BSc Degree Examination 2018-9

Department: BIOLOGY

Title of Exam: Animal and Plant Biology part 1

Time Allowed: 1 hour and 30 minutes

Marking Scheme: Total marks available for this paper: 50
The marks available for each question are indicated on the paper

Instructions: Answer all questions in the spaces provided on the examination paper

Materials Supplied: CALCULATOR

For marker use only: Office use only:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total as %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DO NOT WRITE ON THIS BOOKLET BEFORE THE EXAM BEGINS
DO NOT TURN OVER THIS PAGE UNTIL INSTRUCTED TO DO SO BY AN INVIGILATOR

Page 1 of 6
1) Briefly explain how the evolution of plants contributed to the diversity of life on the planet (5 marks)

The evolution of early land plants triggered significant falls in atmospheric CO2 and global temperature (1 mark). This also enabled new plant groups to evolve larger and broader leaves. The success and diversification of plants led to further reduction in atmospheric CO2 and global temperatures (1 mark), as well as further increases in atmospheric O2 (1 mark) enabling animals to establish themselves on land (1 mark). Later, the evolution and diversity of Angiosperms, or flowering plants, had a significant impact on the number and diversity of insects and terrestrial arthropods by producing more diverse opportunities of food and nutrition (such as seeds and nectar) (1 mark).

2) Briefly describe an example where experimental evidence has been used to demonstrate that increased pollination efficiency promotes outbreeding (5 marks)

A good example is an experiment using Antirrhinum which has flowers that are relatively large and can be only opened by bees. The flowers also have a landing platform, bee guides and nectar. Experimental evidence demonstrates that Antirrhinum emits a scent, a volatile ester called methyl benzoate, which is relatively straightforward to detect and measure (1 mark). The scent exclusively attracts bees. The scent is produced in the highest quantities when bees are most active at midday (1 mark). The scent is produced from petal tissue closest to the opening of the flower, which encourages bees to enter the corolla tube. The peak of scent production coincides with the dehiscence of the anthers and ripening of the pollen grains, and prior to the stigma becoming receptive to pollen (1 mark). This strategy is also successful because it targets a single pollinator (1 mark). Bees show an increase in the frequency of visits to a different Antirrhinum plants that is dependent on these scent emissions, transferring pollen between different individual plants to promote outbreeding (1 mark).

3) Briefly describe and explain a mechanism that enables plants to avoid inbreeding (5 marks)

Plants use a number of mechanisms to avoid inbreeding. Dichogamy (protandry or protogynry) are good examples of these. Other examples include sporophytic or gametophytic self incompatibility, dioecy or monoecy. The model answer below is one possible answer to this question.

Geranium columbinum operates a mechanism of 3 phase protogynry (1 mark); in phase 1 stigmas are open to favour cross pollination (1 mark), in phase 2 the first five anthers open this again favours cross pollination (because pollen is likely transferred to other plants), but is also a fail mechanism because the stigma are still open and receptive (1 mark), in phase 3
the sigmas wither after pollination, but another five anthers mature and release pollen promoting outbreeding with other flowers (1 mark). This strategy demonstrates that phased release of pollen can favour outbreeding by increasing the amount of available pollen to plants of this species via the pollinators they attract and at a point at which the female reproductive structures are receptive to pollen (1 mark).

4) Briefly describe the experimental approach and conclusions from the original experiment that demonstrated that plants can develop systemic acquired resistance to a virus (5 marks)

This experiment was carried out by Frank Ross in 1961. He hypothesised that plants can gain immunity from infection by a virus to resist further attack and spread of a disease. A single leaf from a plant is infected with a virus (1 mark). One week later a different leaf from the same plant is infected with the same virus (1 mark). The first leaf that is infected shows necrotic lesions form the hypersensitive response (1 mark). The second leaf shows no visible sign of infection or disease (1 mark). Conclusion the plant has acquired immunity to the virus that is transmitted to previously undamaged parts of the plant (1 mark).

5) Briefly describe the experimental evidence that explains why some wild populations of chilli pepper taste ‘hot’ and others do not (5 marks)

It has been shown that wild chilli peppers are adapted to different environments (1 mark) and phenotypic variation is important in wild populations of chillies. This variation appears balanced between different environments due to an evolutionary trade-off between the hotness of chilli peppers (due to the amount of capsaicin present in the fruit), and the density of stomata in the leaves (1 mark). Pungent plants have been shown to be much more resilient to fungal attack than non-pungent plants in wet or humid conditions (1 mark). This has been examined further and evidence also suggests that even though pungent plants produce fewer seeds, they have a fitness advantage in humid or wetter climates (1 mark). In drier climates a lower stomatal density is much more advantageous because it reduces water loss. In areas where pathogens are much less prevalent, it has been shown that populations of non-pungent chilli peppers benefit more than pungent plants. In these conditions non-pungent plants appear to use limited water resources more efficiently than than pungent plants (1 mark).
6) a. Briefly describe how CO\(_2\) uptake and water loss in plants are linked and how this is regulated.  

CO\(_2\) is taken up into the plant by the stomata and water is lost by the same route (1 mark). Stomata close in response to low water sensed at the roots (1 mark) and open in response to light (1 mark). 

*a lot of answers not getting the full mark because they’re not saying what *opens* the stomata or they’re not saying *where* the signals are detected.* 

*a lot using CAM as an example - give credit but not what I was looking for* 

If only one response was given, I wanted more about the regulation - if you mentioned ABA only as a response to water limitation, then you had to mention it was at the roots, for example.

b. A plant breeder has developed two varieties of wheat that differ only in the stomatal density on the leaves. Variety A has normal stomatal density, and variety B has higher stomatal density. Do you think the growth of these varieties will be different? Explain your answer. 

The answer to this question hinges on the whether the stomatal physiology remains the same in both varieties, or whether stomatal conductance will change as a result. (1 mark) If stomatal behaviour is the same, then variety B, the novel one with higher stomatal density, will lose more water, despite the potential for increased CO\(_2\) uptake, so growth will be less (2 marks). The alternative is that the variety B plants will adapt stomatal opening so that CO\(_2\) uptake and water loss are the same as variety A (1 mark). 

*credit given for sensible interpretations.*

*many are assuming this is physiological - ie as a consequence of dev in high co2 - and not reading the Qn...* 

*excess of stomata = thicker leaves...? where has that come from?* 
*I’m saying *what would happen if water is limiting? A lot are sayig this is an issue, but not saying that the plant would just close the stomata *more* and thus be unaffected wrt A*

7) a. Describe an example of a plant association with a soil organism that increases plant nutrient uptake (2 marks) 

accept legume-nodulation; arbuscular mycorrhizas; ectomycorrhizas. 

*earthworms? usual confisuion about N uptake and N fixing - need to say what each partner gets, lots of people not saying plants give carbon*
b. Consider 2 plant species, one that has short, unbranched roots and the other with a large, finely branched root system. Briefly compare the trade-offs each plant species is making between nutrient uptake and growth (5 marks).

The main point of this answer is demonstrate that you understand how investment in non-photosynthetic tissues such as roots, may affect growth.

The plant with a large root system invests a lot of carbon in root, but in doing so, increases surface area, and will take up enough nutrients to fuel photosynthesis and growth. (2 marks)
The plant with a poor root system may lose less carbon to growing roots (1 mark) but if soil nutrient concentrations are high, then growth and photosynthesis should not be affected. (1 mark). Alternatively, these species are more likely to spend additional carbon on nutrient acquisition methods, eg mycorrhization or cluster roots (1 mark)

weaker answers are not making the link between soil nutrients and carbon - can't have above ground growth without enough nutrients - gave credit where ruderal traits were used as explanation. *penny drops* short unbranched is being interpreted as tap roots, ie storage a lot of answers treat this as zero-sum - both types are the same “size” but infact the bigger root system facilitates more C uptake

8)

a. Describe how the arrival of action potentials at a chemical synapse leads to neurotransmitter release. (3 marks)

The arrival of action potentials leads to the opening of voltage-gated calcium ion channels (1). Calcium ions enter the axon terminal (1), and the increased calcium ion concentration leads to the fusion of vesicles containing neurotransmitter molecules with the presynaptic membrane, thereby releasing the neurotransmitter (1).

Many answers were awarded full marks. The first mark was not awarded if it was not made clear that the calcium ion channels are voltage-gated.

b. Explain how exposure of the postsynaptic membrane to neurotransmitter molecules can inhibit the generation of action potentials in the signal-receiving neuron. (5 marks)

Binding of neurotransmitter molecules to receptors at the postsynaptic membrane leads to the opening of ion channels (1). If the opening of these channels allows an outflux of positively charged ions (1) or an influx of negatively charged ions (1), this leads to membrane hyperpolarisation (1). The hyperpolarisation counteracts any depolarisation that could trigger the generation of action potentials (1).

Many good answers, but often not enough detail included (e.g. often not explained how hyperpolarisation is achieved). Some confusions with the refractory period.

c. What are the three key characteristics of a reflex? (3 marks)
A reflex is an automatic (1), rapid (1) and predictable (1) response to a stimulus.

Most answers mentioned that the response is automatic and rapid, but not many answers included that the response is predictable.