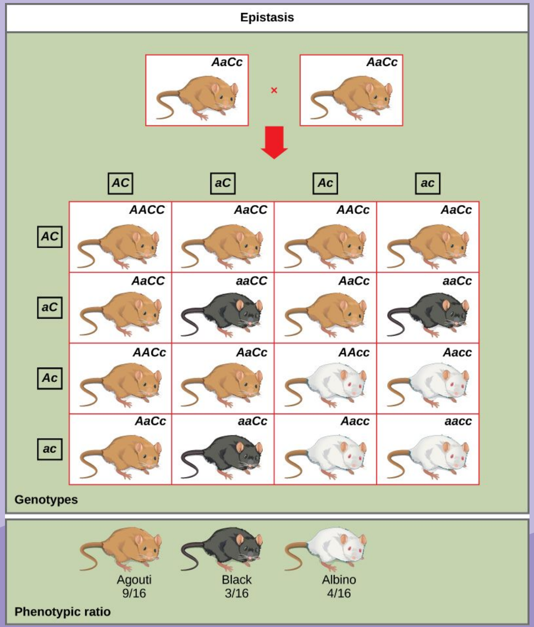
Epistasis

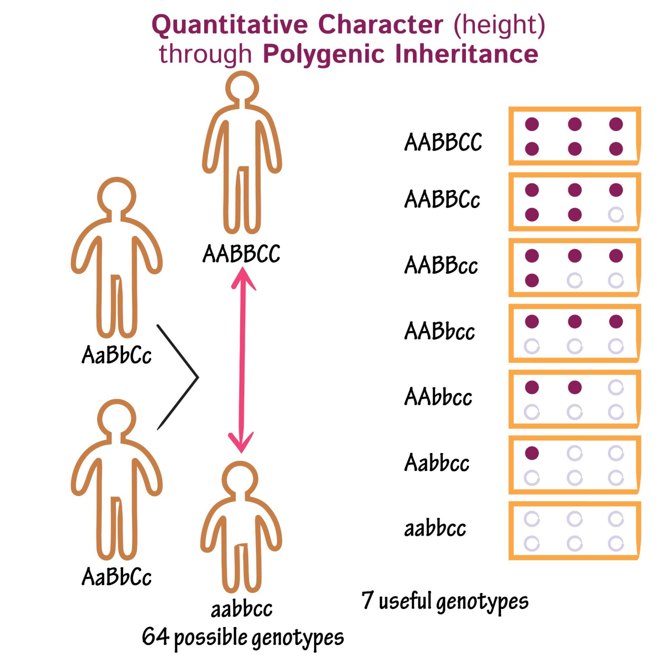
- One gene influences the expression of another
- Example: Mice coat color



https://s3-us-west-2.amazonaws.com/courses-images/wp-content/uploads/sites/110/2016/05/02183244/Figure_12_03_05.jpg

Polygenic Inheritance

- Quantitative characters - on a gradient
- Ex. height, eye color



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Hardy-Weinberg

The genotype frequencies in a population stay the same if there isn't evolution

The Equation(s)

$$p + q = 1$$

Freq. of A

Freq. of a

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

Freq. of AA

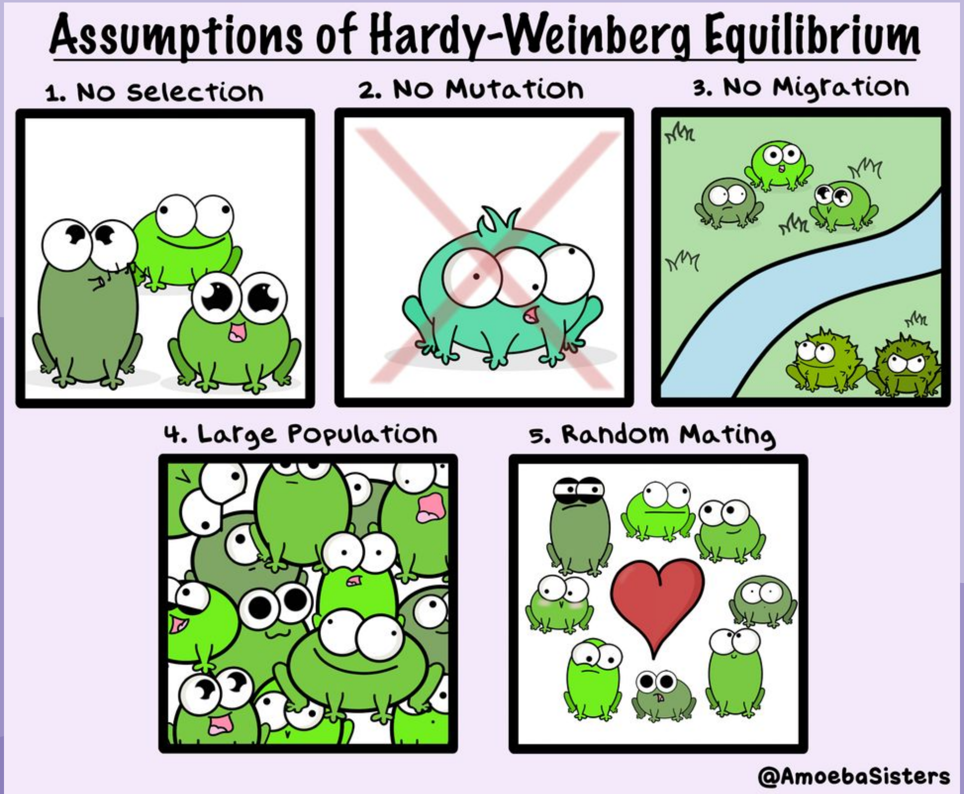
Freq. of Aa

Freq. of aa

p^2 and 2pq individuals appear the same with complete dominance

Hardy Weinberg Equilibrium

PS, 3M



Practice

41. Olney, IL, is known for its white squirrel population. In this squirrel population, assume that 10% of the genes are for albino coat color and 90% are for gray coat. If Hardy-Weinberg assumptions are true, what percentage of the squirrels are heterozygous?

A. 90
B. 81
C. 18
D. 9
E. 1

Solving for 2pq

$p = .9$
$q = .1$

$2pq = .18$

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

$p^2 = .81$
$q^2 = .01$

$.81 + 2pq + .01 = 1$

2013

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Hamilton’s Rule

The Equation

Natural selection favors altruism if:

$$rB > C$$

Relatedness

Benefit to recipient

Cost to altruist

Calculating Relatedness

Relationship	Description	Example	r
Parent / Offspring	Transmission of 1 of 2 alleles per locus	## 2 & 4	**1/2**
Full sibs	offspring of same parents	## 3 & 4	**1/2**
Half sibs Aunts/uncles, nieces/nephews	offspring with one parent in common	not shown	**1/4**
1st cousins	offspring of full sibs	## 7 & 8	**1/8**
2nd cousins	offspring of 1st cousins	## 12 & 13	**1/16**

https://www.mun.ca/biology/scarr/4250_Measurement_of_relatedness.html

Calculating B and C

- B is the # of surviving offspring

- C is the # of offspring cost

Practice

32. Person A and Person B, who are cousins, are both childless. Their fathers were brothers, while their mothers are unrelated. Person B is engaged and intends to have nine children. Person A is married expects to have only one child. One day, Person B falls into a river, from which he cannot swim out alone and would die otherwise. Person A has a 40% chance of saving Person B if he enters the river. However, entering the river also means certain death for Person A, regardless of whether or not he saves Person B.

Calculate the coefficient of relatedness between Person A and Person B and decide whether, based on Hamilton's rule, Person A should try to save Person B.

~~A.~~ 0.25; Person A should try to save B.
B. 0.125; Person A should NOT try to save B.
~~C.~~ 0.25; Person A should try to save B.
~~D.~~ 0.0625; Person A should NOT try to save B.
E. 0.125; Person A should try to save B.

Yes, if $rB > C$
$(\frac{1}{8})(\frac{2}{5})(9) > 1$, not true

2016

Additional Practice

2018 Opens

36. A 30-year old woman (is planning to have a child and visits a genetic counselor. The only observed genetic disorder in her immediate family is that her brother was afflicted by Hurler syndrome (also known as mucopolysaccharidosis type I), a monogenic, autosomal recessive metabolic disorder caused by a loss of function of a lysosomal enzyme named alpha-L iduronidase. Hurler syndrome manifests itself early in childhood and is often fatal. What is the probability that the woman is a carrier for a disease-causing allele of alpha-L iduronidase?

A. ¼.
B. ½.
C. 9/16.
D. 2/3.
E. ¾.

2017 Opens

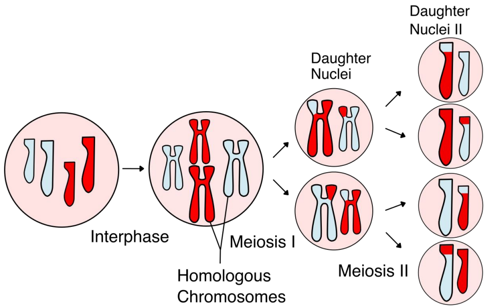
36. Consider a diploid snail species that has 34 chromosomes (2n = 34). This species has an XX/XY-like sex determination system, with males hemizygous for a particular locus on chromosome 2. Without considering crossing over, how many genetically unique individuals can one pair of snails potentially produce when reproducing sexually?

A. 68.
B. $2^{34} \times 2^{34}$.
C. 2×34^{2}.
D. $2^{17} \times 2^{17}$.
E. It is impossible to know.

2017 Opens

43. John has Downs Syndrome. At a given locus on chromosome 21 in a region with low crossover, John's genotype is ACC. At this same locus, his father has genotype AC and his mother BC. In which stage of his parents' meiosis could nondisjunction have occurred (*Select ALL that apply*)?

A. Meiosis I of the father.
B. Meiosis II of the father.
C. Meiosis I of the mother.
D. Meiosis II of the mother.
E. None of the above.



2016 Opens

35. At the end of a perfect week, Barney is suddenly confronted by the horrible news that he is the father of a baby girl. After Barney disappears to Bermuda, the mother orders a paternity test to confirm that Barney truly is the father. If Barney's blood type is AB and Rh^-, which of the following blood types could his daughter NOT have?

A. A and Rh^+.
B. B and Rh^-.
C. AB and Rh^-.
D. AB and Rh^+.
E. O and Rh^-.

Human skin pigmentation and height may vary greatly and are probably controlled by multiple genes. This is an example most specifically of:

W) pleiotropy

X) polygenic inheritance

Y) epistasis (read as: ep-ee-STAY-sis)

Z) incomplete codominance

The black fur allele B (read as: big b), is dominant over the white fur allele b (read as: little b). Two mice with black fur mate, producing four offspring: one is white and three are black. What are the likely genotypes of the two parents?

W) Bb and Bb
X) BB and Bb
Y) BB and BB
Z) BB and bb

Which of the following statements best describes the sex chromosome content of female and male cells in birds?
W) Females are ZW, males are ZZ
X) Females are WW, males are ZW
Y) Females are ZZ, males are ZW
Z) Females are ZZ, males are WW

Thanks!

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