Transport in plants

Model Answers 3

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Exchange and transport
Topic	Transport in plants
Booklet	Model Answers 3

Time allowed: **55 minutes**

Score: **/41**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

A student designed an investigation into the rate of transpiration in plants. They used eight leaves of the same size, age and species. They kept environmental conditions such as wind speed, temperature and humidity constant.

Why did the student take readings from eight different leaves? **[1]**

A. to make their investigation valid

B. to increase the accuracy of their readings

C. to assess the repeatability of their data

D. to improve the precision of their results

Repeats = reliability

Accuracy = narrower intervals

Precision = smaller scale

Validity = control variables

Question 2

Plants transport water and assimilates through specialised tissues.

(a) Fig. 4.1 shows a tissue plan of a vertical section through part of a leaf.

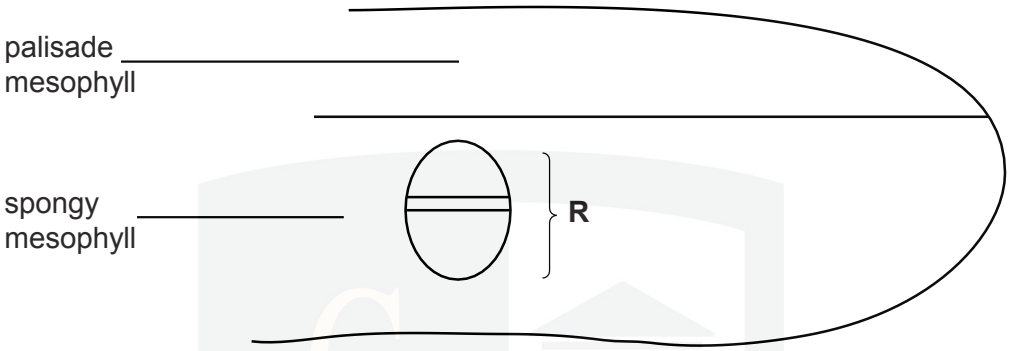
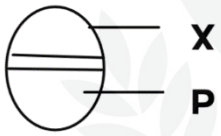


Fig. 4.1

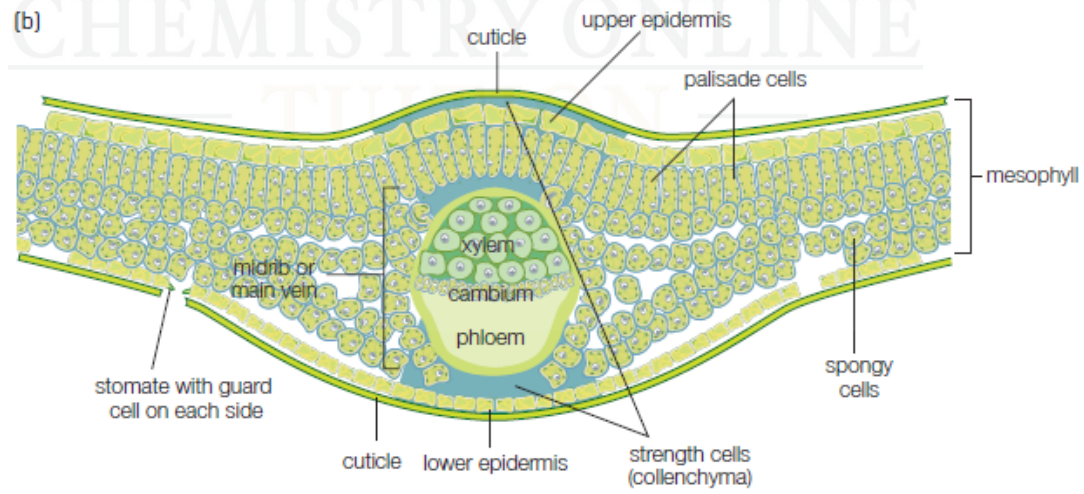
(i) **On Fig. 4.1**, identify with a letter **X** the position of the xylem **and** identify with a letter **P** the position of the phloem.

The answer to this question should be drawn on Fig. 4.1. **[1]**



The xylem must be on the upper part of the vascular bundle in the leaf and the phloem on the lower, separated by the cambium, as shown by the diagram below:

Transverse section



Further information for this dotpoint can be found in Biology in Focus (Preliminary) pages 141-144

(ii) Name structure **R**.

[1]

- R is referred to as the **vascular bundle** or the **vein**

(b) The majority of cells in phloem tissue are either companion cells or sieve tube elements.

A scientist isolated companion cells and conducted some experiments to investigate the mechanism involved in loading sucrose into the sieve tubes.

He recorded the following observations:

observation 1	isolated companion cells became slightly negatively charged compared with their surroundings
observation 2	companion cells could decrease the pH of the surrounding solution from 7.0 to 5.6
observation 3	the pH inside the companion cells rose from 7.0 to 8.2
observation 4	treatment with cyanide (which stops aerobic respiration) prevents the change in pH occurring

From **observation 1**, the scientist concluded that the mechanism involved a transfer of charged particles (ions) between the companion cells and their surroundings.

(i) What conclusions can be drawn from **observations 2 and 3** about the mechanism?

[2]

Observations 2 and 3 suggest that:

- The charged particles are **hydrogen ions**
- The ions are moved **out** of the cells

They must be hydrogen ions to alter the pH. As the pH inside the companion cells rose (obs 3) and the pH outside dropped (obs 2), the ions must be moving out.

(ii) What conclusions can be drawn from **observation 4** about the mechanism? **[1]**

Observation 4 suggests that:

- Active transport is involved

This is because we have been told that cyanide stops aerobic respiration in the question. If aerobic respiration cannot occur, then there will be insufficient ATP. Therefore this suggests that the change in pH is due to an active process as it does not occur in the presence of cyanide.

(c) The scientist drew a diagram to explain the mechanism used to load sucrose into the sieve tube elements.

His diagram is shown in Fig. 4.2.

A
charged particles are removed from the companion cells

B
co-transport of charged particles and sucrose into the companion cells

C
sucrose moves into the sieve tube elements

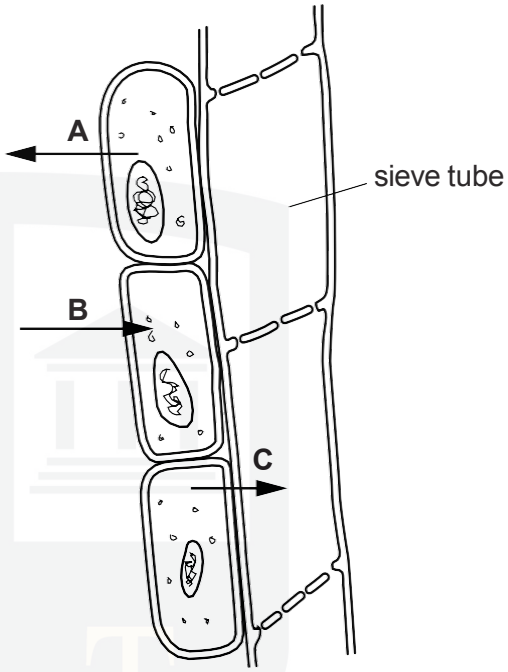
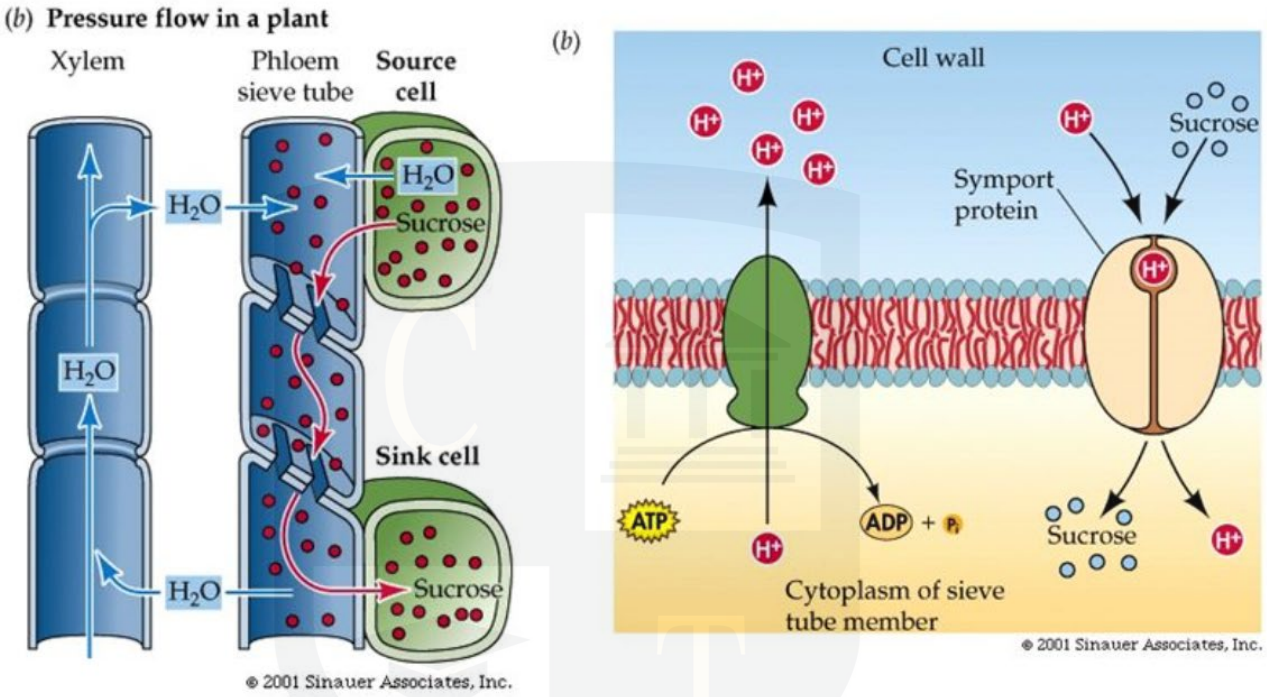


Fig. 4.2

(i) The following paragraph is an extract from the scientist's work.
Complete the paragraph. **[5]**

At step **A**, charged particles are moved out of the companion cells by the process of ..... Active transport ..... . This creates a ..... Concentration/ electrochemical/ H+/ proton ..... gradient between the companion cell and its surroundings. At step **B**, the charged particles and assimilates are co-transported by ..... Facilitated ..... diffusion into the companion cells. The assimilates build up in the companion cells and move by ..... Diffusion ..... into the sieve tube elements at step **C**. Assimilates, such as sucrose and ..... Amino acids ..... , can be loaded in this way.

Diagram to show the process of translocation: the mechanism used to transport sucrose around the plant:



(ii) The structure of cells is usually adapted to carry out their functions.

The scientist used an electron microscope to look for further evidence to support the mechanism involved in loading sucrose into the sieve tubes.

Suggest what evidence the scientist might expect to see in companion cells, using an electron microscope.

[2]

The scientist would expect to see:

- Many **mitochondria**
- **Plasmodesmata** between companion cells and sieve tube
- Many **ribosomes**
- Many **proteins** in the plasma membrane

This is because these organelles would all be vital for this mechanism of active loading into the phloem.

[Total: 12]

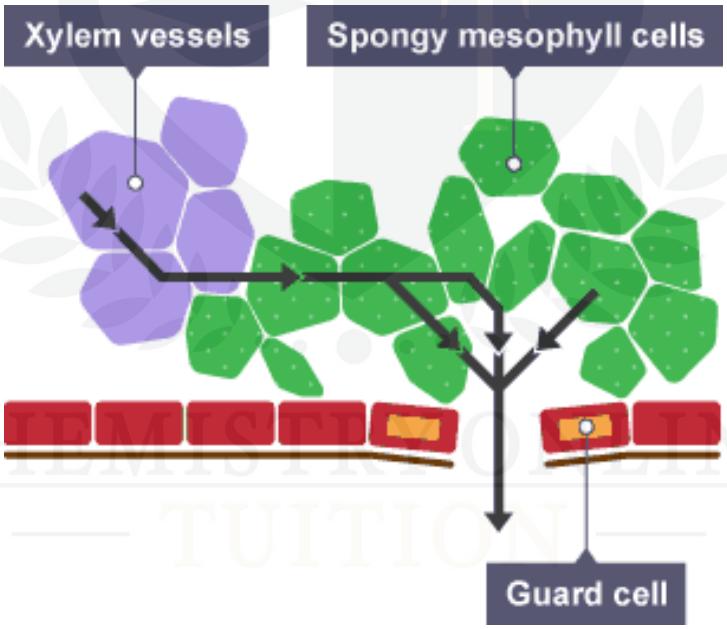
Question 3

(a) Distinguish between the term *transpiration* and the *transpiration stream*. **[3]**

- ***Transpiration*** is the **loss of water vapour**
- From **aerial parts of the plant**
- The ***transpiration stream*** is the **movement of water** up the xylem vessels
- From roots to leaves

The stream refers to the entire process of mass flow of water within a plant. Transpiration itself, is a process that occurs due to the evaporation of water from the leaf, via stomata.

A diagram to show the process of transpiration from a leaf:



(b) Xerophytes are plants that are adapted to living in dry conditions.

The lists below describe four general features of leaves. From each list, select the leaf that belongs to a xerophyte.

Place a tick (✓) in the correct box. The first one has been done for you. **[3]**

Presence of hairs on leaves

Leaf **A**	no	
Leaf **B**	yes	✓
Leaf **C**	no	

Mean number of stomata (cm^{-2})

Leaf **D**	30000	
Leaf **E**	23000	
Leaf **F**	13000	✓

Mean surface area of one leaf (cm^2)

Leaf **G**	0.2	✓
Leaf **H**	10.0	
Leaf **I**	23.0	

Thickness of cuticle (μm)

Leaf **J**	4.25	
Leaf **K**	8.50	✓
Leaf **L**	2.00	

The example here shows that leaf B, with hairs on leaves, is a xerophyte. Hair are an adaptation as they allow a micro-climate to be set up surrounding the stomata on a leaf, creating a more 'humid' environment. In this way, there will be less of a water gradient between the inside of the lead and the environment and hence less transpiration.

- **F (13,000)**

Xerophytes try to conserve as much water as possible. By minimising the number of stomata, they have less chance of losing water by transpiration at the leaf surface.

- **G (0.2)**

This is the leaf with the smallest mean surface area. This is a similar idea to the question above; if a leaf has less surface area, there is less area for transpiration and water loss to take place.

- **K (8.50)**

This is the leaf with the thickest cuticle; this ensures no water loss from the leaf surface by evaporation.

(c) The transport system of multicellular plants consists of xylem and phloem tissue.

The table below contrasts the structure and roles of xylem and phloem.

Complete the table using the most appropriate word or words. **[4]**

Xylem	Phloem
xylem transports water and **mineral ions**	phloem transports assimilates such as **Sucrose/amino acids**
No end walls	sieve tubes contain perforated cross walls
xylem vessel walls are impregnated with **Lignin**	sieve tube walls have no additional support
xylem vessel walls contain **Pits** that allow water to pass into adjacent vessels	there are many gaps in the cell walls between companion cells and sieve tube elements called **Plasmodesmata**

Xylem	Phloem
mineral ions You will not gain a mark anywhere here for the term 'nutrients', as this is far too vague.	**Sucrose/amino acids** You will not get a mark here for proteins or sugars.
No end walls These are completely lost in xylem vessels.	-
Lignin This is present to strengthen the walls of the xylem	-
Pits Ensure you use the correct name here, as holes or pores will not be accepted.	**Plasmodesmata** This is the name given to gaps between cells walls of adjacent plant cells.

[Total: 10]

Question 4

(a) A student used a potometer to investigate the effect of leaf area on the rate of transpiration.

This apparatus is shown in Fig. 4.1.

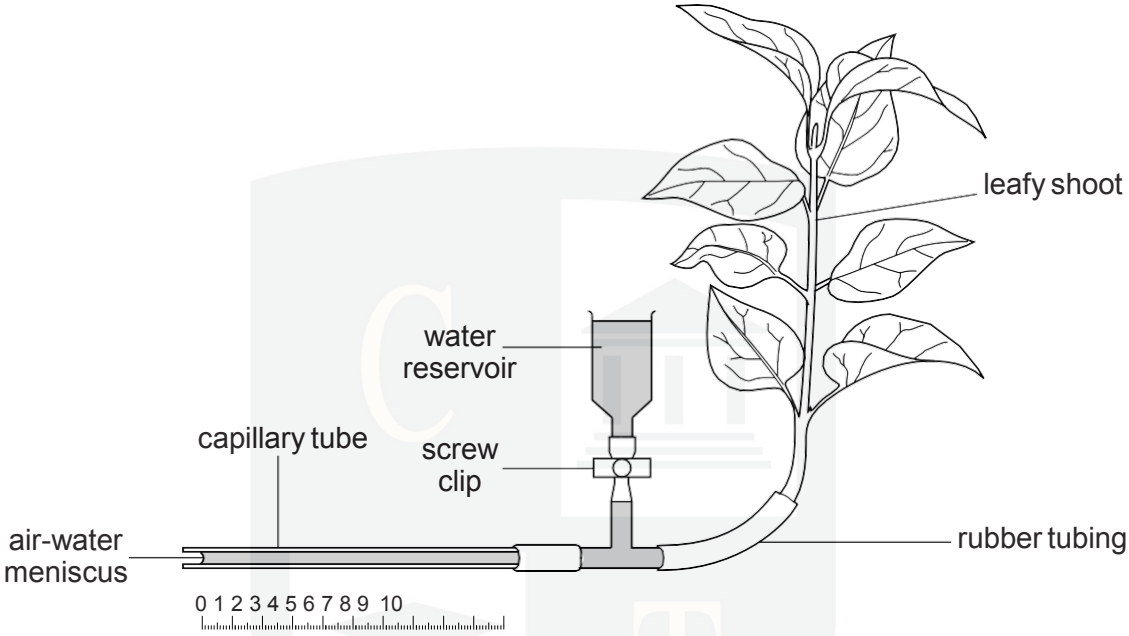


Fig. 4.1

The student presented the results of their investigation in a table, as shown below.

Number of leaves present on shoot attached to potometer	Mean rate of bubble movement
0	7
2	28
4	49
6	73
8	92

Table 4.1

(i) State what information the student has **not** included in their table of results. **[2]**

Any two from:

- **Units** (**mm s^{-1}**) in the table headings
- **Raw data** from which the means were calculated
- **Leaf area**

(ii) Describe **and** explain the data shown by the student's results. **[3]**

Any three from:

- The mean rate of bubble movement **increases** with the number of leaves present on the shoot
- E.G. 7 bubble movement with 0 leaves and 92 bubble movement with 8 leaves
- Because an increased number of leaves increases the overall **surface area**
- Therefore more **stomata**
- Therefore more **transpiration**
- Which would therefore require a faster uptake of water by the shoot
- There is some bubble movement with no leaves as not all uptake at the shoot is due to transpiration from leaves

***Exam tip**: in 'describe' questions you should remember to quote paired data with units, if applicable. Here you also need to explain **why** the trend is seen.*

(b) As part of the evaluation of the investigation, the student wrote the following statements:

1 One limitation is that the leaves were not all the same size.

2 I assembled the potometer under water and the leaves got wet.

3 During my investigation the sun came out and the lab warmed up very quickly.

For each statement, explain why this may affect the results **and** suggest how the student could improve the investigation.

[6]

Statement 1:

- This would affect the results because the **surface area** and **number of stomata** would differ between leaves
- The student could improve this by **choosing a shoot with similar sized leaves** or carry out **repeats** to calculate a **mean**

Statement 2:

- This would affect the results because wet leaves **reduces the water potential gradient** between the inside and outside of the leaf
- This could be improved by assembling the potometer **without wetting the leaves**, or by waiting for the leaves to dry

Statement 3:

- This would affect the results because **higher temperatures result in more transpiration**

This could be improved by carrying the experiment out in a **room with a controlled temperature**

***Exam tip**: go through each statement and for each ensure you describe how each would affect the results **and** suggest an explanation of how to improve the protocol.*

[Total: 11]

Question 5

Fig. 6.1 shows an aphid feeding from a plant stem. The aphid feeds by inserting its tube-like mouthparts into the tissue that transports sugar solution. Some details of this transport tissue are shown in the vertical section.

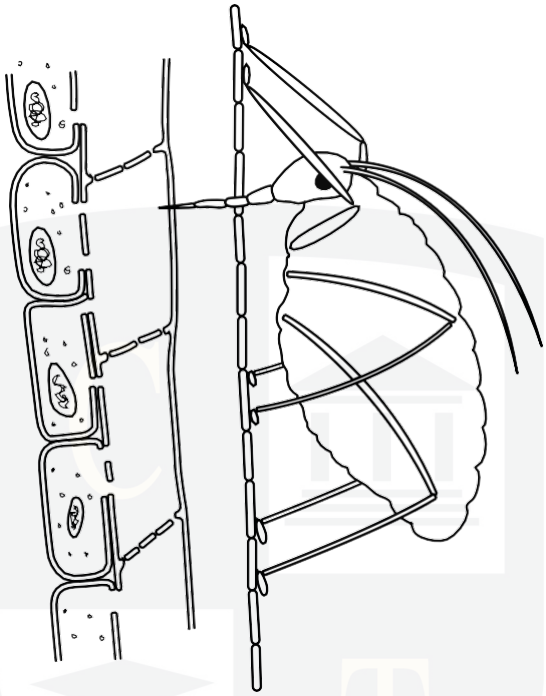


Fig. 6.1

(a) (i) Name the sugar most commonly transported through the stem of a plant **and** the tissue that transports this sugar. **[1]**

sugar **Sucrose**

tissue **Phloem**

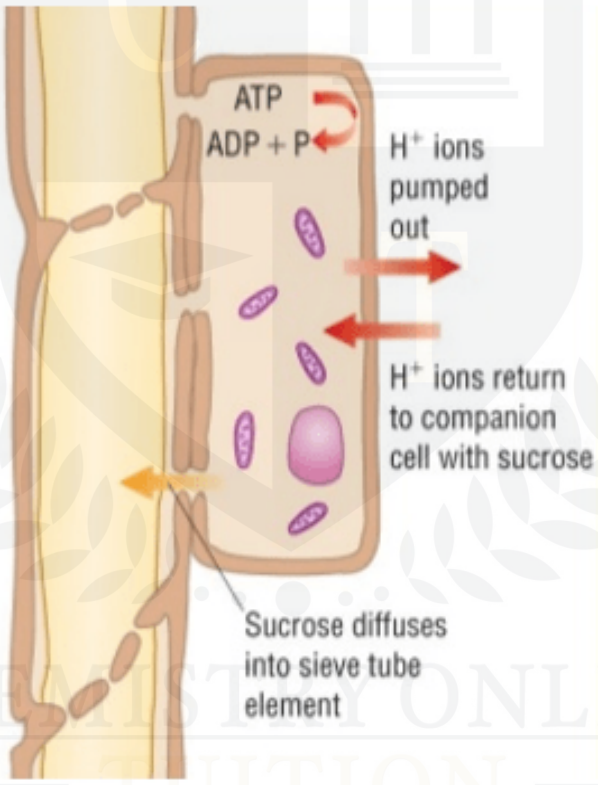
(ii) Sugar molecules are actively loaded into the transport tissue.

Describe how active loading takes place. **[3]**

- Active loading is driven by **hydrogen ions** being pumped out of companion cells
- This increases the hydrogen ion concentration outside of the companion cell
- Causing hydrogen ions to re-enter the companion cells
- Down a **concentration gradient**
- **Sucrose** moves with the hydrogen ions

- via **facilitated diffusion**
- with **cotransporter** proteins
- The sucrose then **diffuses** into the sieve tube
- through **plasmodesmata**

Diagram to show the active loading of sugar:



(b) A classic experiment investigated the effect of temperature on the rate of sugar transport in a potted plant.

Aphid mouthparts were used to take samples of sugar solution from the transport tissue in the stem. The sugary solution dripped from the mouthparts. The number of drips per minute was counted.

The procedure was repeated at different temperatures.

Table 6.1 shows the results obtained. **[3]**

Table 6.1

temperature (°C)	number of drips per minute
5	3
10	6
20	14
30	26
40	19
50	0

Suggest brief explanations for these results.

- Active transport requires ATP

At low temperatures:

- Molecules have little kinetic energy
- Therefore less ATP made in respiration
- Therefore less loading of sugars into sieve tube
- Therefore less movement of water into sieve tube
- A low hydrostatic pressure created

As temperature increases:

- Molecules have more kinetic energy
- Therefore more respiration & more ATP made
- Therefore more loading of sugars into sieve tube
- More movement of water into sieve tube
- Higher hydrostatic pressure created
- At high temperature enzymes are denatured

This results in less loading of sugars into the sieve.

[Total: 7]