RHS

Including Examiners Comments

R3101

PLANT TAXONOMY, STRUCTURE & FUNCTION

Level 3
Wednesday 19 June 2024

09:00 – 10:40

Written Examination

Candidate Number: .....

Candidate Name: .....

Centre Name: .....

IMPORTANT – Please read carefully before commencing:

i) The duration of this paper is **100** minutes;

ii) **ALL** questions should be attempted;

iii) **EACH** question carries **10 marks**;

iv) Write your answers legibly in the spaces provided. It is **NOT** necessary that all lined space is used in answering the questions;

v) Use **METRIC** measurements only;

vi) Use black or blue ink only. Pencil may be used for drawing purposes only. Ensure that all diagrams are labelled accurately with the line touching the named object;

vii) Where plant names are required, they should include genus, species and where appropriate, cultivar;

viii) Where a question requires a specific number of answers; only the first answers given that meet the question requirement will be accepted, regardless of the number of answers offered;

ix) Please note, when the word 'distinct' is used within a question, it means that the items have different characteristics or features.

ANSWER ALL QUESTIONS

MARKS

Q1 a) Place **EACH** of the following plant categories in the group to which they belong by completing the table below: **3**

i) liverworts
ii) *Ginkgo biloba*
iii) ferns
iv) horsetails
v) conifers
vi) mosses

Bryophytes	**Pteridophytes**	**Gymnosperms**

b) State **TWO** conditions that favour the growth of mosses. **2**

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Please see over/…..

MARKS

c) Describe the structure of a typical moss. **5**

Please turn over/….

Total Mark

MARKS

Q2 a) Describe the structure of parenchyma tissue and cells **6**

Please see over/…..

MARKS

b) **NAME TWO** parenchyma tissues found in a woody stem. **2**

c) State the function for **EACH** of the tissues named in b) above. **2**

Please turn over/…..

Total Mark

MARKS

Q3 a) Explain how the following environmental factors affect transpiration water loss from leaves:

i) increasing temperature **3**
ii) decreasing windspeed **2**

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ii) .....

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MARKS

b) State how increasing the rate of transpiration affects plant growth. **5**

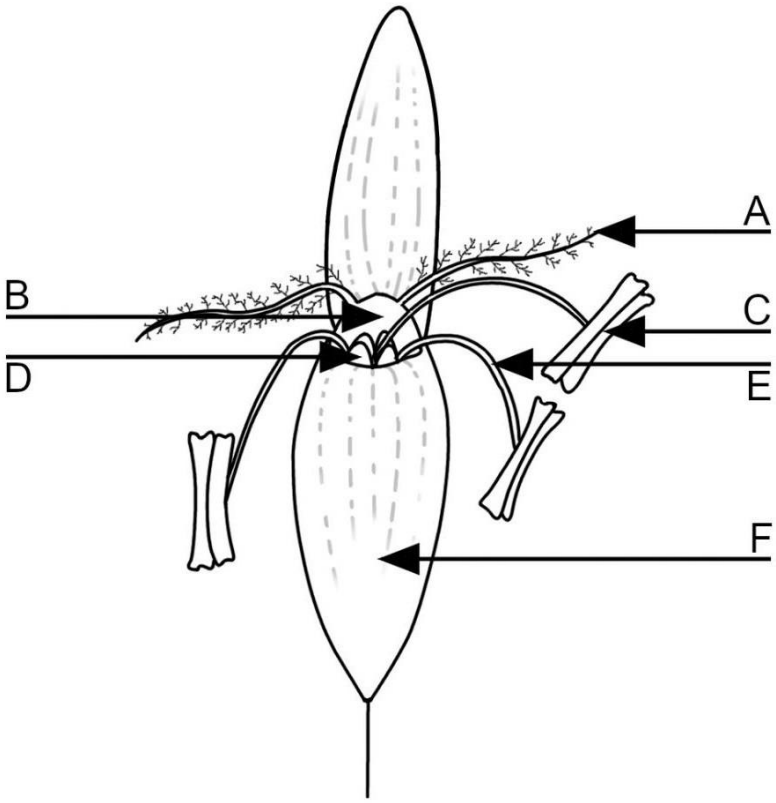
Please turn over/…..

Total Mark

MARKS

Q4 a) Name the features labelled A-F on the diagram grass flower below: **6**

A typical grass flower



A.....

B.....

C.....

D.....

E.....

F.....

Please see over/…..

b) State how **FOUR** of the features named in a) adapt the flower for wind pollination.

MARKS
4

Total Mark

Please turn over/….

MARKS

Q5 a) State the difference between synthetic and endogenous plant growth regulators (PGRs). **2**

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b) State **TWO** benefits of synthetic PGRs compared with endogenous PGRs. **2**

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Please see over/…..

MARKS

c) State the purpose of **TWO NAMED** PGRs for **TWO** distinct **NAMED** horticultural situations. **6**

Total Mark

Please turn over/…..

MARKS

Q6 Describe the process of fertilisation in a flowering plant. **10**

Please see over/…..

MARKS

Please turn over/…..

Total Mark

MARKS

Q7 a) Light is a key environmental factor in plant growth and development

Describe the role of the following substances in a plant's response to light:

i) chlorophyll **3**
ii) phytochrome **4**
iii) auxin **3**

Please see over/…..

MARKS

Please turn over/…..

Total Mark

MARKS

Q8 a) State the difference between dehiscent and indehiscent fruits **2**

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b) Describe the fruit characteristics of **TWO NAMED** dehiscent dry fruits and provide two plant examples. **8**

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Please see over/…..

MARKS

Total Mark

Please turn over/…..

MARKS

Q9 a) Name **ONE** environmental condition which favours C4 plants over C3 plants. **1**

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b) i) Name **ONE** C3 plant. **1**

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ii) Name **ONE** C4 plant. **1**

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c) Compare how photosynthesis differs in C3 and C4 plants under **EACH** of the following headings:

i) the photosynthetic process **4**
ii) leaf anatomy **3**

i) .....

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Total Mark

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Q10 a) Explain **TWO** reasons why the botanical names of plants might change.

MARKS 4

Please see over/…..

b) Explain how specific epithets can give information about plants using **THREE** distinct **NAMED** plant examples.

MARKS

6

Total Mark

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R3101 June 24 Examiner's Report

General points:

Where a plant example is chosen, it is important to write the FULL botanic name and not just a partial name, following the correct naming protocols.

Where named plant examples are required, ***common names are not credited*** *at level 3. Spellings of scientific terms and botanic plant names need to be full and accurate - poor spellings may be penalised.*

Where a number of answers are asked for e.g. ***THREE*** *environmental conditions, only the first three in a list will be marked.*

<table>
<tr><th></th><th></th><th></th><th>MARKS</th></tr>
<tr><td>Q1</td><td></td><td>Question</td><td></td></tr>
<tr><td></td><td>a)</td><td>Place EACH of the following plant categories in the group to which they belong by completing the table below:

i) liverworts
ii) Ginkgo biloba
iii) ferns
iv) horsetails
v) conifers
vi) mosses

<table><tr><th>Bryophytes</th><th>Pteridophytes</th><th>Gymnosperms</th></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table></td><td>3</td></tr>
<tr><td></td><td>b)</td><td>State TWO conditions that favour the growth of mosses</td><td>2</td></tr>
<tr><td></td><td>c)</td><td>Describe the structure of a typical moss</td><td>5</td></tr>
</table>

a) Most candidates correctly identified the plant categories as given below:

Bryophytes	**Pteridophytes**	**Gymnosperms**
liverworts	ferns	*Ginkgo biloba*
mosses	horsetails	conifers

b) Most candidates correctly gave moisture or a damp environment or high humidity and shade/low light as their answer.
c) Candidates struggled to describe the structure of a moss with many describing function rather than structure or describing the moss life cycle.

Better answers included:
no true leaves, roots or stems
low growing
with rhizoids, but several candidates misnamed these as rhizomes so gained no mark for this statement;
no vascular system no cuticle.

Most candidates knew that mosses produced spores and some correctly described the seta and capsule and a few correctly stated that there are two different structures (gametophyte and sporophyte) in the life cycle. Antheridia and archegonia were also credited if described.

			MARKS
Q2		**Question**	
	a)	Describe the structure of parenchyma tissue and cells	**6**
	b)	Name **TWO** parenchyma tissues found in a woody stem	**2**
	c)	State the function of **EACH** of the tissues named in b) above	**2**

a) This section was not well answered and few candidates could give 6 points describing the structure of parenchyma. Many described function or location. Some incorrectly stated cells were lignified or gave a list of organelles instead.

Better candidates included the following in their answers:

- Thin cell wall
- Cellulose cell wall
- Large vacuole
- Spherical
- Air spaces between cells
- May contain starch grains
- Contains organelles, credit was given to a named organelle

Candidates were credited if they stated that parenchyma tissue can be specialised as ‘chlorenchyma’ or ‘aerenchyma’

b) This was not well answered.

Most candidates correctly named medullary/parenchyma rays but secondary cortex/phelloderm was not generally known, some credit was given for stating ‘cortex’.

‘Xylem’ and ‘phloem’ were commonly mentioned but as these are both complex tissues, each containing more than one type of cell, credit could only be awarded for ‘xylem *parenchyma*’ and ‘phloem *parenchyma*’

c) The function of ray parenchyma transporting gases/ waste products/ sugars was generally well known.

The function most candidates mentioned was ‘storage’, but for a full mark to be awarded this needed to be qualified, e.g. ‘storage of starch’

			MARKS
Q3		**Question**	
	a)	Explain how the following environmental factors affect transpiration water loss from leaves:	
		i) increasing temperature	**3**
		ii) decreasing windspeed	**2**
	b)	State how increasing the rate of transpiration affects plant growth	**5**
			MARKS

This question was not answered well. Few candidates were awarded the full marks available for part a) and even fewer for part b).

a) Most candidates correctly stated that increasing temperature increases transpiration whereas decreasing windspeed reduces it.

Fewer candidates were able to explain why this occurs; for example, increased temperature speeds up the rate of water vapour diffusion from the leaf but some candidates confused the processes of evaporation and diffusion. Evaporation of water (liquid to vapour) occurs within the leaf whereas the vapour diffuses out through the stomata (not evaporates out through the stomata), but at very high temperatures stomata close and transpiration ceases. Decreasing windspeed led to a wider boundary layer and increases humidity next to the leaf so decreasing the water vapour gradient and thus decreasing the rate of diffusion of the water vapour from the stomata.

b) This was poorly answered. General statements like 'wilting' or 'reduced growth' did not earn full marks. Although these statements were credited, they needed to be qualified in the context of the question, e.g., a statement of HOW wilting affects plant GROWTH. e.g., Wilting will reduce light interception for photosynthesis, reducing the rate of photosynthesis and potential growth of the plant.
The expected level of response included:
High transpiration rates reduce cell turgor so cells do not expand fully leading to smaller plants and can also cause leaf shedding both of which will reduce photosynthesis and therefore the supply of sugars for growth.
High transpiration rates can lead to water stress and stomatal closure which will reduce CO_2 uptake for photosynthesis, again reducing the rate of photosynthesis and plant growth.
As the transpiration stream is responsible for movement of minerals up the plant an increased rate of transpiration would increase the supply to leaves and developing/growing fruit, with the potential of increasing growth.

Q4		Question	
	a)	Name the features labelled A-F on the diagram grass flower below: <u>A typical grass flower</u>	6
	b)	State how **FOUR** of the features named in a) adapt the flower for wind pollination	4

a) This was badly answered by a surprisingly large proportion of candidates

Most candidates were able to correctly name stigma and anther although some confused ovary and lodicule and some lemma with sepal.

A = stigma,
B = ovary**,**
C = anther,
D = lodicule, petal was given some credit
E = filament
F = lemma, 'bract' was given some credit where 'lemma' was not named;

Some credit was given for 'stamen' for either the anther C, or filament D (but not both)

b) Where candidates identified the flower parts correctly in a) they were mostly able to gain full marks, however few gained full marks for this question.

For a full mark the candidate needed to state how each feature aided wind pollination.

Flower parts described were:

A = stigma – this is feathery/hangs outside flower and increases surface area to catch pollen
C = anther – versatile/hinged or moves in breeze to release pollen, contains
many pollen grains which are light and small
D = lodicule – reduced size so as not to impede pollen release
E = filament – holds anther outside flower, is pendulous and flexible to catch the wind aiding pollen release
F = lemma - folds back/loosens as flower matures and exposes flower parts to wind for release and capture of pollen

			MARKS
Q5		**Question**	
	a)	State the difference between synthetic and endogenous plant growth regulators (PGRs)	**2**
	b)	State **TWO** benefits of synthetic PGRs compared with endogenous PGRs	**2**
	c)	State the purpose of **TWO NAMED** PGRs for **TWO** distinct **NAMED** horticultural situations.	**6**

a) Almost all candidates answered this correctly stating that synthetic PGRs are 'manmade' or are produced outside the plant whereas endogenous PGRs are produced within the plant or are naturally occurring

b) Most candidates were able to provide two benefits although marks were lost though lack of detail. Common examples of advantages of synthetic PGRs were:

- more <u>control over application</u> / timing / dosage/can mix different PGRs so easier to use in a horticultural situation. The practicalities of application and control over the time and place of application was the most cited benefit
- <u>choice of products so can tailor to the horticultural situation</u>
  products may have a broad spectrum or may be species specific

- May be <u>cheaper as easier to synthesise/ can produce in larger amounts</u> than natural PGRs whereas naturally occurring PGRs are present in very low concentration

The following benefits were not well known:

- Synthetic PGRs usually stable/store well whereas some naturally occurring PGRs break down e.g. Abscisic Acid ABA which is photosensitive
- Plants are less sensitive to synthetic PGRs so these are easier to utilise in a horticultural situation and you can apply in larger amounts than would occur naturally
- Not broken down by the plant so effect lasts longer/persist
- May have novel effects in the plant e.g. anti-gibberellins, inhibiting ethylene, destroying apical meristems etc**.** These effects are not available in naturally occurring PGRs

c) Marks were awarded for naming a horticultural situation together with the name of the PGR used and its purpose or effect.

There were many examples given which for which candidates were credited.
Distinct horticultural situations were needed for full marks, for example –paclobutrazol, daminozide and chlormequat are all used in bedding plant or protected plant production so could not be credited separately.

Common correct answers were**:**

Horticultural situation-Pot plant /bedding plant/protected plant /named plant e.g. chrysanthemum production
Plant growth regulator- paclobutrazol/daminozide/chlormequat
Purpose- Dwarfing agent/more branching/growth control/earlier budding

Turf/amenity grassland/sports pitches
Plant growth regulator - Trinexapac-ethyl
Purpose - Reduces height of sward/reduces need for mowing/growth retardant

<u>Stem/semi ripe/hardwood cuttings</u>
Plant growth regulator – Indole-3- butyric acid IBA
Purpose -to induce roots

Banana postharvest treatment in storage
Ethene/ethylene/Cerone
Control ripening

Potato/onion in storage
Ethene/ethylene/Cerone OR maleic hydrazide
To prevent sprouting

Apple orchards
Gibberellins
Improve fruit set improves fruit yield/quality/reduce russeting

Forestry seed/*Nothofagus* propagation *(not just general seed germination)*
Gibberellins
Stimulates germination

Micropropagation only one of the following PGRs could be credited as micropropagation is the horticultural 'situation' so where the different balance of auxin and cytokinin was discussed to develop roots and shoots, marks could only be awarded for one of the PGRs
Cytokinin /kinetin/ zeatin
Stimulates shoot development
Auxin/IAA /NAA
Stimulates root development

			MARKS
Q6		**Question** Describe the process of fertilisation in a flowering plant.	**10**

Fertilisation was not well described with few candidates scoring highly. There was a general lack of detail in their answers.
There was confusion about the role of the male gametes, the female gamete/ovum and the endosperm nucleus.
Some candidates thought that pollen grows down the style and that the pollen itself was the male gamete.

Candidates who scored highly described the process in chronological sequence
and included all main/key parts of the process in their description**- in bold below**

- Pollen grain is received on stigma (part of pollination process)
- Pollen grain germinates
- **A pollen tube, which contains two male gametes, grows from the pollen grain and down through style**
- Pollen tube also contains one pollen tube nucleus
- **Pollen tube enters** the ovule **through the micropyle**
- Delivers male gametes into the ovule
- Male gametes/ovum are haploid
- **One male gamete fuses with ovum/female gamete/egg cell**
- **One male gamete fuses with endosperm nucleus**
- Endosperm nucleus is diploid
- To give/produce triploid endosperm
- Fertilisation of ovum gives rise to zygote (diploid)
- Described as double fertilisation

			MARKS
Q7		**Question** Light is a key environmental factor in plant growth and development Describe the role of the following substances in a plant's response to light: i) chlorophyll ii) phytochrome iii) auxin	 **3** **4** **3**

Many found this very challenging, and some did not attempt it at all or only in part. Marks were lost in each section due to a lack of detail.
The roles of chlorophyll and auxin were more commonly attempted than that of phytochrome which was not understood by many.

i) The role of chlorophyll was generally well understood in its role of absorbing /capturing light for photosynthesis. Although everyone knew that it is involved in photosynthesis (as expected), some did not expand on this further, e.g., that the light absorbed is of specific wavelengths (400-700nm/PAR)

A proportion also stated this chlorophyll is involved in the light dependent reactions of photosynthesis.

No one stated that chlorophyll is part of the two photosystems or that chlorophyll is present in two forms, a and b.

ii) Many candidates did not answer this part of the question.
Phytochrome is involved in the photoperiodic response which is the response of plants to the relative length of alternating periods of light and dark/daylength/night length which may trigger flowering or vegetative growth.
Phytochrome exists in two forms – Pr which absorbs red light (which converts it to Pfr) and Pfr which absorbs far red light which converts it to Pr**.** It is fully in the form Pfr in daylight and converts slowly to Pr at night.
Pfr is the active form and the amount of Pfr at end of night triggers the plant 's response**.**

In relation to photoperiodic response candidates generally mentioned short-day plants (SDPs), long day plants (LDPs) (day-neutral plants not being affected).

Where the critical daylength (CDL) was mentioned in context, this was also credited.

Phytochrome is also involved in the response to seasonal changes and other developmental processes such as etiolation, storage organ development, leaf abscission.

iii) This was attempted by most candidates and was generally described in relation to phototropic response; thigmotropism and gravitropism are not responses to light and therefore were not credited.
Auxin is Involved in the plant's phototropic response. Most candidates described the tropic response in the shoot in detail.
Auxin is produced in apex of shoot and translocated down shoot**,** it accumulates on shaded side of the shoot where it stimulates cell enlargement causing the shoot to bend/grow towards the light - a positively phototropic response.

			MARKS
Q8		**Question**	
	a)	State the difference between dehiscent and indehiscent fruits	**2**
	b)	Describe the fruit characteristics of **TWO NAMED** dehiscent dry fruits and provide two plant examples.	**8**

a) Some candidates incorrectly described dry and succulent fruits here rather than fruits which split open to release seeds (dehiscent) and fruits which are broken down to release seeds (indehiscent).

b) This section was generally well answered if candidates had correctly understood/applied the term dehiscent.

The emphasis of this question was the requirement for a description of the fruit characteristics - Describe the fruit characteristics of **TWO NAMED** dehiscent dry fruits and provide two plant examples.
Candidates were rewarded for details of fruit characteristics relating to their two named dehiscent dry fruits, and correctly named plant examples for these fruit types. Because of the perceived ambiguity of the question, maximum marks could also be achieved by candidates if the fruit characteristics given matched two named plant examples for each fruit type.
The most common answer given was legume, followed by capsule.

Examples of correct answers are given below:

Name of dehiscent dry fruit	**Fruit characteristic**	**Plant example/s**
Legume	• 1 carpel • Splits along two sides • 1+ seeds • Pericarp twists apart on drying	*Phaseolus vulgaris* *Vicia faba*
Capsule	• 2+ carpels • Seeds shaken out through pores • Censer	*Papaver orientale* *Viola odorata*
Follicle	• 1 carpel • Splits along one side • 2+ seeds	*Magnolia stellata* *Paeonia lactiflora*
Siliqua/silicule	• 2 carpels • Pericarp splits along all sides • 2+ seeds • central septum/replum left on dehiscence	*Lunaria annua* *Capsella bursa-pastoris*

Q9		Question	
	a)	Name **ONE** environmental condition which favours C4 plants over C3 plants	**1**
	b)	i) Name **ONE** C3 plant	**1**
		ii) Name **ONE** C4 plant	**1**
	c)	Compare how photosynthesis differs in C3 and C4 plants under **EACH** of the following headings:	
		i) the photosynthetic process	**4**
		ii) leaf anatomy	**3**

a) Most candidates were able to describe one environmental condition favouring C4 plants as either high temperature or high light intensity.
'Desert conditions' was not accepted as a response as this may include low temperature.

b) Most candidates were able to name one C4 plant, almost always *Zea mays or Saccharum officinarum* and one C3 plant, however a surprising number of candidates could not name a C3 plant, e.g. *Quercus robur*, *Rosa rugosa* (most plants which have evolved in temperate climates) and some incorrectly named succulents /CAM plants instead of C4 plants.

c) i)This section was not well answered, with few candidates being able to describe the differences in the photosynthetic process, many candidates confusing C4 with CAM plants.

Maximum marks could be achieved by candidates stating that:

- C3 plants are less efficient at high temperatures than C4 plants
  or conversely C4 plants are more efficient than C3 at high temperatures

- Oxygen inhibits CO_2 fixation/photosynthesis in C3 plants but not in C4 plants;
  Photorespiration occurs in C3 plants but not in C4 plants

- In C4 plants CO_2 is fixed into C4 molecule/malate
  In C3 plants CO_2 is fixed into C3 molecule
  or CO_2 fixed as different molecules

- In C3 plants CO_2 fed directly into Calvin cycle in chloroplasts of mesophyll
  whereas in C4 plants the C4 molecule/malate is transported to centre of leaf/bundle sheath or CO_2 released into chloroplasts in the bundle sheath

Details or metabolic pathways were not required, however where candidates gave accurate information about the different enzymes and acceptor molecules involved in C3 and C4 plants this was credited.

c) ii) Few candidates were able to accurately compare leaf anatomy of C3 and C4 plants

Valid comparisons included:
In C3 plants chloroplasts in mesophyll carry out both stages of photosynthesis, i.e light dependent and light independent stages, whereas in C4 plants *light dependent reactions* occur in mesophyll cells and *light independent reactions* in bundle sheath cells/ cells in centre of leaf.

In C3 plants the chloroplast structure is consistent throughout the mesophyll but in C4 plants there are different chloroplast structures in different parts of the leaf.

C3 plants have a less developed or absent bundle sheath
C4 plants have Krantz anatomy with a pronounced bundle sheath

There are no chloroplasts in bundle sheath cells in C3 plants, or C3 plants have chloroplasts only in mesophyll cells, whereas C4 plants have chloroplasts in bundle sheath cells and mesophyll cells

Leaves of C4 plants are darker green around vein whereas leaves of C3 plants are lighter colour around vein

			MARKS
Q10		**Question**	
	a)	Explain **TWO** reasons why the botanical names of plants might change.	**4**
	b)	Explain how specific epithets can give information about plants using **THREE** distinct **NAMED** plant examples	**6**

a) Most candidates were able to describe two reasons from:

- **reclassification**/put in another taxonomic group due to new knowledge, the results of DNA testing were often correctly mentioned by candidates as the reason for reclassification

- **nomenclatural / compliance with rules of ICN (International Code of Nomenclature)** e.g. due to Law of Priority OR a description of a rule OR new name not accepted so old name may be conserved

- **mistaken identification** wrong name given on introduction /new research shows it is a different plant to that which it was thought to be/tradename or cv. name used instead of botanical name. Some candidates mentioned because of comparison with herbarium specimens (which are now becoming available in digital format) and this was also credited.

b) This part was generally well answered with most candidates giving three plant examples and explaining the meaning of each specific epithet.

Some candidates confused specific epithet, the second part of a binomial name of a plant species, with genus which was not credited, likewise, cultivar and variety names were not credited.
Better candidates gave the full meaning rather than general concepts such as ‘origin’ or ‘colour’. Some examples are:

Camellia japonica indicates the species originated in Japan
Sambucus nigra indicates colour -in this case black - referring to the black berries
Caltha palustris indicates its natural habitat in marshland
Trifolium repens indicates a creeping habit - this plant creeps using stolons
Quercus robur- meaning robust- referring to the strength of its hard wood
Berberis darwinii named in commemoration of /after Charles Darwin -in this case the plant was discovered by Charles Darwin