Lecture Outline 9/15

- Linkage of genes on chromosomes
  - Estimating recombination fraction
  - Chi-square tests for independence
  - Predicting offspring phenotypes when genes are linked
  - Three-point mapping

I have posted a new homework assignment on the web page

Chi-square Test for Independence

- Test Cross AaBb x aabb
- Results:
  - A-B- 70
  - A-bb 20
  - aAB- 25
  - aabb 85
  - Total = 200

Are these loci independent? If not, how far apart are they?

Chi-square Test for Independence

- Test if genes assort independently into gametes
- Results of test cross:
  - A-B- 70
  - A-bb 20
  - aAB- 25
  - aabb 85
  - Total = 200

What did the parental gametes have to be?

Chi-square Test for Independence

- 2 way table of gamete frequencies for each locus

<table>
<thead>
<tr>
<th></th>
<th>Aa</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>a</td>
<td>20</td>
<td>105</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Bb</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>70</td>
<td>105</td>
</tr>
<tr>
<td>b</td>
<td>25</td>
<td>35</td>
</tr>
</tbody>
</table>

What is the Prob( A and b), if the loci are independent?

Prob (A and b) = 55/200 * 20/200 = 0.023

Expected value = Row total * Column total / Grand Total

A  | a  | total |
---|----|-------|
 B | 70 | 90    |
 b | 20 | 110   |

P(A) = 90/200
P(b) = 105/200

Expected NUMBER = 0.236 * 200 = 47.25

Chi-square Test for Independence

Expected value = Row total * Column total / Grand Total

A  | a  | total |
---|----|-------|
 B | 70 | 95    |
 b | 20 | 85    |

P(A) = 90/200
P(b) = 105/200

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P(A) = 90/200
P(b) = 105/200

Expected NUMBER = 0.236 * 200 = 47.25
Chi-square Test for Independence

Degrees of freedom = (Rows-1) * (Cols-1)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>a</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>70</td>
<td>25</td>
<td>95</td>
</tr>
<tr>
<td>b</td>
<td>20</td>
<td>85</td>
<td>105</td>
</tr>
<tr>
<td>total</td>
<td>90</td>
<td>110</td>
<td>200</td>
</tr>
</tbody>
</table>

Chi-square Test for Independence

\[ X^2 = \sum \frac{(O-E)^2}{E} \]

\[ X^2 = \frac{(70-42.75)^2}{42.75} + \frac{(25-52.25)^2}{52.25} + \frac{(85-57.75)^2}{57.75} \]

\[ X^2 = 17.37 + 14.21 + 15.71 + 12.85 = 60.14 \]

Testcross AaBb x aabb

- Results:
  - A-B- 70
  - A-bb 20
  - aabb 85
  - Total = 200

  \[ \frac{45}{200} = 0.225 = 22.5 \text{ cM} \]

Are these loci independent?

- No (significance test of 60.14 > 3.84)

How far apart are they?

- What fraction of the gametes are recombinant?

Predicting phenotypes in crosses with linked genes

- In maize, the genes g and r are 20 cM apart on Chromosome 10. What are the expected phenotypic classes in the cross:

  \[ gr/GR \times gr/gr \]

  - What would you expect if the map distance was zero?
  - What would you expect if they were unlinked?
  - So, what if \( r = 0.20 \)?

Predicting phenotypes in crosses with linked genes

Possible Offspring Genotypes

- GgRr: Parental
- Ggrr: Recombinant
- ggRr: Recombinant
- Ggrr: Parental

Map distance = 20 cM

Possible Offspring Genotypes

- GgRr: Parental
- Ggrr: Recombinant
- ggRr: Recombinant
- Ggrr: Parental

Total recombinants = 20%

Three-point crosses

Cross:

Gray body, Red-eye, normal wing \( \times \)
yellow body, white eye, miniature wing

\( (+++ \times ywm) \)

Results:

- +++ 758
- +wm 16
- y++ 0
- ywm 700

--What is the order of these genes on the X chromosome?

--What are the map distances?
### Three-point crosses

**Results:**

- ++ 758
- +m 401
- +wm 16
- y+ 12
- y+wm 1
- ywm 317
- ywm 700

1. Find reciprocal pairs
2. Which are the parents? single recombinants? double recombinants?

### Interference

- You can predict the frequency of double crossovers:
  - It should be the product of the two single crossovers
    \[ R(ab) \times R(bc) \]
  - Why is it a product?

- Often the observed number is less than expected due to interference

**Coincidence coefficient**

\[ \text{observed double crossovers / expected double crossovers} \]

- Interference can differ among organisms:
  - In Drosophila, there is complete interference (no double crossovers) to about 10 cM.
  - In yeast, only partial interference at 3 cM
  - There is essentially no interference beyond 20 or 30 cM in most organisms

### Now you try it:

<table>
<thead>
<tr>
<th></th>
<th>d a n</th>
<th>299</th>
</tr>
</thead>
<tbody>
<tr>
<td>d a+</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>d + n</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>d + +</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>+ + n</td>
<td>308</td>
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<tr>
<td>+ + +</td>
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</tr>
<tr>
<td>+ a+</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>+ a n</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

Total = 1000