Week 54

# A-Level Biology

Homework bundle for this week

本周作业合集

exercises.lol

## Contents 目录





A-Level Biology Name: _____ Score: _____

1. Recombinant DNA is:
   - ☐ DNA made by joining together DNA from two different sources
   - ☐ DNA from a single organism only
   - ☐ a type of protein
   - ☐ a damaged chromosome
2. The polymerase chain reaction (PCR) is used to:
   - ☐ amplify DNA, making millions of copies
   - ☐ cut DNA into fragments
   - ☐ separate DNA by length
   - ☐ join two genes
3. Genetically modified bacteria can be used to make human insulin.

   ☐ True ☐ False
4. An organism whose genes have been deliberately changed, often with a gene from another species, is a genetically _____ organism.

   _____
5. Recombinant DNA is made by joining DNA from two different sources (e.g. a human gene into a bacterial plasmid).

   ☐ True ☐ False
6. The technique that makes millions of copies of a DNA sample is the _____ chain reaction.

   _____
7. An advantage of making insulin as a recombinant human protein is that it:
   - ☐ is an exact human copy, safer and never in short supply
   - ☐ must be taken from animals
   - ☐ cannot be made in large amounts
   - ☐ works less well than animal insulin
8. Insect-resistant GM cotton works because it:
   - ☐ makes a protein that kills the insect pests
   - ☐ grows faster

☐ is resistant to a herbicide

☐ needs no water

9. Reverse transcriptase is used to:

   ☐ make DNA from an mRNA template

   ☐ cut DNA at a specific sequence

   ☐ join two DNA pieces

   ☐ copy DNA directly

10. Human insulin made by genetically modified bacteria is described as _____ insulin.



## 19. Genetic technology

**Answers · 答案**

A-Level Biology

1. **DNA made by joining together DNA from two different sources**

   Recombinant DNA combines DNA from two sources — e.g. a human gene joined into a bacterial plasmid.

2. **amplify DNA, making millions of copies**

   PCR amplifies DNA through repeated heat/cool cycles using Taq polymerase.

3. **True**

   The human insulin gene is inserted into the bacteria, which then make exact human insulin.

4. **modified**

   A GMO carries a gene added by genetic engineering.

5. **True**

   Because the genetic code is universal, a human gene works inside a bacterium that takes it up.

6. **polymerase**

   PCR (the polymerase chain reaction) uses Taq polymerase to copy DNA over many cycles.

7. **is an exact human copy, safer and never in short supply**

   Recombinant insulin is identical to human insulin, available in quantity, and avoids animal/donor sources.

8. **makes a protein that kills the insect pests**

   The engineered cotton produces a protein toxic to insect pests, protecting the crop.

9. **make DNA from an mRNA template**

   Reverse transcriptase builds a DNA copy from mRNA — one way of obtaining the gene to transfer.

10. **recombinant**

    Recombinant = the human gene has been combined into the bacterium's DNA.

A-LEVEL BIOLOGY • EXERCISE SHEET

# 19.1 Principles of genetic technology

Name: _____ Class: _____ Date: _____ **Total: 34 marks**

**KEY WORDS** gene 基因 • plasmid 质粒 • polymerase 聚合酶 • polymerase chain reaction 聚合酶链式反应 • gel electrophoresis 凝胶电泳

## Objective

Build the skills to answer exam questions on the **principles of genetic technology** — **recombinant DNA** 重组 DNA, the tools of **genetic engineering** 基因工程, **PCR** 聚合酶链式反应 and **gel electrophoresis** 凝胶电泳.

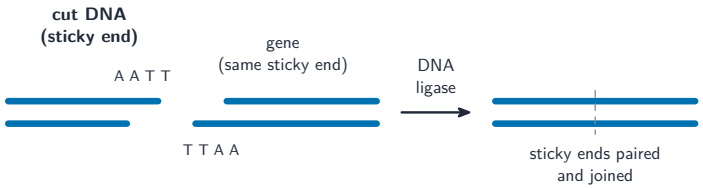
**You must be able to:**

- define recombinant DNA and explain the roles of the key enzymes and a plasmid vector
- explain why a promoter and a marker gene are transferred with a gene
- describe PCR and gel electrophoresis

## 1 Worked examples

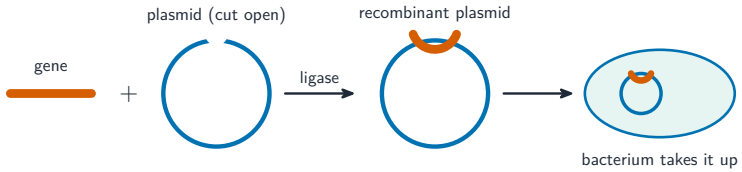
### The tools

**Recombinant DNA** is DNA joined from two different sources. The gene can be cut from a **donor** 供体, made from its mRNA by **reverse transcriptase** 逆转录酶, or built from **nucleotides** 核苷酸.




*A restriction endonuclease leaves matching sticky ends; DNA ligase joins the gene to the cut DNA*

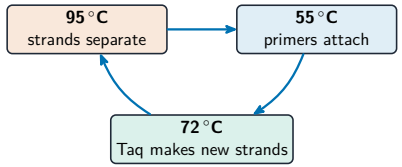





*A plasmid is a cloning vector: the gene is joined into it, and the recombinant plasmid enters a bacterium*

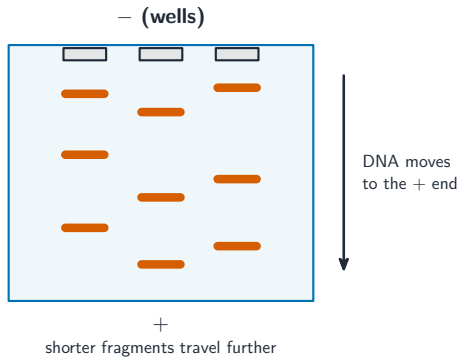
- **restriction endonuclease** 限制性内切酶 — cuts DNA at a specific sequence (sticky ends); **DNA ligase** — joins DNA; **plasmid** 质粒 — a vector to carry the gene; **DNA polymerase** — copies DNA.
- a **promoter** 启动子 (the gene's "switch") must be transferred so the gene is transcribed; a **marker gene** 标记基因 (e.g. fluorescent) confirms the transfer worked.

### Copying and sorting DNA




each cycle **doubles** the DNA → millions of copies

*PCR doubles the DNA each cycle, making millions of copies*




*Gel electrophoresis sorts DNA fragments by length — shorter fragments move further*

■ **The tools, in the order a gene actually moves**



| Tool | What it does |
|---|---|
| **restriction endonuclease** 限制性内切酶 | cuts DNA at a specific base sequence, often leaving **sticky ends** 黏性末端 |
| **DNA ligase** DNA 连接酶 | joins the sugar–phosphate backbones of two fragments |
| **plasmid** 质粒 or virus | the **vector** 载体 that carries the gene into the host cell |
| **reverse transcriptase** 逆转录酶 | makes complementary DNA (cDNA) from an mRNA template |
| **PCR** 聚合酶链式反应 | copies a DNA fragment millions of times |
| **gel electrophoresis** 凝胶电泳 | separates fragments by length — small fragments travel furthest |

**The standard route, which is what an extended question asks for:**

1. **Isolate the gene** — cut it out with a restriction enzyme, or build it from mRNA using reverse transcriptase.
2. **Cut the vector with the SAME restriction enzyme**, so its sticky ends are complementary to the gene's. This step is the one candidates omit, and it is always a mark.
3. **Anneal and join** — the complementary sticky ends pair by hydrogen bonding, and DNA ligase seals the backbones, giving **recombinant DNA** 重组 DNA.
4. **Transform the host** — the plasmid is taken up by bacteria, usually after treatment with calcium ions and heat shock, or by electroporation.
5. **Identify the transformed cells** with a **marker gene** — for example antibiotic resistance, or a fluorescent gene, so only cells that took up the plasmid grow or glow.
6. **Culture** the successful cells so the protein is produced in quantity.

**Why sticky ends matter.** They are short single-stranded overhangs. Because both the gene and the plasmid were cut with the same enzyme, their overhangs are complementary and pair specifically — which is what makes the joining reliable rather than random.

**Worked example.** Explain why human insulin made this way is better than insulin extracted from pigs. It is identical to human insulin, so it works properly and is far less likely to provoke an immune response or allergy; it can be produced in unlimited quantity from bacterial culture rather than depending on a supply of animal pancreases; and it avoids the religious and ethical objections some patients have to an animal product.

## 2 Practice

**2.1** Name the enzyme that (a) cuts DNA at a specific sequence and (b) joins DNA fragments. [2]

**2.2** State why a marker gene is transferred along with the desired gene. [1]

**2.3** Name the enzyme that cuts DNA at a specific sequence, and the enzyme that joins two fragments. [2]

**2.4** Explain why the gene and the plasmid must be cut with the same restriction enzyme. [2]

**2.5** State the purpose of a marker gene. [2]

## 3 Exam-style questions

**3.1** What is the role of a plasmid in genetic engineering? [1]

- **A** to cut the DNA
- **B** to act as a vector that carries the gene into a cell
- **C** to copy the DNA millions of times
- **D** to separate DNA fragments by length



**3.2** In gel electrophoresis, the DNA fragments that travel **furthest** are the: [1]

- **A** longest
- **B** shortest
- **C** most positively charged
- **D** circular ones

**3.3** (a) Explain why a promoter must often be transferred along with a gene. [2]

(b) Describe how the polymerase chain reaction (PCR) makes many copies of a DNA sample. [3]

**3.4** Explain why restriction enzymes and DNA ligase are both needed to make recombinant DNA. [2]

**3.5** A gene for a human protein is to be transferred into bacteria so that the protein can be produced commercially.

(a) Describe how the gene can be obtained from a human cell that expresses it, naming the enzyme used. [3]

(b) Explain the role of sticky ends in inserting the gene into a plasmid. [3]

(c) Name the enzyme that seals the gene into the plasmid, and state what the product is called. [2]

(d) Describe how the bacteria that have taken up the plasmid can be identified. [3]

(e) Suggest two advantages of producing this protein in bacteria rather than extracting it from animals. [2]

(f) Explain how gel electrophoresis could be used to check that a fragment of the expected length has been inserted. [3]



## Solutions

**2.1** (a) restriction endonuclease; (b) DNA ligase.

**2.2** to check (confirm) that the gene has been taken up and is expressed.

**2.3** Restriction endonuclease; DNA ligase.

**2.4** Each restriction enzyme cuts at one specific sequence and leaves a particular sticky end; using the same enzyme on both means their overhangs are complementary, so the gene and the plasmid pair together specifically.

**2.5** It allows the cells that have taken up the plasmid to be identified; for example an antibiotic-resistance gene lets only transformed cells grow on a medium containing that antibiotic.

**3.1 B**. A plasmid is a vector carrying the gene into the cell.

**3.2 B**. Shorter fragments move further through the gel.

**3.3** (a) the promoter is the switch that starts transcription; without it the transferred gene would not be transcribed / stay silent.
(b) heat to ~95 °C to separate the strands; cool to ~55 °C so primers attach; 72 °C lets Taq polymerase build new strands — repeating the cycle doubles the DNA each time.

**3.4** the restriction enzyme cuts the gene and the plasmid, leaving matching sticky ends; DNA ligase joins the gene into the plasmid to make recombinant DNA.

**3.5** (a) Extract the mRNA for the protein from a cell that expresses it; use reverse transcriptase to make complementary DNA from that mRNA template; this cDNA is the gene, and it has no introns. (Cutting the gene from the genome with a restriction endonuclease is also accepted.)
(b) Sticky ends are short single-stranded overhangs left when the restriction enzyme cuts; the gene and the plasmid are cut with the same enzyme, so their overhangs are complementary; the bases pair by hydrogen bonding, holding the gene in place in the plasmid.
(c) DNA ligase; the product is recombinant DNA.
(d) The plasmid also carries a marker gene, for example antibiotic resistance; the bacteria are grown on a medium containing that antibiotic; only the cells that took up the plasmid survive and form colonies, so those are the transformed cells. (A fluorescent marker viewed under UV is equally acceptable.)
(e) Any two of: the protein is identical to the human one, so it is less likely to cause an immune response; it can be produced in unlimited quantity by culturing bacteria; production does not depend on a supply of animal tissue; it avoids religious or ethical objections to an animal product.
(f) Cut the plasmid with the same restriction enzyme to release the insert; run the fragments through a gel under an electric field, where smaller fragments travel further; compare the distance travelled with a set of fragments of known length, and a band at the expected position shows the insert is the right size.

**8** LibertyLink® soybean is a genetically modified crop. It was first grown in 1996 and used in food products from 1998. It has been grown in 6 countries and used in food products in 21 countries.

Table 8.1 summarises the modifications made to the soybean plant to produce LibertyLink® soybean.

**Table 8.1**

| name of introduced gene | gene donor organism | gene product | function of gene product |
|---|---|---|---|
| *pat* | *Streptomyces viridochromogenes* | phosphinothricin *N*-acetyltransferase | stops action of glufosinate, a herbicide |

**(a)** Explain how the modification made to produce LibertyLink® soybean may help to solve the global demand for food.

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..... [4]

**(b)** **(i)** Name the type of enzyme that could be used to cut out the *pat* gene from *S. viridochromogenes*.

..... [1]

**(ii)** Name the enzyme that could be used to join the *pat* gene to a plasmid by forming phosphodiester bonds.

..... [1]

**(c)** Suggest reasons why LibertyLink® soybean is used in food products in 21 countries but only grown in 6 countries.

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[Total: 9]



**5** Metachromatic leukodystrophy (MLD) is a genetic disease that affects the nervous system.

MLD is caused by mutations in the *ARSA* gene located on chromosome 22. The *ARSA* gene, which is 3150 base pairs (bp) in length, includes 8 exons and is shown in Fig. 5.1.

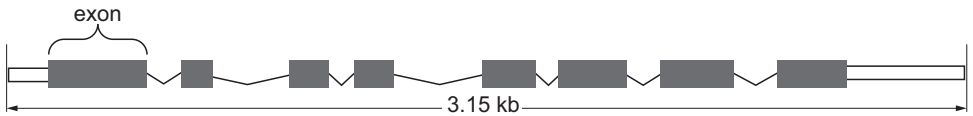


**Fig. 5.1**

A genetic test using DNA sequencing is available to identify mutations associated with MLD in the *ARSA* gene. The sequencing method can only work if a DNA fragment size is less than 1000 bp.

The test involves a number of different stages:

- Genomic DNA is extracted from a blood sample.
- Polymerase chain reaction (PCR) using 5 pairs of primers selects 5 different DNA fragments of the *ARSA* gene.
- Gel electrophoresis is carried out on the DNA fragments.
- The DNA fragments are sequenced and analysed for mutations.

Table 5.1 shows the length of the DNA fragments and the exons present in each DNA fragment.

**Table 5.1**

| fragment number | DNA fragment length / bp | exons in DNA fragment |
|---|---|---|
| 1 | 405 | 1 |
| 2 | 737 | 1-2 |
| 3 | 706 | 2-4 |
| 4 | 860 | 5-7 |
| 5 | 916 | 7-8 |

**(a)** Genomic DNA and primers are added to the PCR machine.

Name **two** other substances that are added to the PCR machine, **and** explain why each substance is added.

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**(b)** Gel electrophoresis is carried out on the 5 different DNA fragments produced as a result of PCR. Each DNA fragment is put into a loading well on the gel.

The final lane on the electrophoresis gel contains a DNA ladder of known lengths of DNA.

Fig. 5.2 shows the results of the gel electrophoresis.

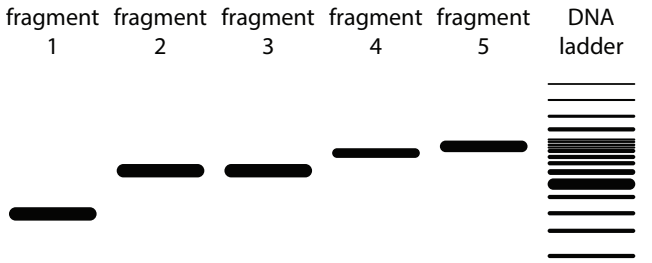


**Fig. 5.2**

**(i)** Suggest the role of the DNA ladder.

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..... [2]

**(ii)** In the genetic test for MLD, PCR and gel electrophoresis are carried out before DNA sequencing.

Suggest **and** explain reasons why PCR and gel electrophoresis are carried out before DNA sequencing.

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**(c)** Calculate the number of copies of DNA that are obtained if PCR is run for 35 cycles.

Assume that there is only 1 copy of DNA at the start of PCR.

Give your answer in standard form to **two** significant figures.

number of copies .....

[1]

**(d)** MLD is a rare autosomal recessive disease. It is estimated that there is one case of MLD in every 40 000 births worldwide. Children with MLD have a reduced life expectancy.

- MLD is a degenerative disease that causes severe disability.
- Before 2022, there was no known cure for MLD and the only treatment for symptoms was to provide pain relief.

A new gene therapy treatment known as Libmeldy® became available in a number of countries in 2022. The treatment must start before symptoms are present. Although the treatment may provide a cure for MLD, a single dose is extremely expensive.

Blood samples from newborn babies are screened for a number of rare genetic diseases (neonatal screening) in most countries of the world, but none include screening for MLD.

Discuss the social and ethical considerations of including screening for MLD when carrying out neonatal screening in a country where gene therapy for MLD is available.

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[Total: 14]





**3** **(a)** Genetic engineering is a modern method for producing crop plants with improved characteristics.

One example of a crop plant with improved characteristics is soybean, *Glycine max*, which has been genetically modified to make it resistant to a herbicide. This genetically modified soybean is called GM soybean.

To create GM soybean, a bacterial gene and a section of regulatory DNA were introduced into soybean cells.

Outline the roles of enzymes and a section of regulatory DNA in the creation of genetically modified organisms such as GM soybean.

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..... [5]

**(b)** In 2018, an area of 123.5 million hectares was used to grow soybean crops worldwide. GM soybean was grown in 73% of this area.

In 2018, soybeans accounted for 50% of the total GM crop area worldwide.

Calculate the total area used to grow GM crops worldwide in 2018.

Show your working.

..... hectares [2]

**(c)** Discuss the social implications of growing GM crops.

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..... [4]

[Total: 11]



A-LEVEL BIOLOGY • EXERCISE SHEET

# 19.2 Genetic technology applied to medicine

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

**KEY WORDS** breast cancer 乳腺癌 • gene therapy 基因治疗 • genetic screening 基因筛查 • insulin 胰岛素 • recombinant human proteins 重组人蛋白

## Objective

Build the skills to answer exam questions on **genetic technology applied to medicine** — **recombinant human proteins** 重组人蛋白, **genetic screening** 基因筛查, **gene therapy** 基因治疗, and their ethical issues.

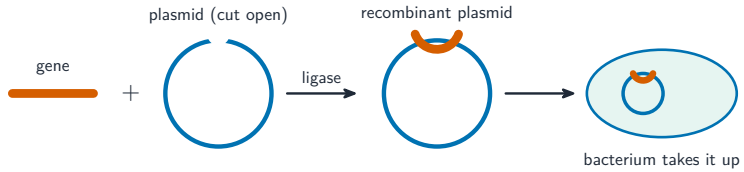
**You must be able to:**

- explain the advantages of recombinant human proteins (insulin, factor VIII, ADA)
- outline genetic screening (BRCA, Huntington's, cystic fibrosis) and gene therapy (SCID)
- discuss social and ethical considerations

## 1 Worked examples

### Recombinant human proteins


*The insulin gene goes into bacteria, which become living factories — an exact human copy, never in short supply*




*A plasmid vector carries the human gene into bacteria*

A human gene is placed in bacteria so they make a **recombinant** human protein — an exact copy. Advantages: it is identical to the human protein, never in short

supply, and avoids using animal/donor proteins (so fewer allergic reactions or infections). Examples: **insulin** 胰岛素 (diabetes), **factor VIII** (haemophilia), **adenosine deaminase** (a faulty immune system).

### ■ Genetic screening and gene therapy

**Genetic screening** tests DNA for disease alleles before symptoms appear — e.g. **BRCA1/BRCA2** (breast cancer risk), **Huntington's disease**, **cystic fibrosis** 囊性纤维化. **Gene therapy** puts a working gene into a patient's cells — used for **SCID** (failed immune system) and some inherited eye diseases.

### ■ Ethics

Concerns: who may see your results; misuse by insurers/employers; safety and permanence of changes; who decides. These are weighed against the benefits.

## 2 Practice

**2.1** State **two** advantages of using recombinant human insulin rather than insulin from animals. [2]

**2.2** Name **one** disease that can be detected by genetic screening. [1]

## 3 Exam-style questions

**3.1** Gene therapy treats a genetic disease by: [1]

- **A** giving the patient a recombinant protein
- **B** putting a working copy of a gene into the patient's cells
- **C** screening the patient's DNA
- **D** removing the faulty allele from all body cells permanently



**3.2** Which is an advantage of making insulin from genetically engineered bacteria? [1]

- **A** it is slightly different from human insulin
- **B** it is identical to human insulin and never in short supply
- **C** it must be extracted from animal pancreases
- **D** it cannot be purified

**3.3** (a) Explain **one** advantage of genetic screening for a person with a family history of Huntington's disease. [2]

(b) Discuss **one** ethical concern raised by genetic screening. [2]

**3.4** Explain how gene therapy could help a child with SCID. [2]

**3.5** Human insulin for treating diabetes is produced by genetically modified bacteria.

(a) Describe how the human insulin gene is obtained and inserted into a bacterium, naming the enzymes and the vector used. [5]

(b) Explain why a marker gene is included, and describe how it is used. [3]

(c) Explain **two** advantages of using recombinant human insulin rather than insulin extracted from animals. [2]

(d) Distinguish between genetic screening and gene therapy, and state one ethical concern raised by each. [4]



## Solutions

**2.1** any two: identical to human insulin; never in short supply; fewer allergic reactions; no risk of animal-borne infection; no ethical objection from using animals.

**2.2** any one: breast cancer (BRCA1/BRCA2); Huntington's disease; cystic fibrosis.

**3.1 B**. Gene therapy adds a working copy of the gene to the patient's cells.

**3.2 B**. Engineered bacteria make insulin identical to human insulin, in unlimited supply.

**3.3** (a) it lets the person know their risk before symptoms appear, so they can make informed choices about treatment, monitoring or having children.
(b) e.g. results could be misused by insurers/employers, or cause anxiety / there is no cure for Huntington's.

**3.4** a working copy of the faulty gene is inserted into the child's cells; the cells then make the missing protein, restoring immune function.

**3.5** (a) The mRNA for insulin is taken from human pancreatic cells and **reverse transcriptase** is used to make a complementary DNA copy of the gene; alternatively the gene is cut from the genome with a **restriction endonuclease**, which leaves sticky ends; a **plasmid** vector is cut with the same enzyme so its sticky ends are complementary; the gene and plasmid are joined by **DNA ligase**; the recombinant plasmid is then taken up by the bacterium, for example after treatment with calcium ions and heat shock.
(b) Only a small proportion of bacteria take up the plasmid, so the transformed cells must be identified. A marker gene — for antibiotic resistance or for a fluorescent protein — is carried on the same plasmid; growing the culture on a medium containing that antibiotic, or under UV light, leaves only the transformed bacteria visible or alive.
(c) It is identical to human insulin, so it works exactly as the body's own does and is far less likely to cause an allergic reaction; it can be produced in unlimited quantity by fermentation, and is acceptable to people whose religion or beliefs forbid animal products.
(d) **Genetic screening** tests a person, embryo or fetus for alleles causing a genetic condition — it identifies risk but changes nothing; a concern is that the results could be used by insurers or employers to discriminate, or could pressure a couple's reproductive decision. **Gene therapy** inserts a working allele into a patient's cells to treat the condition; somatic therapy affects only that patient, but germ-line therapy would change every future generation, with consequences that cannot be predicted or consented to.

**3** Porphyria is a group of rare genetic diseases in which molecules called porphyrins accumulate in the body.

Three examples of porphyria are:

- X-linked protoporphyria
- variegate porphyria
- congenital erythropoietic porphyria (CEP).

**(a)** X-linked protoporphyria is caused by a mutant allele located on the X chromosome.

Fig. 3.1 shows the pattern of inheritance of X-linked protoporphyria in one family.

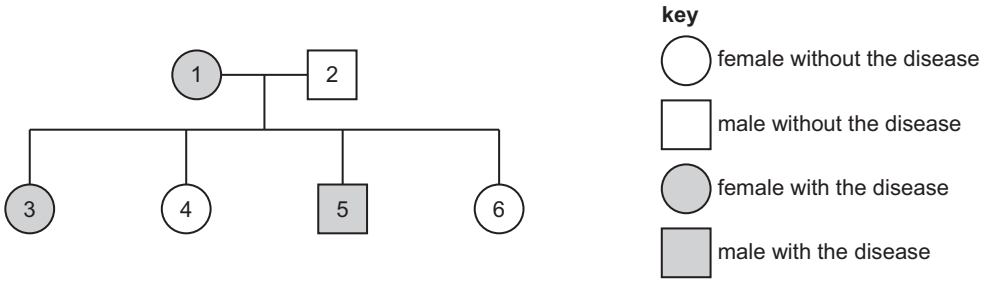



**Fig. 3.1**

X-linked protoporphyria is described as a sex-linked disease.

Use the information in Fig. 3.1 to make **one** other conclusion about the pattern of inheritance of X-linked protoporphyria.

Give evidence to support your conclusion.

conclusion .....

evidence .....

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[2]





**(b)** Variegate porphyria occurs in 1 in 100 000 people in Europe.

In the 1600s, approximately 100 Dutch people migrated from Europe to South Africa.

The population of people of Dutch descent in South Africa is now 2.5 million. Variegate porphyria occurs in 1 in 1000 people in this population.

Suggest **and** explain why variegate porphyria is more common among people of Dutch descent in South Africa than among people in Europe.

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..... [3]

**(c)** Microarrays can be used to detect various forms of porphyria caused by mutant alleles.

Describe how microarrays can be used to detect a disease by analysing gene expression.

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**(d)** The nucleotide sequences of alleles that cause rare genetic diseases, such as the various forms of porphyria, are stored in a database.

State **one** benefit of having a database of nucleotide sequences for alleles that cause rare diseases.

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..... [1]

**(e)** Congenital erythropoietic porphyria (CEP) is caused by a substitution mutation in a gene coding for an enzyme.

The mutant CEP allele codes for an enzyme with little or no function.

Scientists used gene editing in the laboratory to correct the nucleotide sequence of the mutant allele in cultured human cells.

The scientists introduced three molecules to the cells:

- an enzyme called Cas9 that causes breaks in DNA strands
- guide RNA (gRNA), attached to Cas9, that is complementary to the mutant CEP allele
- a short length of DNA, known as template DNA, that can replace the section of the allele where the substitution mutation has occurred.

The repair mechanism within the cell allows the template DNA to be inserted so that the mutation is corrected.

Fig. 3.2 shows part of the nucleotide sequence in the mutated CEP allele before and after the gene editing procedure.

T A T G G C T C G —gene editing→ T A C G G C T C G

**Fig. 3.2**

In the future, this gene editing procedure may be used in a person with CEP to prevent the accumulation of porphyrins in the body.

Suggest **and** explain how this gene editing procedure will prevent the accumulation of porphyrins in a person with CEP without damaging other genes.

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..... [3]



A-LEVEL BIOLOGY • EXERCISE SHEET

# 19.3 Genetically modified organisms in agriculture

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

**KEY WORDS** herbicide 除草剂 • gm salmon 鲑鱼 • gmos 转基因生物 • genetic engineering 基因工程 • soybean 大豆

## Objective

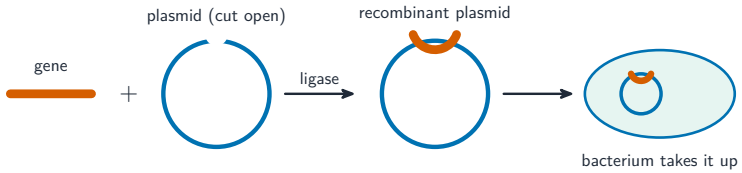
Build the skills to answer exam questions on **genetically modified organisms in agriculture** — how **GMOs** 转基因生物 improve crops and farm animals, and their ethical and social implications.

**You must be able to:**

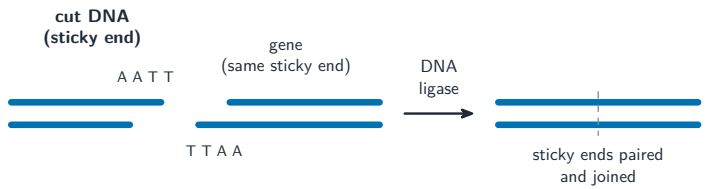
- explain how genetic engineering can improve the quality and productivity of crops and animals
- give the examples of GM salmon, herbicide-resistant soybean and insect-resistant cotton
- discuss the ethical and social implications of GMOs in food production

## 1 Worked examples

### Improving crops and animals




*The same gene-transfer tools are used to make a genetically modified organism*




*Restriction enzymes and ligase build the recombinant DNA*

Genetic engineering can help feed a growing world by adding useful genes:

- **GM salmon** 鲑鱼 — grow to size faster.
- herbicide-resistant **soybean** 大豆 — weeds can be sprayed with a **herbicide** 除草剂 without harming the crop.
- insect-resistant **cotton** 棉花 — makes a protein that kills the insect **pests** 害虫.

### ■ Ethical and social implications

Concerns include: whether GMOs are safe to eat; their effect on the environment and wild species; whether the engineered genes might spread to wild plants; and whether a few large companies should control the food supply. These must be weighed against the benefits of higher yields.

## 2 Practice

**2.1** State the advantage to a farmer of growing herbicide-resistant soybean. [2]

**2.2** State how insect-resistant cotton protects itself from pests. [1]



## 3 Exam-style questions

**3.1** GM salmon have been engineered mainly to: [1]

- **A** resist herbicides
- **B** grow to market size faster
- **C** kill insect pests
- **D** survive in fresh water

**3.2** A concern about growing herbicide-resistant crops is that: [1]

- **A** the crop cannot photosynthesise
- **B** the resistance gene might spread to wild plants (weeds)
- **C** the crop needs no water
- **D** the crop produces no seeds

**3.3** (a) Explain how insect-resistant cotton increases the yield of a crop. [2]

(b) Discuss **one** environmental and **one** social concern about growing GM crops. [2]

**3.4** Suggest why some people are cautious about eating food made from GMOs. [2]

## Solutions

**2.1** the field can be sprayed with herbicide to kill weeds without harming the crop, so the crop has less competition and a higher yield.

**2.2** it makes a protein that kills the insect pests that eat it.

**3.1 B**. GM salmon are engineered to grow to size faster.

**3.2 B**. The resistance gene could spread to wild plants.

**3.3** (a) the cotton makes a protein that kills insect pests; fewer pests eat the crop, so more survives — a higher yield.
(b) environmental, e.g. harm to non-pest insects / gene spread to wild plants; social, e.g. a few companies controlling the seed supply / cost to small farmers.

**3.4** they may worry the food is not proven safe to eat, or have ethical objections to altering organisms' genes.





**8** LibertyLink® soybean is a genetically modified crop. It was first grown in 1996 and used in food products from 1998. It has been grown in 6 countries and used in food products in 21 countries.

Table 8.1 summarises the modifications made to the soybean plant to produce LibertyLink® soybean.

**Table 8.1**

| name of introduced gene | gene donor organism | gene product | function of gene product |
|---|---|---|---|
| *pat* | *Streptomyces viridochromogenes* | phosphinothricin *N*-acetyltransferase | stops action of glufosinate, a herbicide |

**(a)** Explain how the modification made to produce LibertyLink® soybean may help to solve the global demand for food.

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..... [4]

**(b)** **(i)** Name the type of enzyme that could be used to cut out the *pat* gene from *S. viridochromogenes*.

..... [1]

**(ii)** Name the enzyme that could be used to join the *pat* gene to a plasmid by forming phosphodiester bonds.

..... [1]

**(c)** Suggest reasons why LibertyLink® soybean is used in food products in 21 countries but only grown in 6 countries.

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[Total: 9]