Genetic Linkage and Mapping

Notation

Aa
Diploid
Adult

\[
\begin{align*}
\text{Haploid gametes} & \quad \text{(single chromatid)} \\
\begin{array}{c}
\text{A} \\
\text{a}
\end{array}
\end{align*}
\]

Two homologous chromosomes, four chromatids total

\[
\begin{align*}
\text{1/2 A : 1/2 a}
\end{align*}
\]

Dihybrid Cross

\[
\begin{align*}
P: & \quad \text{AA BB Female} \\
& \quad \text{aa bb Male} \\
\text{Gametes:} & \quad \text{Egg (A B)} \\
& \quad \text{Sperm (a b)}
\end{align*}
\]
F1 adult

after the S phase

F1: 

A  B
a  b

4 gamete types, equally frequent

F2 of dihybrid cross when genes not linked

What proportion of the gametes of the double heterozygote are recombinant?

But what if the genes are on the same chromosome?

(What if the genes are linked?)

They do not assort independently at meiosis
Two linked genes

P:

Female
A
B

Male
a
b

Gametes:
Egg (A B)
A
B

Sperm (a b)
a
b

When there is no crossing over between markers, all gametes are ________

F1:
A
B

No crossing over between markers

A
B

a
b

A
B

a
b

A
B

a
b

A
B

a
b

F1:
A
B

Crossing over in 4-strand stage

A
B

X

a
b

a
b

A
b

a
B

3
When there is a crossover, _____ of gametes are parental and _____ are recombinant

When genes are on the same chromosome, but far apart:

Crossing over between them will be common, approaching 100% of the time

In this case, what proportion of all F1 gametes will be recombinant (have a combination of alleles that was not present in the original true-breeding parents)?
Genes that are so far apart on the same chromosome that crossing over occurs between them in 100% of meioses behave as if they are unlinked:

____ parental combinations
____ recombinants

What if genes are close together?

Say that crossing over occurs between the genes in 20% of meioses

What proportion of F1 gametes will be recombinant?

If crossing over between genes occurs in 20% of meiosis

____ of gametes will be recombinant
Genes with < 50% recombination are on the same chromosome

Genes that have 50% recombination (independent assortment) are either on non-homologous chromosomes or ________________________

The frequency of crossing over between two genes on the same chromosome is proportional to the distance between the genes

This is the basis of genetic mapping

At small distances crossing over is rare and few gametes are recombinant (r is near 0%)

As distance between genes increases, crossover frequency increases, and more gametes are recombinant (___ < r < ___)

At greater distances, crossover nearly always occurs and r --> ___

How would you tell if a gamete produced by a double heterozygote is recombinant or parental?

How would you determine the genotypes of gametes produced by a doubly-heterozygous individual?
Mate double heterozygote to an individual that is homozygous recessive for both traits

Two linked genes

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>bw</td>
<td>bw+</td>
</tr>
<tr>
<td>hv</td>
<td>hv</td>
</tr>
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</table>

P:  

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If 15% of the offspring of the testcross are recombinant, what proportion of meioses had crossover between the brown and the heavy-veined genes?
If 15% of the gametes are recombinant, the genes are said to be ___ map units apart on a genetic map.

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**Unit of distance in linkage map**

A map unit is a map unit: 1 map unit is equal to 1 percent recombination.

A map unit is also equivalent to the physical distance along a chromosome which will experience 1 crossover event in every ____ meiotic divisions.

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**Two X-linked genes**

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<tr>
<td>w</td>
<td>m+</td>
</tr>
<tr>
<td>w+</td>
<td>m</td>
</tr>
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</table>

Gametes:

- Egg (A B)
- Sperm (a b)
62.8% non-recombinant offspring, 37.2% recombinant offspring

How far apart (in map units) are the genes?

___ map units

If two genes are 50 map units apart, what proportion of recombinant offspring would you observe?

What would you conclude about these two genes?