Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

BIOLOGY **9700/22**

Paper 2 AS Level Structured Questions **May/June 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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1 Root hair cells are specialised plant cells located in the outer layer of young roots of plants. Root hair cells have an essential role in the uptake of water and dissolved mineral ions from the soil solution.

The transport of water across the root to reach the central xylem tissue can occur by the symplast pathway or apoplast pathway.

(a) Fig. 1.1 is a diagram of a photomicrograph of a root hair cell.

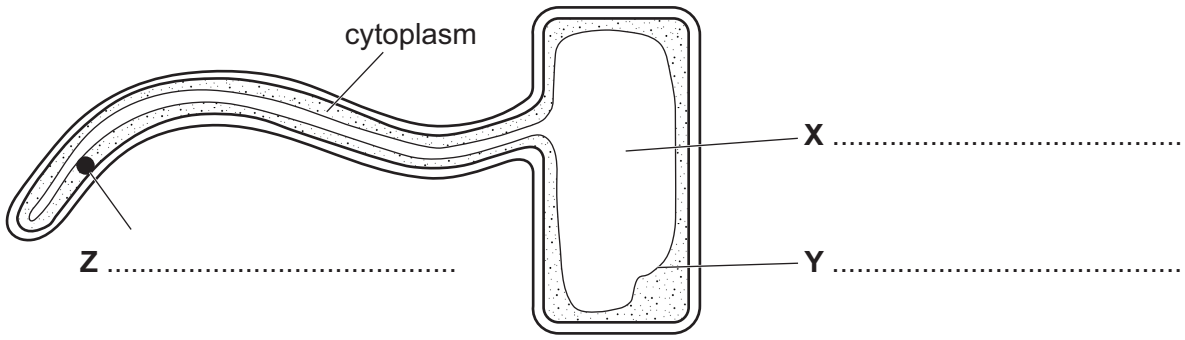

Fig. 1.1

On Fig. 1.1, name cell structures **X**, **Y** and **Z**.

[3]

(b) In the symplast pathway, water passes through the cells of the different tissues in the root before entering the xylem vessels of xylem tissue.

Name the tissues of the root, in the correct sequence, through which water passes in the symplast pathway.

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..... [2]

(c) In the apoplast pathway, water passes along the cell walls of adjacent plant cells and through the intercellular spaces. This is more efficient than the symplast pathway.

Explain the structural features of plant cell walls that make the apoplast pathway an efficient pathway for the transport of water.

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..... [3]

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(d) Root hair cells also synthesise and secrete substances into the soil.

Electron microscopy of the structure of root hairs has identified endoplasmic reticulum (ER), a number of small Golgi bodies, and numerous vesicles.

- Root hair cells of the barley plant secrete enzymes known as acid phosphatases, which catalyse the release of inorganic phosphate ions from organic phosphates in the soil.
- Root hair cells of the sorghum plant secrete a hydrophobic, lipid compound known as sorgoleone, which slows down the growth of neighbouring plants.

(i) Explain why the proportion of rough ER to smooth ER may be different in the root hair cells of barley plants compared with the root hair cells of sorghum plants.

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..... [2]

(ii) Student **X** stated that acid phosphatases and sorgoleone could be transported out of root hair cells using the **same** process.

Student **Y** stated that acid phosphatases and sorgoleone are transported out of root hair cells using **different** processes.

Suggest the reasons given by student **X** and by student **Y** to support their statements.

student **X** .....

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student **Y** .....

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[4]

[Total: 14]

DO NOT WRITE IN THIS MARGIN

2 The transport of respiratory gases involves blood plasma and red blood cells. Red blood cells contain the globular protein, haemoglobin.

(a) Describe features of a haemoglobin molecule that are typical of a globular protein, **other than** having an approximately spherical shape.

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..... [2]

(b) A number of substances are involved in the transport of respiratory gases.

Complete Table 2.1 by stating the name of the substance that matches the description of its role in the transport of respiratory gases.

The first row has been completed for you.

Table 2.1

substance	role in the transport of respiratory gases
carbon dioxide	In the capillaries of respiring tissues, this combines with water to form carbonic acid.
	In the capillaries of respiring tissues, this enters red blood cells through a membrane transport protein.
	In red blood cells, this is formed when carbon dioxide binds to haemoglobin.
	In alveolar capillaries, this combines with a hydrogen ion in red blood cells to form carbonic acid.
	In alveolar capillaries, this is formed in red blood cells as a result of oxygen binding to a haem group.
	In red blood cells, this combines with haemoglobin to form haemoglobinic acid.

[5]

[Total: 7]

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3 Carrots are root vegetables of the carrot plant. The carrot plant is an important food crop that is grown throughout the world. Carrots have a sweet taste because sugars form a proportion of the total carbohydrate present.

Plant breeding has produced many different varieties of carrot, with different levels of sweetness.

(a) One of the sugars found in carrots is galactose.

Galactose has the same molecular formula, $C_6H_{12}O_6$, as α-glucose.

Fig. 3.1 shows the molecular structure of galactose found in carrots. This is similar, but not identical, to the molecular structure of α-glucose.

In Fig. 3.1, the six carbon atoms are numbered 1 to 6.

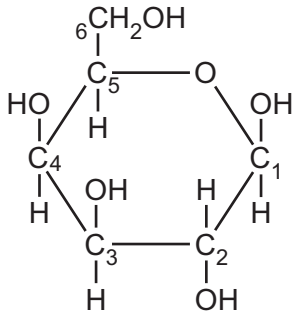

Fig. 3.1

State the differences between the molecular structure of galactose, shown in Fig. 3.1, and the molecular structure of α-glucose.

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..... [1]

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(b) An investigation was carried out to determine the sugar content of mature carrots produced by different local varieties of carrot plants that are grown in Tunisia, North Africa.

Carrot plants were grown from seed under standardised conditions. When mature, the carrots were harvested.

The different sugars present in the carrots were identified. Measurements of sugar content for each of the sugars were made.

Table 3.1 shows the results for five different local varieties of carrot plant, **A** to **E**.

Table 3.1

local variety	sugar content of carrots / mg g^{-1} of dry weight			
	fructose	galactose	glucose	sucrose
A	183.04	1.43	173.28	73.73
B	194.43	1.13	188.18	46.20
C	200.15	5.99	125.19	85.93
D	157.35	4.88	137.28	89.57
E	170.38	4.54	133.57	60.27

After studying the results shown in Table 3.1, a student concluded that the carrots from the local varieties contain the same four sugars.

The student made three other conclusions from the data in Table 3.1.

conclusion 1 There are non-reducing and reducing sugars in the carrots.

conclusion 2 There are monosaccharide and disaccharide sugars in the carrots.

conclusion 3 The carrots have the same pattern of results.

DO NOT WRITE IN THIS MARGIN

Explain the evidence in Table 3.1 that supports these three other conclusions.

conclusion 1 .....

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conclusion 2 .....

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conclusion 3 .....

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[3]

(c) Carbohydrates that are **not** sugars are also present in carrots.

Name **one** carbohydrate that is present in carrots and that is **not** a sugar.

..... [1]

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(d) Each carrot plant produces a carrot in the first year of growth.

If the carrot is **not** removed from the plant after it matures, the plant passes through a dormant period and shoots develop from the carrot in the second year of growth. This allows flowers to be produced and seed formation to occur before the plant dies.

Explain, with reference to the life cycle of the carrot plant, when the carrot acts as a **source and** when the carrot acts as a **sink**.

source .....

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sink .....

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[3]

(e) Carrot virus Y is a pathogen of carrot plants. The virus, which belongs to a group known as *Potyvirus*, replicates its viral nucleic acid and proteins within host carrot cells.

The general structure of potyviruses is shown in Fig. 3.2.

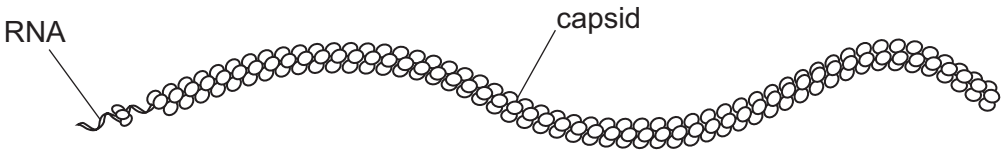

Fig. 3.2

The synthesis of viral proteins in host carrot cells only involves the process of translation. The process of transcription does **not** occur.

Suggest why translation occurs in host carrot cells during the synthesis of **viral** proteins, but transcription does **not** occur.

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[Total: 10]

DO NOT WRITE IN THIS MARGIN

4 Tuberculosis (TB) is an infectious disease that is caused by a bacterial pathogen.

The pathogen has mechanisms to avoid digestion by phagocytes. Macrophages may engulf the bacteria, but in some cases the bacteria remain alive within the cells instead of being killed.

(a) Although there are two main species of bacterium causing TB, it is rare for the species that causes bovine TB in cattle to infect humans.

Name the species of bacterium that is the **main** cause of TB in humans.

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(b) Explain how the pathogen named in **(a)** is transmitted from a person with the disease to a person who is uninfected.

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(c) State the type of therapeutic drug used to treat TB.

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(d) Fig. 4.1 is a photomicrograph of a section of lung tissue taken from a person who has **not** been infected with the bacterial pathogen and who does **not** have TB.

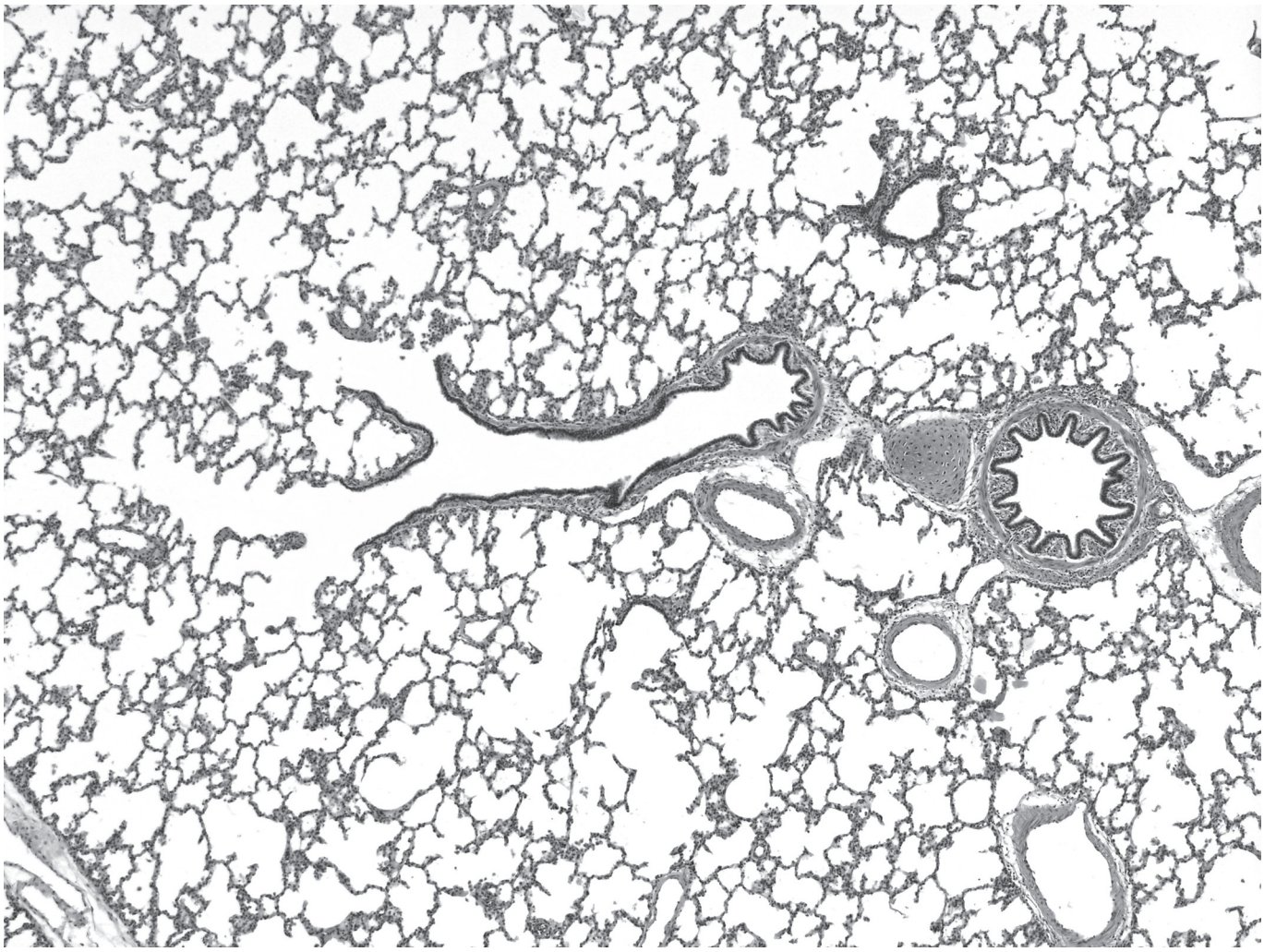

Fig. 4.1

Blood vessels and some structures of the gas exchange system are visible in Fig. 4.1.

On Fig. 4.1, use a label line and label:

- a bronchus
- a bronchiole
- a blood vessel.

[3]

DO NOT WRITE IN THIS MARGIN

(e) In some people with TB, areas known as granulomas may form in lung tissue as part of an immune response to the pathogen.

Fig. 4.2 is a photomicrograph of a granuloma in lung tissue.

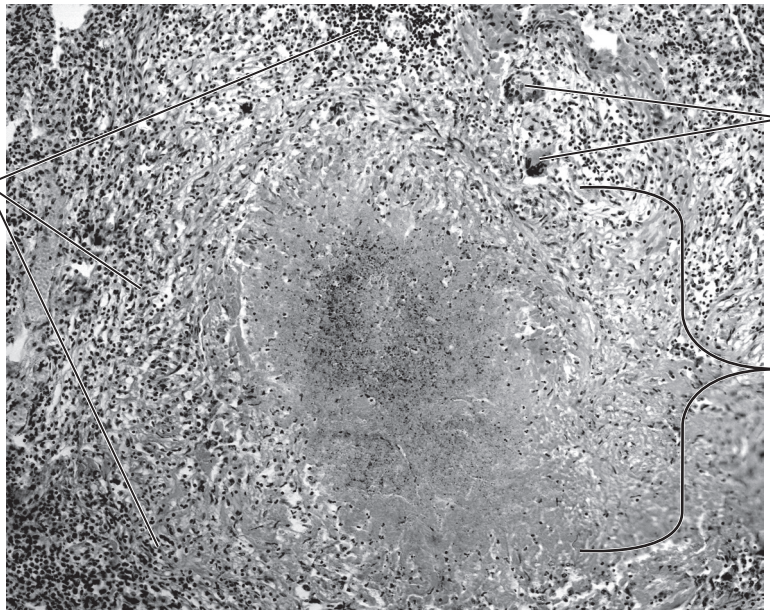

Fig. 4.2

With reference to Fig. 4.1 and Fig. 4.2, describe **and** explain how the changes that occur as a result of granuloma formation:

- can affect gas exchange and harm the health of an infected person
- may help to prevent TB developing in other parts of the body.

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[Total: 12]

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5 There is a global shortage of blood for transfusions. Researchers can culture bone marrow stem cells in the laboratory to manufacture red blood cells for potential use as an artificial blood product.

The researchers collect bone marrow stem cells that are present in small quantities in blood, rather than extracting them from bone marrow.

- Antibodies, specific to bone marrow stem cells, are attached to tiny magnetic beads.
- The beads are added to a sample of blood.
- An electric field is applied to immobilise the beads so that the bone marrow stem cells can be collected.

(a) The antibodies are attached to the beads so that the sites used for binding to specific molecules on the bone marrow stem cells are left exposed.

Name the term given to the specific molecules on the bone marrow stem cells that attach to the antibody binding sites.

..... [1]

(b) Suggest **and** explain the advantages of using bone marrow stem cells from the blood sample to manufacture artificial red blood cells.

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(c) One desirable feature of artificial blood products, such as artificial red blood cells, is that they should be economical to produce.

Suggest **other** desirable features of artificial blood products.

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[Total: 7]

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6 Horseradish peroxidase (HRP) is an enzyme that can be extracted from the roots of the horseradish plant, *Armoracia rusticana*. HRP is used extensively in industry and technology.

In the reaction catalysed by HRP, hydrogen peroxide (H_2O_2) is used to oxidise an organic substrate. This is summarised in Fig. 6.1.

$$\text{organic substrate + hydrogen peroxide} \xrightarrow{\text{HRP}} \text{oxidised substrate + water}$$

Fig. 6.1

(a) Inhibitors can have an effect on V_{max}, the maximum rate of reaction, and K_m, the Michaelis–Menten constant, of HRP.

Fig. 6.2 shows the effect of substrate concentration on the rate of reaction of HRP.

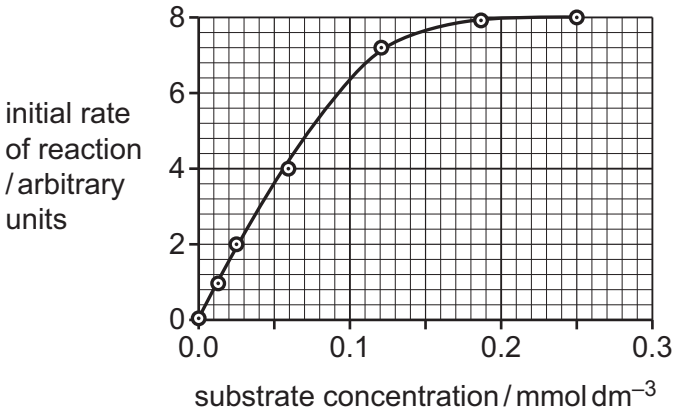

Fig. 6.2

Complete Fig. 6.2 by drawing a curve to show how the presence of a non-competitive inhibitor will affect the rate of reaction of HRP.

Use the curve **you have drawn** to obtain an estimate of K_m.

K_m = ... [2]

(b) Scientists can design synthetic DNA nucleotide sequences to produce a synthetic HRP gene. These sequences will include a start codon and a stop codon so that translation of messenger RNA (mRNA) can occur.

Explain what is meant by a start codon **and** a stop codon.

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..... [2]

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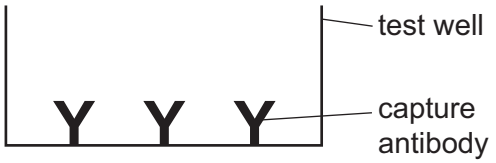
(c) HRP is used in an immunological test known as a sandwich ELISA. One use of the test is to diagnose disease.

Fig. 6.3 outlines the main steps in a sandwich ELISA in which a toxin released by a pathogen is detected in a sample of body fluid taken from a person who is ill.

The test involves two types of monoclonal antibody that can bind to the toxin, a capture antibody and a detection antibody.

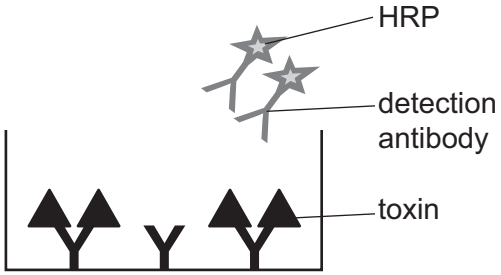
step 1 Prepare a test well by immobilising the capture monoclonal antibody to the support surface.



step 2 Remove a sample of the body fluid from the person who is ill and add the sample to the test well.

step 3 Wash out the test well to remove any substances not bound to the capture antibody.

step 4 Add detection antibody to the test.



step 5 Wash out the test well to remove any detection antibody that is not bound to the toxin.

step 6 Add substrates for catalysis by HRP and add acid after a set time to stop the reaction.

Fig. 6.3

(i) Complete Fig. 6.4 to show the situation in the test well after **step 5**.

Fig. 6.4

[1]

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(ii) With reference to Fig. 6.3, describe **one** difference between the capture antibody and the detection antibody.

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..... [1]

(iii) Fig. 6.5 outlines the reaction catalysed by HRP in **step 6**. The organic substrate, TMB, is in excess and changes colour when it is oxidised. This indicates a positive test result.

$$\underset{\text{colourless}}{\text{TMB}} + H_2O_2 \xrightarrow{\text{HRP}} \underset{\text{blue-green}}{\text{oxidised TMB}} + \text{water}$$

Fig. 6.5

A student suggested that:

- a low concentration of toxin may by diagnosed as a negative result instead of a positive result
- using a colorimeter after **step 6** in the sandwich ELISA test would provide a quantitative result and help to avoid this error.

With reference to Fig. 6.5, explain why using a colorimeter would provide a quantitative measurement for detection of a low concentration of the toxin and help to confirm a positive result.

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[Total: 10]

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