Punnett Squares

Essential Question

How can we predict the traits of offspring?

Punnett Squares

Setting Up a Punnett Square

- Write one parent's possible gametes across the top
- Write the other parent's possible gametes down the side
- Fill each box with the two alleles that meet
- Each box is equally likely

Rr x Rr

(R = round, r = wrinkled)

	R	**r**
R	RR	Rr
r	Rr	rr

Genotypes: 1 RR : 2 Rr : 1 rr

Phenotypes: 3 round : 1 wrinkled

Probability of wrinkled (rr) = 1/4

Probability of round = 3/4

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Probability

- Each box in a 2 x 2 square has a probability of 1/4
- Add the boxes that give the same phenotype
- For two separate events, multiply their probabilities
- Probability describes chance, not a guarantee for each offspring

Offspring	Genotype	Boxes	Probability
Wrinkled	rr	1 of 4	1/4
Round	RR or Rr	3 of 4	3/4
Heterozygous	Rr	2 of 4	1/2

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Test Crosses

- A dominant phenotype can be homozygous (PP) or heterozygous (Pp)
- A test cross crosses the unknown plant with a homozygous recessive plant (pp)
- If all offspring show the dominant trait, the parent is probably PP
- If about half show the recessive trait, the parent is Pp

If the purple plant is PP

PP x pp

	P	**P**
p	Pp	Pp
p	Pp	Pp

All offspring purple

If the purple plant is Pp

Pp x pp

	P	**p**
p	Pp	pp
p	Pp	pp

1/2 purple : 1/2 white

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A Human Trait: Cystic Fibrosis

- Cystic fibrosis is caused by a recessive allele (c)
- A person with genotype cc has cystic fibrosis
- A carrier (Cc) does not have the condition but can pass on the allele
- Two carriers have a 1/4 chance of a child with cystic fibrosis

Cc x Cc

(C = typical, c = cystic fibrosis allele)

	C	**c**
C	CC	Cc
c	Cc	cc

CC no cystic fibrosis, not a carrier

Cc no cystic fibrosis, a carrier

cc has cystic fibrosis

Probabilities: CC 1/4, Cc 1/2, cc 1/4

Example 1: A Monohybrid Cross

Two heterozygous pea plants (Rr), with R = round seeds and r = wrinkled seeds, are crossed. (a) Complete a Punnett square and give the genotype ratio. (b) If the cross produces 200 seeds, about how many are wrinkled? (c) What is the probability that two seeds picked at random are both wrinkled?

Parent 1	**Parent 2**
Rr (round)	Rr (round)

Solution: A Monohybrid Cross

(a) Punnett square: Gametes from each parent: R or r. The boxes are RR, Rr, Rr, and rr, so the genotype ratio is 1 RR : 2 Rr : 1 rr.

(b) Wrinkled seeds: Only rr is wrinkled, which is 1/4. 1/4 x 200 = 50 seeds.

(c) Two wrinkled seeds: The seeds are separate events, so multiply: 1/4 x 1/4 = 1/16.

Answer: (a) 1 RR : 2 Rr : 1 rr. (b) About 50 seeds. (c) 1/16.

Example 2: A Test Cross

A purple pea plant (P = purple, p = white) is crossed with a white plant. The offspring are shown in the table. (a) What is the genotype of the purple parent? (b) What would the results look like if the purple parent were PP?

Offspring phenotype	Number
Purple	26
White	24

Solution: A Test Cross

(a) Use the white parent: The white parent is pp, so every offspring gets a p from it. White offspring (pp) must also get a p from the purple parent, so the purple parent has a p allele. It is purple, so it also has a P: genotype Pp. Check: Pp x pp should give 1/2 purple and 1/2 white. 26 : 24 is close to 1 : 1.

(b) If PP: PP x pp gives only Pp offspring, so all 50 would be purple.

Answer: (a) Pp. (b) All offspring would be purple.

Example 3: Predict a Human Trait

Two parents are carriers of cystic fibrosis (Cc), where c is the recessive allele. (a) What is the probability that a child has cystic fibrosis? (b) What is the probability that two children both have it? (c) A child of these parents does not have cystic fibrosis. What is the probability that the child is a carrier?

Parent 1	Parent 2
Cc (carrier)	Cc (carrier)

Solution: Predict a Human Trait

(a) One child: Cc x Cc gives CC, Cc, Cc, and cc. Only cc has cystic fibrosis, so the probability is 1/4.

(b) Two children: Each child is a separate event, so multiply: 1/4 x 1/4 = 1/16.

(c) A child without the condition: We know the child is not cc, so only 3 boxes remain: CC, Cc, and Cc. Two of these 3 are carriers, so the probability is 2/3.

Answer: (a) 1/4. (b) 1/16. (c) 2/3.

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Big Ideas

- A Punnett square shows every way two parents' alleles can combine
- Each box is equally likely, so boxes become probabilities
- Multiply probabilities for separate events
- A test cross reveals a hidden recessive allele
- Probabilities predict chance, not what will happen in each family