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# SL Paper 1

What is the name given to a heritable factor which controls a specific characteristic?

- A. Allele
  - B. Chromosome
  - C. Gene
  - D. Mutation
- 

What was an aim of genetic modification of organisms?

- A. To provide stem cells from embryos for medical use
  - B. To make crop plants resistant to herbicides
  - C. To provide sperm cells for in vitro fertilization (IVF)
  - D. To produce genetically identical sheep
- 

Which disease is an example of sex-linked (X-linked) inheritance?

- A. AIDS
  - B. Down syndrome
  - C. Sickle-cell anemia
  - D. Hemophilia
- 

A man has hemophilia, a condition caused by a recessive sex-linked allele carried on the X chromosome.

Which of his grandparents must be a carrier if none of them had the disease?

- A. Maternal grandmother (his mother's mother)
  - B. Maternal grandfather (his mother's father)
  - C. Paternal grandmother (his father's mother)
  - D. Paternal grandfather (his father's father)
-

If a man with blood group O and a woman with blood group AB have children, which blood group(s) could the children have?

- A. Group O only
  - B. Groups A and B only
  - C. Group AB only
  - D. Groups O, A, B and AB
- 

What is a possible source of the chromosomes used for pre-natal karyotype diagnosis?

- A. The mother's lymphocytes
  - B. The mother's cheek cells
  - C. The cells from chorionic villi
  - D. The fetal hair root cells
- 

Sickle-cell anemia is caused by a mutation. How many changes to the amino acid sequence are caused by this mutation?

- A. 1
  - B. 2
  - C. 3
  - D. 4
- 

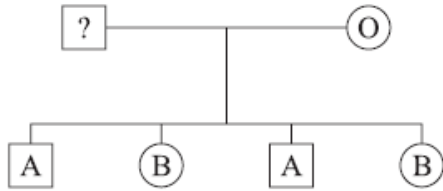
A man of blood group A and a woman of blood group B have a child. If both are heterozygous for the gene, what are the chances of them having a child with blood group B?

- A. 0%
  - B. 25%
  - C. 50%
  - D. 75%
- 

What makes gene transfer between species possible?

- A. All species use the same genetic code.
  - B. All species have the same genetic material.
  - C. All species produce the same polypeptides.
  - D. All species transcribe genes using plasmids.
-

The blood groups of a mother and four children are indicated on the pedigree chart below.



What are the possible blood groups of the father?

- A. Group A only
  - B. Group A or B only
  - C. Group AB only
  - D. Group A, B or AB only
- 

What is produced by somatic-cell nuclear transfer?

- A. Adult sheep
  - B. Cloned embryos
  - C. Rooted stem-cuttings
  - D. Genetically modified food
- 

A human cell has between 20 000 and 25 000 genes whereas an *E. coli* cell has approximately 4000 genes. Which of the following statements is true?

- A. The human genome is larger than the *E. coli* genome.
  - B. There are more genes on each human chromosome than on the *E. coli* chromosome.
  - C. The human cell and the *E. coli* cell produce approximately the same variety of proteins.
  - D. The DNA in both organisms is associated with histones (proteins).
- 

Which statement is a definition of a gene?

- A. The whole of the genetic information of an organism
  - B. The factor that affects the phenotype in the homozygous state
  - C. A heritable factor that controls a specific characteristic
  - D. The factor that affects the phenotype in the heterozygous state
- 

Which phase of cell division is photographed in order to make a karyotype?

- A. Anaphase of mitosis
  - B. Anaphase I of meiosis
  - C. Metaphase of mitosis
  - D. Metaphase II of meiosis
-

If the haploid number of a species is 14, how many chromatids will there be in metaphase I in a dividing diploid cell?

- A. 7
  - B. 14
  - C. 28
  - D. 56
- 

A body cell of a goat has 60 chromosomes. What would be produced following meiosis in the testis of a male goat?

- A. 2 cells each with 60 chromosomes
  - B. 4 cells each with 60 chromosomes
  - C. 2 cells each with 30 chromosomes
  - D. 4 cells each with 30 chromosomes
- 

What distinguishes an allele from a gene?

- A. An allele is made of RNA.
  - B. An allele is shorter.
  - C. An allele is a variety of a gene.
  - D. An allele cannot be transferred during genetic modification.
- 

What is the composition of eukaryotic chromosomes?

- A. DNA only
  - B. DNA and ribose
  - C. DNA and RNA
  - D. DNA and proteins
- 

In some people, hemoglobin always contains the amino acid valine in place of a glutamic acid at one position in the protein. What is the cause of this?

- A. An error in transcription of the hemoglobin gene
  - B. An error in translation of the mRNA
  - C. Lack of glutamic acid in the diet
  - D. A base substitution in the hemoglobin gene
- 

Which is a characteristic of the pairs of sister chromatids that are visible during meiosis?

- A. They result from the replication of DNA before meiosis.
  - B. They are only present in meiosis I.
  - C. They split apart during metaphase I in meiosis.
  - D. They are only present in meiosis II.
- 

A man has hemophilia, a condition caused by a recessive sex-linked allele carried on the X chromosome.

His wife does not carry the hemophilia allele. What would be expected in their children?

	<b>Sons</b>	<b>Daughters</b>
A.	all normal	all carriers
B.	half hemophiliac	all carriers
C.	all normal	half carriers
D.	half hemophiliac	all normal

---

A parent organism of unknown genotype is mated in a test cross. Half of the offspring have the same phenotype as the parent. What can be concluded from this result?

- A. The parent of unknown genotype is heterozygous.
  - B. The parent of unknown genotype is homozygous dominant.
  - C. The parent of unknown genotype is homozygous recessive.
  - D. The parent of known genotype is heterozygous.
- 

Which individuals are colour blind in this Punnett grid?

	$X^B$	Y
$X^B$	$X^B X^B$	$X^B Y$
$X^b$	$X^B X^b$	$X^b Y$

- A.  $X^B Y$
- B.  $X^B X^B$
- C.  $X^b Y$
- D.  $X^B X^b$

A woman who is a carrier for hemophilia and a man who does not have hemophilia have a child. What is the probability that the child will have hemophilia?

	If it is a girl	If it is a boy
A.	0%	50%
B.	0%	0%
C.	50%	50%
D.	50%	0%

Rhesus factor is an antigen present on the surface of red blood cells of Rhesus positive individuals. Rhesus positive ( $Rh^+$ ) is dominant to Rhesus negative ( $Rh^-$ ). A mother with Rhesus negative blood gives birth to a baby with Rhesus positive blood and there are concerns that subsequent pregnancies will trigger an immune response.

What is a possible explanation for why subsequent pregnancies could trigger an immune response?

- A. Exposure to the  $Rh^+$  antigen in the first pregnancy triggered the development of antibodies that could attack the blood of a future  $Rh^+$  baby.
- B. Exposure to the  $Rh^+$  antigen in the first pregnancy triggered the development of specific phagocytes that could attack the blood of a future  $Rh^+$  baby.
- C. The mother has developed passive immunity to the  $Rh^+$  factor.
- D. The mother's immune system has been weakened by pregnancy.

Boys can inherit the recessive allele (c) that causes red-green colour blindness from their mother, not from their father. The allele for normal red and green vision is C. Which of the following genotypes are possible in men?

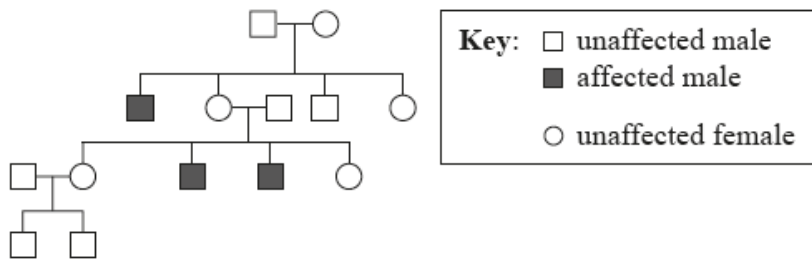
- A. c only

- B. C or c only
- C. CC or cc only
- D. CC, Cc or cc only

In a human with type A blood, what determines the blood group?

- A. Sex chromosomes
- B. One or two alleles
- C. Multiple alleles
- D. Codominant alleles

The following shows a pedigree chart.



What type of inheritance is shown in this pedigree chart?

- A. X-linked recessive
- B. Y-linked dominant
- C. X-linked dominant
- D. Y-linked recessive

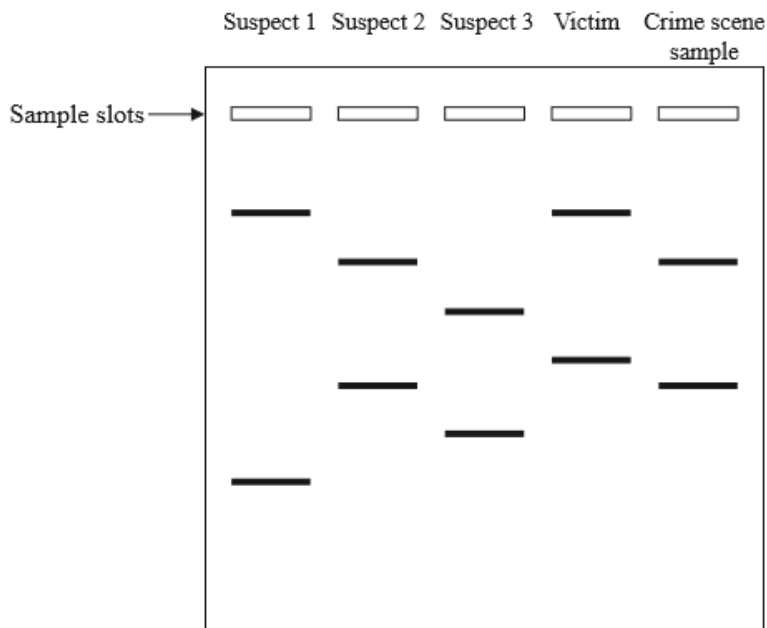
What would be the expected result if a woman carrier for colour blindness and a colour blind man had many children?

- A. All offspring will be colour blind.
- B. All male offspring will be colour blind and all females normal.
- C. All males will be normal and all females will be colour blind.
- D. All females will be carriers of colour blindness or colour blind

It is possible for two parents to have children with each of the four ABO blood groups. What blood groups would the parents have?

	Mother	Father
A.	O	O
B.	AB	O
C.	AB	AB
D.	A	B

The diagram below represents the results obtained in a DNA profile from a crime scene.



Suspect 2 is most likely to be the criminal because the band pattern coincides with that of the crime scene sample. What do these bands represent?

- A. DNA fragments
- B. Genes
- C. Chromosomes
- D. Chromatids

Which enzymes are needed to produce recombinant plasmids to be used in gene transfer?

- A. DNA polymerase and DNA ligase
- B. DNA polymerase and restriction enzyme (endonuclease)
- C. Transcriptase and RNA polymerase
- D. Restriction enzyme (endonuclease) and DNA ligase

If an organism that is homozygous recessive for a trait is crossed with a heterozygote, what is the chance of getting a homozygous recessive phenotype in the first generation?



- A. 0%
  - B. 25%
  - C. 50%
  - D. 100%
- 

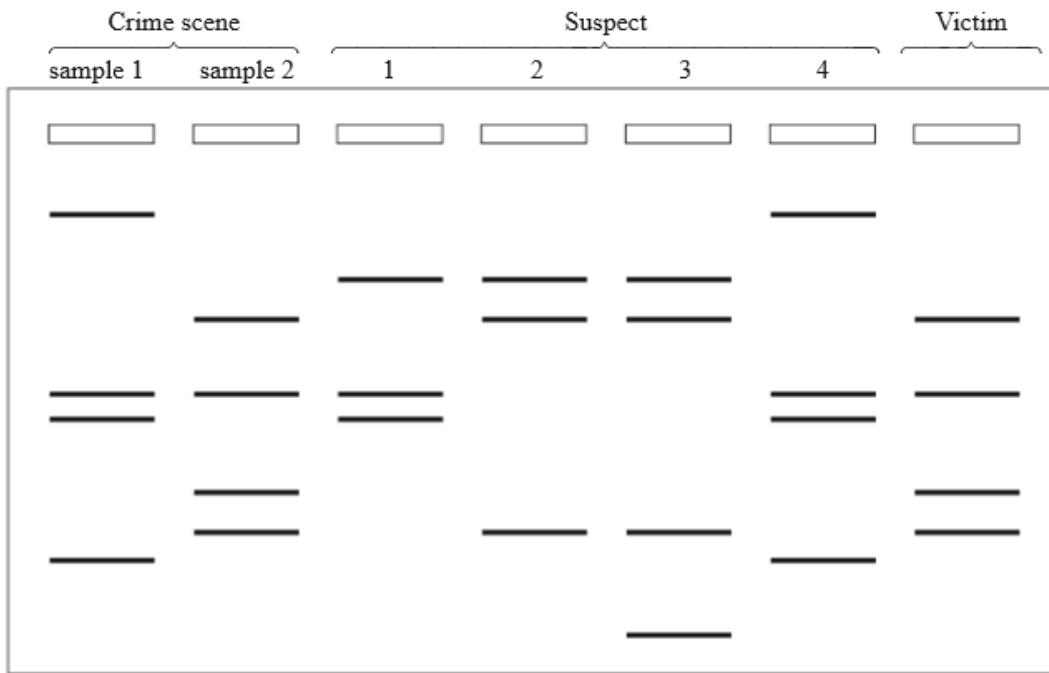
Which of the following involves meiosis?

- A. Tissue repair
  - B. Production of gametes
  - C. Asexual reproduction
  - D. Growth
- 

Which of the following statements relate(s) to Down syndrome (trisomy 21)?

- I. It can be detected in chorionic villus samples.
  - II. It results from non-disjunction in meiosis.
  - III. It is caused by gene mutation.
- A. I and II only
  - B. I and III only
  - C. II only
  - D. III only
- 

The diagram shows results of electrophoresis of DNA from a crime scene.



Which suspect could be implicated as the criminal, according to the gel of DNA shown?

- A. Suspect 1
- B. Suspect 2
- C. Suspect 3
- D. Suspect 4

*Hind*III is an endonuclease that recognizes the sequence A A G C T T, cutting between the two adenines.

5' T T A A G C T T A A G A A G A A G C T T 3'  
 3' A A T T C G A A T T C T T C T T C G A A 5'

Into how many DNA fragments would the strand shown be cut by *Hind*III?

- A. 2
- B. 3
- C. 4
- D. 5

What is the cause of sickle-cell anemia?

- A. A change to the base sequence of a hemoglobin gene
- B. Mosquitoes acting as the vector for malaria
- C. Iron deficiency due to the malaria parasite
- D. Production of more white blood cells than red blood cells by bone marrow

Which genotypes are possible when a male with blood group AB and a female with blood group O have offspring?

- A.  $I^A i$  only
  - B.  $I^A i$  and  $I^B i$
  - C.  $I^A i$  and  $ii$
  - D.  $I^A i$ ,  $I^B i$  and  $ii$
- 

Laboratory analysis of DNA from a 40 000 year old woolly mammoth used the polymerase chain reaction (PCR). What role did the PCR have in the analysis?

- A. DNA denaturation
  - B. DNA comparison
  - C. DNA separation
  - D. DNA amplification
- 

A small amount of a suspect's DNA is obtained from a crime scene. What techniques would be used to carry out DNA profiling?

- A. Gel electrophoresis and paternity testing
  - B. Paternity testing and the polymerase chain reaction (PCR)
  - C. Polymerase chain reaction (PCR) and gel electrophoresis
  - D. Test crossing and pedigree analysis
- 

Which technique separates proteins according to size?

- A. Treatment with restriction endonucleases
  - B. PCR
  - C. Gel electrophoresis
  - D. DNA profiling
- 

The diploid number of chromosomes in humans (*Homo sapiens*) is 46 and the diploid number of chromosomes in rice (*Oryza sativa*) is 24. What does this indicate about diploid chromosome numbers?

- A. Plant species have a lower diploid number of chromosomes than animals.
- B. Members of a species have the same diploid number of chromosomes.
- C. The evolutionary progress of species is determined by the diploid number of chromosomes.
- D. The complexity of the organisms is correlated to the diploid number of chromosomes.

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What are homologous chromosomes?

- A. Identical chromosomes
  - B. Non-identical chromosomes with different genes
  - C. Non-identical chromosomes with the same genes in the same sequence but not necessarily the same alleles
  - D. Non-identical chromosomes with the same genes in a different sequence and not necessarily the same alleles
- 

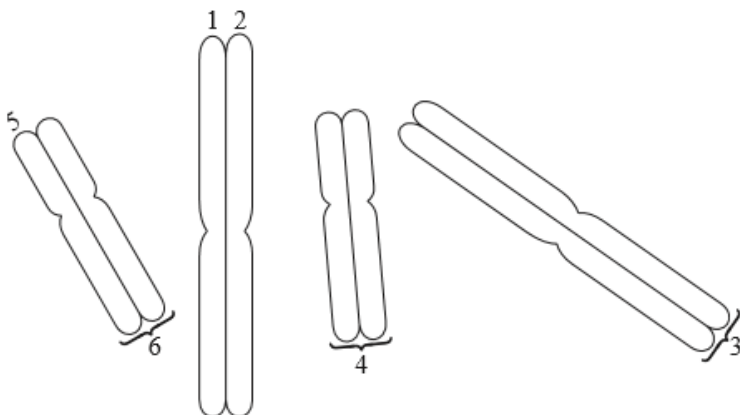
The Human Genome Project allowed the first accurate estimates of the number of different genes in the human genome. What was a typical estimate, based on the results of the Human Genome Project?

- A. 46
  - B. 64
  - C. 25 000
  - D. 1 000 000
- 

What is the chromosome number in a human gamete with non-disjunction?

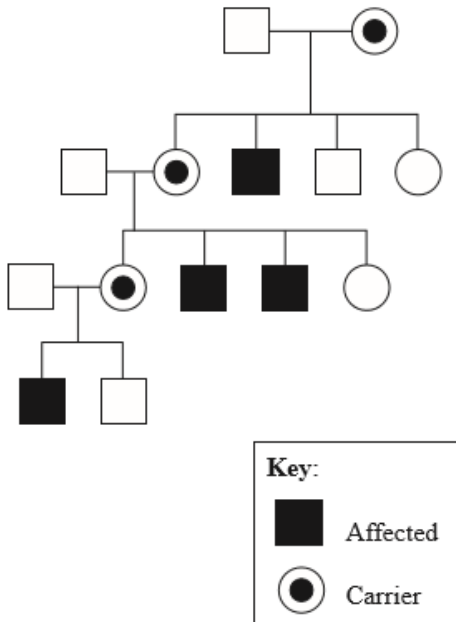
- A. 46
  - B. 45
  - C. 24
  - D. 23
- 

In the following diagram, which pair represents homologous chromosomes?



- A. 1 and 2
- B. 3 and 4
- C. 2 and 5

What type of inheritance is shown in this pedigree chart?



- A. X-linked dominant
- B. Y-linked dominant
- C. X-linked recessive
- D. Y-linked recessive

A colour blind man and a woman carrier for colour blindness have a son. What is the probability that their son will be colour blind?

- A. 25 %
- B. 50 %
- C. 75 %
- D. 100 %

If there are 16 chromosomes in a cell that is about to divide, what will be the number of chromosomes in a daughter cell after division by mitosis or meiosis?

	Mitosis	Meiosis
A.	16	16
B.	16	8
C.	8	16
D.	8	8

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Which process is used in polymerase chain reaction (PCR)?

- A. Transcription
- B. Translation
- C. Replication
- D. Mutation

---

How is the polymerase chain reaction (PCR) used?

- A. To make many copies of a DNA molecule
- B. To cut DNA at specific sequences
- C. To splice fragments of DNA together into a plasmid
- D. To separate fragmented pieces of DNA based on their charge and size

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The sequence of the first six amino acids of the normal  $\beta$  hemoglobin ( $Hb^A$ ) chain are listed.

valine – histidine – leucine – threonine – proline – glutamic acid

Which sequence of amino acids could there be in the first six amino acids of the sickle-cell  $\beta$  hemoglobin ( $Hb^S$ ) chain?

- A. glutamic acid – histidine – leucine – threonine – proline – valine
- B. valine – valine – histidine – leucine – threonine – proline
- C. glutamic acid – histidine – leucine – threonine – proline – glutamic acid
- D. valine – histidine – leucine – threonine – proline – valine

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During reproduction in flowering plants an embryo sac is produced, containing one haploid nucleus. This haploid nucleus divides by mitosis three times. What is produced?

- A. One diploid nucleus
- B. Four diploid nuclei
- C. Four haploid nuclei
- D. Eight haploid nuclei

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What is the set of alleles that an individual possesses?

- A. A gene
- B. A genotype
- C. A genome
- D. A genus

---

Which of the following types of information are needed to construct a karyotype?

- I. Size of the chromosomes
- II. Gene mutations of the chromosomes
- III. Age of the individual

- A. I only
- B. II only
- C. I and II only
- D. I, II and III

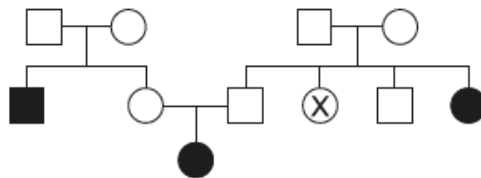
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What is a plasmid?

- A. Chloroplast DNA
- B. Mitochondrial DNA
- C. Small circle of DNA that can transfer genes to or from a prokaryote
- D. The bacterial chromosome

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The diagram shows a pedigree of cystic fibrosis, in which the black colour indicates the presence of cystic fibrosis.



What is the probability that the individual labelled X is a carrier of cystic fibrosis?

- A. 1.00
  - B. 0.50
  - C. 0.25
  - D. 0.00
-

In guinea pigs black coat colour is dominant to white. In a test cross between a black and a white guinea pig both black and white offspring were produced. What percentage of the offspring would be expected to be white?

- A. 75 %
  - B. 50 %
  - C. 33.3 %
  - D. 25 %
- 

Which of the following statements about homologous chromosomes is correct?

- A. Each gene is at the same locus on both chromosomes.
  - B. They are two identical copies of a parent chromosome which are attached to one another at the centromere.
  - C. They always produce identical phenotypes.
  - D. They are chromosomes that have identical genes and alleles.
- 

What is a gene mutation?

- A. Failure of chromosome pairs to separate properly during cell division
  - B. Changes to genes caused by natural selection
  - C. Changes to the nucleotide sequence of the genetic material
  - D. Changes in karyotypes
- 

Which is a feature of sex-linked genes in humans?

- A. Males can only be heterozygous for the gene.
  - B. Females can only be homozygous for the gene.
  - C. Males can be either heterozygous or homozygous for the gene.
  - D. Females can be either heterozygous or homozygous for the gene.
- 

In peas, tall is dominant to dwarf. In a cross between a dwarf plant and a heterozygous tall plant what percentage of the offspring will be dwarf?

- A. 0 %
  - B. 25 %
  - C. 50 %
  - D. 100 %
- 

What is amplified using the polymerase chain reaction (PCR)?

- A. Large amounts of RNA
- B. Small amounts of DNA
- C. Small amounts of protein



D. Large amounts of polymers

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Rhesus factor is an antigen present on the surface of red blood cells of Rhesus positive individuals. Rhesus positive ( $Rh^+$ ) is dominant to Rhesus negative ( $Rh^-$ ). A mother with Rhesus negative blood gives birth to a baby with Rhesus positive blood and there are concerns that subsequent pregnancies will trigger an immune response.

What are the genotypes of the mother and her first baby?

	<b>Genotype of mother</b>	<b>Genotype of first baby</b>
A.	$Rh^- Rh^-$	$Rh^- Rh^-$
B.	$Rh^- Rh^-$	$Rh^+ Rh^-$
C.	$Rh^- Rh^-$	$Rh^+ Rh^+$
D.	$Rh^+ Rh^-$	$Rh^+ Rh^+$

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What happens to DNA fragments in electrophoresis?

- A. They move in a magnetic field and are separated according to their size.
  - B. They move in an electric field and are separated according to their size.
  - C. They move in a magnetic field and are separated according to their bases.
  - D. They move in an electric field and are separated according to their bases.
- 

Which of the following is the cause of sickle-cell anemia?

- A. Tryptophan is replaced by leucine.
  - B. Leucine is replaced by valine.
  - C. Glutamic acid is replaced by valine.
  - D. Lysine is replaced by glutamic acid.
- 

What causes the presence of three chromosomes 21 in Down syndrome?

- A. Crossing over
- B. Allele change
- C. Non-disjunction
- D. Gene mutation

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Which is a source of chromosomes for pre-natal diagnosis of abnormalities by karyotyping?

- A. Sperm
  - B. Ovaries
  - C. Erythrocytes
  - D. Chorionic villi
- 

The Punnett grid shows the inheritance of blood groups.

	$I^A$	$I^B$
$I^A$	$I^A I^A$	$I^A I^B$
$i$	$I^A i$	$I^B i$

What is the ratio of phenotypes of the offspring?

- A. 1 : 1 ratio of blood groups A : B
  - B. 1 : 2 : 1 ratio of blood groups A : AB: B
  - C. 1 : 1 : 1 ratio of blood groups A : AB: B
  - D. 2 : 1 : 1 ratio of blood groups A : AB : B
- 

In a person who is heterozygous for sickle-cell anemia, where is the mutation found?

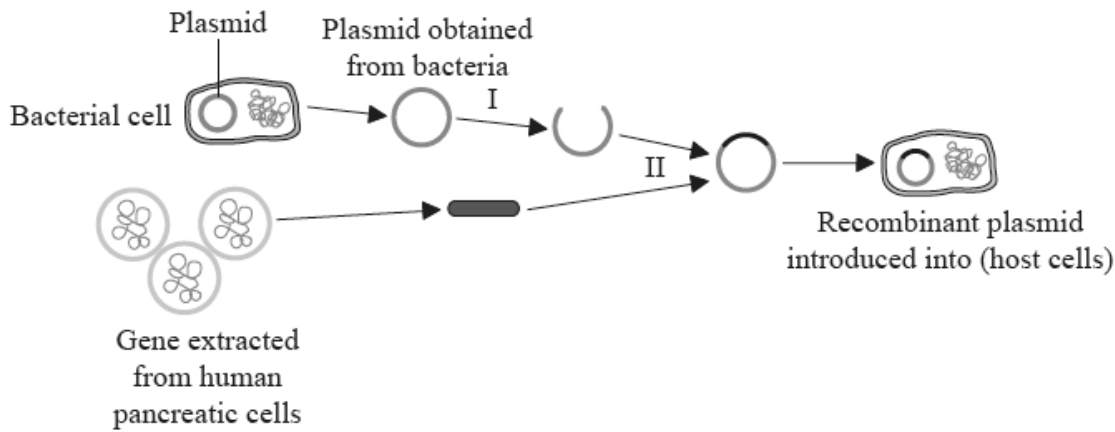
- A. In every gamete produced
  - B. Only in gametes carrying an X chromosome
  - C. In all brain cells
  - D. In blood plasma
- 

A child has blood group A. The father of the child has blood group B. What are the possible genotypes of the mother?

- I.  $I^A I^A$
- II.  $I^A I^B$
- III.  $I^A i$

- A. I only
  - B. I and II only
  - C. II and III only
  - D. I, II and III
-

The flow chart summarizes methods of gene transfer.



[Source: © International Baccalaureate Organization 2014]

Which enzymes are used in steps I and II?

	I	II
A.	DNA ligase	restriction enzyme
B.	restriction enzyme	DNA ligase
C.	DNA polymerase	DNA ligase
D.	restriction enzyme	DNA polymerase

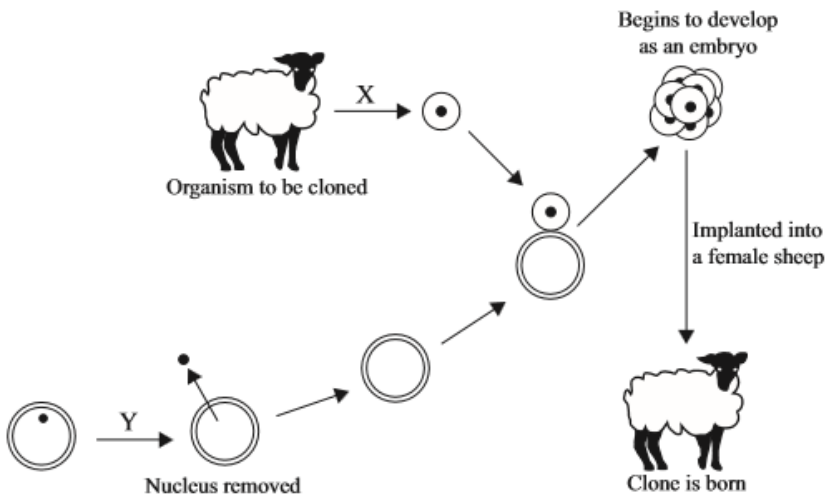
What is the difference between dominant, recessive and codominant alleles?

	Dominant allele	Recessive allele	Codominant allele
A.	only affecting the phenotype when in a homozygous state	always affecting the phenotype	both alleles affect the phenotype
B.	always affecting the phenotype	both alleles affect the phenotype	only affecting the phenotype when in a homozygous state
C.	always affecting the phenotype	only affecting the phenotype when in a homozygous state	both alleles affect the phenotype
D.	both alleles affect the phenotype	only affecting the phenotype when in a heterozygous state	always affecting the phenotype when in a heterozygous state

During which phase of the first division of meiosis can non-disjunction take place and what structure is affected by the non-disjunction?

	Meiotic phase	Structure
A.	Anaphase	chromosomes
B.	Anaphase	chromatids
C.	Metaphase	chromosomes
D.	Metaphase	chromatids

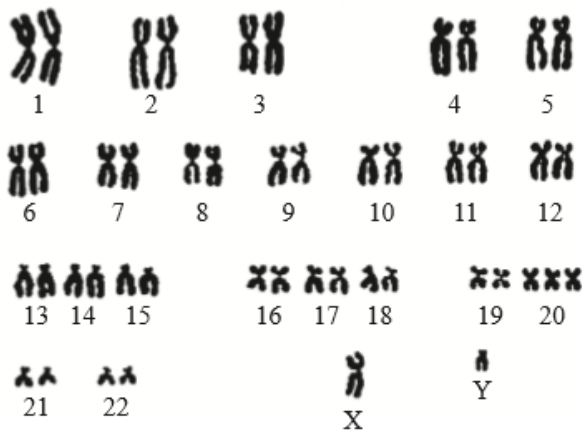
Which processes involved in cloning an animal are indicated by the letters X and Y?



[Source: adapted from [http://www.sciencecases.org/dog\\_cloning/cloning.gif](http://www.sciencecases.org/dog_cloning/cloning.gif)]

	X	Y
A.	differentiated cell removed from animal	nucleus removed from unfertilized egg cell
B.	sex cell removed from animal	nucleus removed from differentiated animal cell
C.	sex cell removed from animal	nucleus removed from unfertilized egg cell
D.	differentiated cell removed from animal	nucleus removed from differentiated animal cell

The image shows a human karyotype.

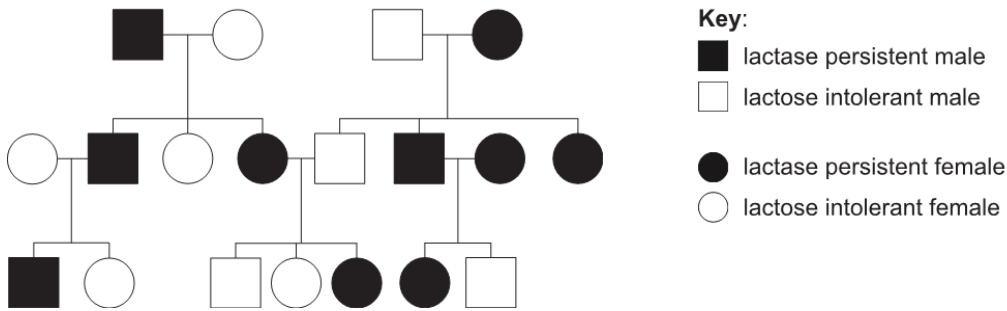


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According to the image, what conditions can be determined?

- A. Non-disjunction has occurred and the individual is male.
- B. Non-disjunction has occurred and the individual is female.
- C. The individual is female and has Down syndrome.
- D. The individual is male and has Down syndrome.

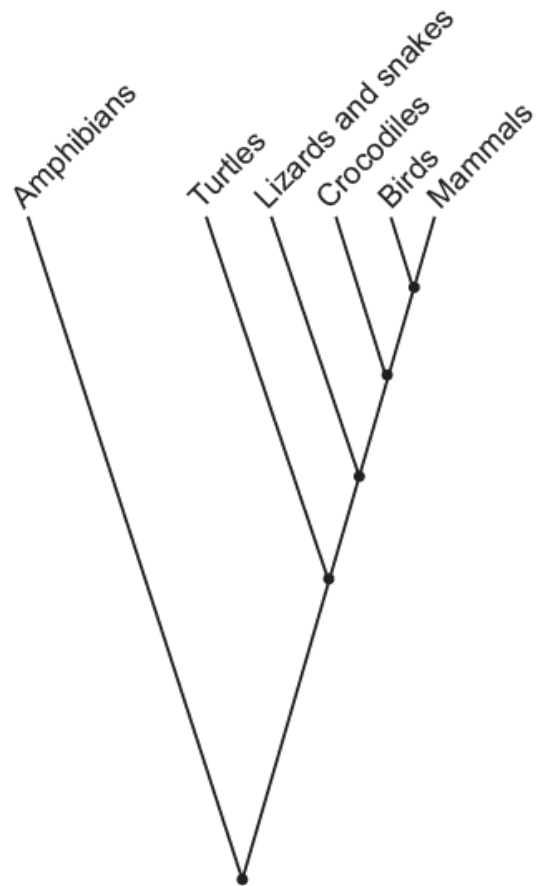
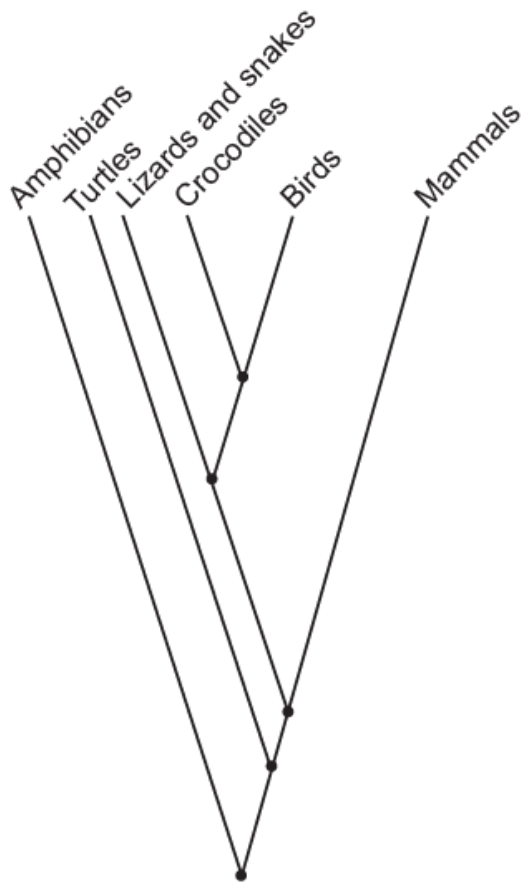
An allele for lactase persistence allows humans to digest milk as adults. People who lack this allele are lactose intolerant in adulthood.



What is the pattern of inheritance?

- A. Lactase persistence is sex-linked recessive.
- B. Lactase persistence is autosomal recessive.
- C. Lactase persistence is sex-linked dominant.
- D. Lactase persistence is autosomal dominant.

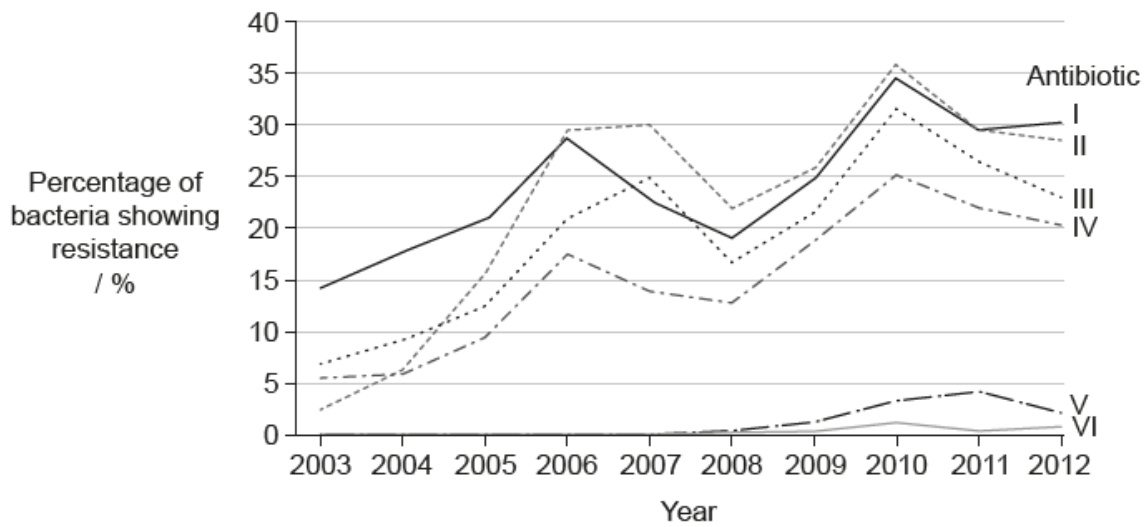
Cladograms can be created by comparing DNA or protein sequences. The cladogram on the left is based on DNA sequences and the cladogram on the right is based on comparing protein sequences.



What is the reason that cladograms based on DNA sequences are more reliable predictors of the phylogenetic relationship of species than cladograms based on protein sequences?

- A. Amino acids are not as chemically stable as DNA nucleotides.
- B. DNA mutates but amino acids do not.
- C. Several different triplets of bases can code for the same amino acid.
- D. There are 20 different amino acids but only 4 nucleotides.

The bacterium *Neisseria gonorrhoeae* causes infections related to the human reproductive system. The graph shows the percentage of samples in which this bacterium showed resistance to six antibiotics over a period of ten years.



[Source: © All rights reserved. National Surveillance of Antimicrobial Susceptibilities of *Neisseria gonorrhoeae* Annual Summary 2012. Public Health Agency of Canada, 2012. Translated, adapted and reproduced with permission from the Minister of Health, 2017.]

What is a possible explanation for the total percentage resistance being larger than 100% in 2010?

- A. People do not take the antibiotics as prescribed.
- B. More people have been sampled in that year.
- C. There was an epidemic of *Neisseria gonorrhoeae* in that year.
- D. Some bacteria are resistant to more than one antibiotic.

What does the karyogram below correspond to?



- A. A normal male
- B. A normal female
- C. A female with Down syndrome
- D. A male with Down syndrome

Some breeds of dogs are characterized by the presence of a melanistic mask, which is a darkening of the fur near the nose, as shown by the arrow in this photograph.

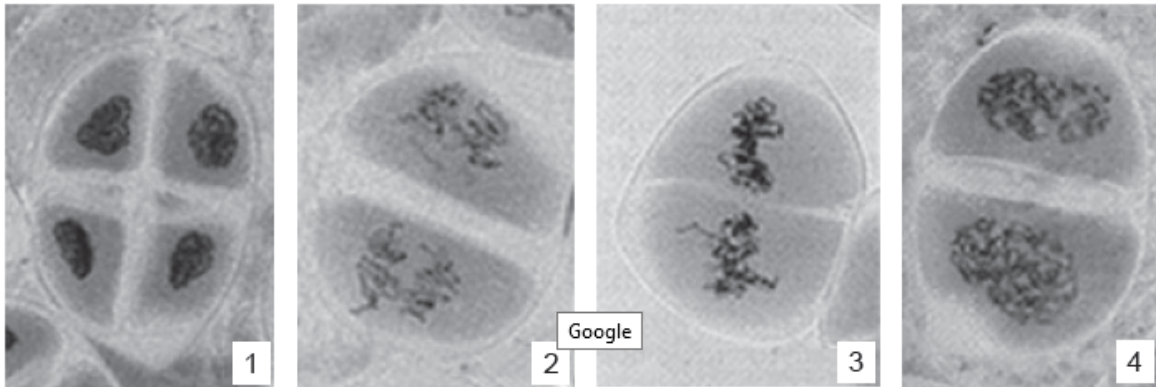


[Source: [https://commons.wikimedia.org/wiki/File:French\\_bulldog\\_on\\_the\\_grass.jpg](https://commons.wikimedia.org/wiki/File:French_bulldog_on_the_grass.jpg)]

Which outcome is matched with a valid conclusion if dogs that were pure breeding for melanistic masks were crossed with dogs without melanistic masks?

- A. If 0 % of the puppies have a mask, the character is recessive.
- B. If 25 % of the puppies have a mask, the character is dominant.
- C. If 75 % of the puppies have a mask, the character is dominant.
- D. If 100 % of the puppies have a mask, the character is recessive.

The micrographs show four different phases from meiosis II. What is the correct order?



[Source: <http://biologyforhighschool.net>]

- A. 3-4-2-1
- B. 2-3-4-1
- C. 4-3-2-1
- D. 4-2-3-1