# Year 12 Science: Meiosis, mutation and inheritance

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A human skin cell has 46 chromosomes. How many does a human sperm cell have?

2. In guinea pigs, black (B) is dominant to brown (b). What percentage of the offspring of Bb × bb would you expect to be brown?

3. A pink snapdragon ($C^RC^W$) is crossed with a white snapdragon ($C^WC^W$). Give the phenotype ratio.

4. Two yellow mice ($A^ya$) are crossed and 12 pups survive. How many would you expect to be yellow, and how many non-yellow (agouti)?

5. Genes A and B are on different chromosomes. What percentage of the offspring of AaBb × aabb would be aabb?

6. Two parents are both carriers (Aa) of a recessive condition. What is the chance their next child is affected?

## Exam-style question: Shorthorn cattle

**A Waikato farmer breeds Shorthorn cattle. Coat colour shows codominance: RR is red, WW is white and RW is roan, with red and white hairs mixed. Polled (no horns, P) is dominant to horned (p). The two genes are on different chromosomes.**

7. Describe codominance, using roan cattle as the example.

8. Two roan cattle are mated many times. Give the expected ratio of coat colours in their calves, using a Punnett square.

9. The farmer's new bull is polled. Explain how a test cross would show whether he is PP or Pp.

10. The bull is mated with three horned cows and all three calves are polled. Discuss whether the farmer can now be sure the bull is PP, using probabilities.

## Fix the mistake

11. Correct this statement: "Crossing over happens between sister chromatids."

12. Correct this statement: "A 3 : 1 ratio means a family with four children will have exactly three with the dominant trait."

13. Correct this statement: "Codominance and incomplete dominance are the same, because the heterozygote looks different from both parents."

14. Correct this statement: "Independent assortment creates new alleles."

## Answer key (for parents and tutors)

1. A human skin cell has 46 chromosomes. How many does a human sperm cell have?
   **23 (gametes are haploid: one chromosome from each pair).**
2. In guinea pigs, black (B) is dominant to brown (b). What percentage of the offspring of Bb × bb would you expect to be brown?
   **Bb × bb gives 1 Bb : 1 bb, so 50% brown.**
3. A pink snapdragon ($C^RC^W$) is crossed with a white snapdragon ($C^WC^W$). Give the phenotype ratio.
   **Gametes $C^R$ or $C^W$, and $C^W$: offspring 1 $C^RC^W$ : 1 $C^WC^W$, so 1 pink : 1 white.**
4. Two yellow mice ($A^ya$) are crossed and 12 pups survive. How many would you expect to be yellow, and how many non-yellow (agouti)?
   **1 $A^yA^y$ (dies) : 2 $A^ya$ : 1 aa, so the survivors are 2 yellow : 1 agouti; 2/3 of 12 is 8 yellow and 4 agouti.**
5. Genes A and B are on different chromosomes. What percentage of the offspring of AaBb × aabb would be aabb?
   **The AaBb parent makes AB, Ab, aB and ab equally; only ab gives aabb, so 1 in 4 = 25%.**
6. Two parents are both carriers (Aa) of a recessive condition. What is the chance their next child is affected?
   **Aa × Aa gives 1 AA : 2 Aa : 1 aa, so 1 in 4 = 25% for each child.**
7. Describe codominance, using roan cattle as the example.
   **In codominance both alleles are fully expressed in the heterozygote: a roan (RW) animal grows red hairs (from R) and white hairs (from W) side by side, rather than one blended colour (Achieved).**
8. Two roan cattle are mated many times. Give the expected ratio of coat colours in their calves, using a Punnett square.
   **RW × RW: gametes R or W from each parent; offspring RR, RW, RW, WW, so 1 red : 2 roan : 1 white, or 25% red, 50% roan, 25% white (Achieved for the ratio with phenotypes).**
9. The farmer's new bull is polled. Explain how a test cross would show whether he is PP or Pp.
   **Mate him with horned (pp) cows, which can only give p gametes. If he is PP, every calf gets P and is polled. If he is Pp, each calf has a 1 in 2 chance of getting his p and being horned (pp). So any horned calf proves he is Pp (Merit: uses the gametes from both parents).**
10. The bull is mated with three horned cows and all three calves are polled. Discuss whether the farmer can now be sure the bull is PP, using probabilities.
    **No. If he were Pp, each calf would still have a 1/2 chance of being polled, so three polled calves in a row happens with probability $(1/2)^3 = 1/8 = 12.5\%$. That is unlikely but far from impossible, so three calves cannot prove he is PP. Each calf is a separate random event, because segregation at meiosis puts P or p into each sperm by chance. With more calves the evidence gets stronger: seven polled calves from a Pp bull would happen only $(1/2)^7 = 1/128$, about 0.8% of the time, but a single horned calf at any point would prove Pp (Excellence: links segregation, gametes from both parents and probability to why the result is not guaranteed).**
11. Correct this statement: "Crossing over happens between sister chromatids."
    **It happens between non-sister chromatids of a homologous pair; sister chromatids are identical, so swapping between them would change nothing.**
12. Correct this statement: "A 3 : 1 ratio means a family with four children will have exactly three with the dominant trait."
    **Each child has a 3 in 4 chance; ratios only show up reliably in large numbers of offspring.**
13. Correct this statement: "Codominance and incomplete dominance are the same, because the heterozygote looks different from both parents."
    **Incomplete dominance blends to an in-between phenotype (pink); codominance shows both phenotypes fully at once (red and white hairs).**
14. Correct this statement: "Independent assortment creates new alleles."
    **Only mutation makes new alleles; meiosis and fertilisation reshuffle existing alleles into new combinations.**