

- 4 In tomato plants, stem colour, leaf shape and leaf colour are controlled by three different genes. These genes are linked. The allele for red stems ( $R$ ) is dominant to that for green stems ( $r$ ). The allele for tomato-leaf-shaped leaves ( $T$ ) is dominant to that for potato-leaf-shaped leaves ( $t$ ). The allele for dark green leaves ( $D$ ) is dominant to that for light green leaves ( $d$ ). The two tomato plants described below were crossed together.

<i>Parent 1</i>	<i>Parent 2</i>
Red stem	Green stem
Tomato-leaf-shaped leaves	Potato-leaf-shaped leaves
Dark green leaves	Light green leaves

The  $F_1$  plants resulting from this cross showed the three characteristics determined by the dominant alleles  $R$ ,  $T$  and  $D$ .

- (a) The parent plants were both pure-breeding. Give the genotype of the  $F_1$  plants.

.....

(1)

The  $F_1$  plants were then crossed to produce an  $F_2$  generation. Because the genes are linked, these  $F_2$  plants were expected to show mostly the two original parental phenotypes.

- (b) Assuming that there is no crossing over between the linked genes,  
 (i) give the genotypes of the  $F_2$  plants showing the same characteristics as parent 1;

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(2)

- (ii) give the expected ratio of all the  $F_2$  genotypes.

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(1)

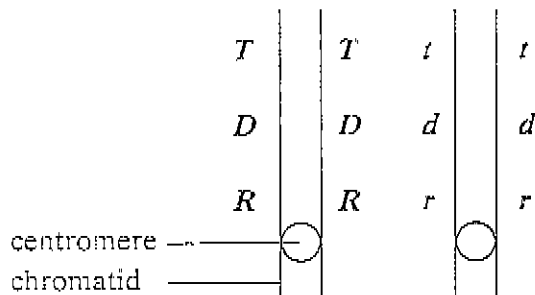
In fact, there were eight different phenotypes among the  $F_2$  plants. This can be explained by crossing over having taken place.

- (c) During which phase of meiosis would crossing over first become visible, using a light microscope?

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(1)

The sequence of the genes on a pair of chromosomes in a tomato plant is shown below.



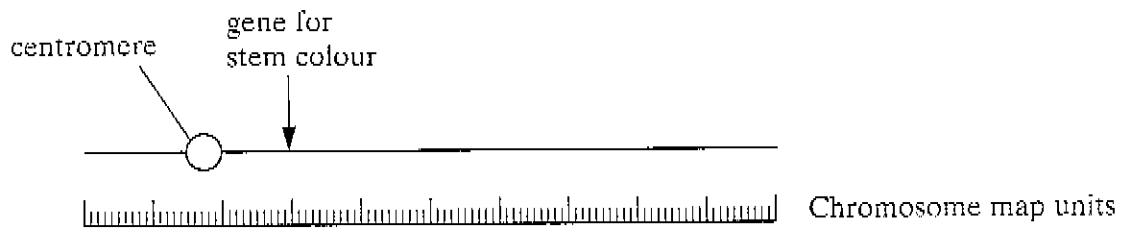
- (d) Draw a similar diagram in the space above to show the appearance of the pair of chromosomes at the end of metaphase I of meiosis after crossing over has separated the alleles  $D$  and  $R$  on one of the chromatids.

(1)

The alleles for red stems and tomato leaf-shaped leaves were shown to be separated in 38% of the  $F_2$  plants, whereas those for red stems and dark green leaves were separated in 34% of the  $F_2$  plants. These figures are known as the cross-over values of the genes concerned and make it possible to draw a linkage map showing the relative positions of these genes on the chromosome.

- (e) Complete the linkage map below to show the probable positions of genes for leaf shape and for leaf colour in relation to the gene for stem colour, the locus of which is shown.

(2)



- (f) What is the expected cross-over value between the gene for leaf colour and the gene for leaf shape?

(1)

(9)