NATURAL SCIENCES TRIPOS 2017

IA PHYSIOLOGY OF ORGANISMS

SENIOR EXAMINER'S SUMMARY REPORT

Examiners

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Structure of the examination

The examination consisted of a Written Practical paper of 90 minutes duration and a Theory paper of three hours duration.

The Written Practical paper consisted of three short-answer questions on material taught in the practical classes. The questions required the candidates to explain experimental procedures, interpret results similar to those acquired in the practical classes, and to perform calculations based on experimental data or measurements made from experimental records. One question related to a Plant Physiology practical class and the other two to Animal Physiology classes. The questions were equally weighted and together carried 25% of the total marks for the examination.

The Theory Paper contained two sections. Section A consisted of 45 multiple choice questions designed to test factual knowledge central to the understanding of the course material. Candidates were asked to select one answer out of five options. The completed sheets were delivered with a master answer sheet to Cambridge Assessment for scoring. Section A carried 25% of the total marks for the examination.

Section B required the candidates to write essays on two questions chosen from a total of six. Four of the six questions required integration of course material relating to animals, plants and microorganisms, while two questions (available as on either/or option) were specific to course sections relating to either plants or animals. Section B accounted for 50% of the final mark with the two essays being equally weighted.

191 candidates completed the examination. After scaling as laid down by the Natural Sciences Committee, 25.13% of candidates received a first class mark, 64.92% a second class mark and 9.95% a third class mark. No candidates failed. One candidate completed only the practical paper (see below) and four withdrew before the start of the examination.

<u>Written Practical Paper</u>

The mean raw mark for this paper was 64.5%, with a standard deviation of 8.9% and a range of 37.7% - 82.5%

Theory Paper: Section A

The mean raw mark for Section A in the Theory Paper was 63.4%, with a standard deviation of 11.9% and a range of 26.7 - 93.3%.

The candidates were divided into quartiles on the basis of their overall Section A mark and the examiners scrutinised the distribution of correct answers given by each quartile. In three questions the first quartile underperformed the second, but on inspecting the questions the examiners allowed the marks for these questions to stand. The lectures setting these questions of those achieving poor discrimination will be informed ahead of the next examination.

Theory Paper: Section B

Marking was guided by the Faculty of Biology mark scheme. The mean raw mark for Section B was 63.6%, with a standard deviation of 8.3% and a range of 43.8 - 85.0%.

Conduct of the examination.

The sitting of both papers passed without incident. The only questions asked of the examiner in attendance at the Written Practical paper concerned writing outside the boxes provided for answers on the question paper. No questions were asked during the Theory Paper.

After the theory paper one script from a candidate sitting the paper in college went missing and was eventually declared lost by the Head of the Board of Examinations, who instructed the Chairman to class the candidate on the basis of the papers completed and marked.

Feedback on the practical component of the exam:

Question 1

Mean mark: 61.8%

Most candidates showed reasonable knowledge of the material covered in this practical. The detail given in description of the procedure for measuring arterial blood pressure by the auscultatory method varied. A number of candidates failed to describe how to obtain an estimate of systolic pressure by palpitation prior to using the auscultatory method and some did not mention the auscultatory gap. A number of candidates did not know how to obtain the mean arterial blood pressure from the systolic and diastolic pressures. Many descriptions of the cardiovascular events during exercise were good, but very few candidates correctly explained how heart rate is increased during exercise. Many candidates did not address the effects of the autonomic nervous system on the sino-atrial node. A large proportion of candidates instead wrote about what they believed to be the underlying causes of the increase in heart rate, suggesting these to be changes in PO_2, PCO_2 and pH in arterial blood. Most measurements made from experimental records and the calculations performed using these data were done well.

Question 2

Mean mark: 64.1%

Most candidates were able to integrate basic knowledge associated with the specific practical on nitrate uptake and induction of nitrate reductase activity procedures, as well as information derived from related practical exercises. There were some issues in terms of graph plotting which related to scaling from calibration data to experimental values, and other errors were made in scaling various components of an assay, or basic assumptions associated with spectroscopy. These errors tended to arise because procedures described in the question differed slightly from those used to generate data in the specific practical, in order to test the depth of understanding of experimental protocols. Other parts of the question required candidates devise additional experimental procedures to test basic assumptions, or account for other confounding factors which may have affected plant growth and responsiveness to nutrient additions. Finally, candidates were expected to apply knowledge gained from a different practical to test their understanding of methodological procedures which would allow a more detailed analysis of protein induction and expression, but a number of candidates failed to do this.

Question 3

Mean mark: 67.5%

The data handling in this question was extremely accessible and students either got most of it right or most of it wrong. One common mistake was to assume that the energy expenditure given (in kcal) referred to useful work instead of total energy expended, which made them carry forward the wrong value for subsequent questions. I don't believe the question was at all ambiguous, and some candidates simply did not read it carefully. The other recurring mistake was in calculating the energy required to heat 500 ml of water by 33ºC (from 4ºC to 37ºC). It was assumed that candidates would know 1 calorie is the energy needed to raise the temperature of one gram of water by one degree Celsius. Many candidates did, but others thought it was 1J, or claimed that they "needed to have been given the heat capacity of water" to be able to answer the question. Many candidates did very well with the data handling but actually had no idea as to the physiological implications of exercising in hot conditions. A few candidates did an outstanding job of thinking about osmoregulation, heart rate, blood pressure changes and other challenges, but most did not think of anything except increased sweating. The ideas as to how to attempt to accurately calculate sweat production were mostly basic and uninspiring (not wrong, but not good), but some students did very well, and others provided what could be considered colourful and entertaining, if implausible, experiments.

Feedback on the essay component of the exam:

Question B1a: ***Discuss the mechanisms involved in the regulation of turgor pressure.***

Mean mark: 59.9%. 22 candidates.

The best answers provided a detailed explanation of the origins and components of turgor pressure, and relative functioning in higher plants, bacteria and fungi to drive growth and differentiation. Other good points included the progressive use of solute accumulation (under drought or salinity) to maintain overall plant turgor pressure. Other key elements occasionally included leaf movement (based on pulvini), or illustrated turgor-driven phloem loading and unloading. Many headed straight to the example of guard cell turgor (gain or loss) and detailed mechanisms of stomatal sensitivity, without initially setting the scene to define how a cellular turgor-based mechanism helps to regulate overall plant water status, and hence turgor. The best essays were well organised with a good sense of progression and integration of ideas, the worst were those which tried to write more comparatively of osmoregulation in animals (sometimes to the exclusion of nearly all plant examples).

Question B1b: ***Discuss the mechanisms involved in the regulation of arterial blood pressure.***

Mean mark: 58.9%. 43 candidates.

Many candidates gave good accounts of the functioning of arterial baroreceptors and outlined baroreflexes. However, the details of the mechanisms underlying the actions of the autonomic transmitters and adrenaline on the heart were often sketchy or absent and many candidates did not mention the role of the vagus nerve in changing heart rate. Many candidates incorrectly proposed that the parasympathetic nervous system has widespread effects on vascular tone. A number of candidates referred to the constriction or dilatation of arteries rather than arterioles and very few mentioned veins. Many candidates did not mention the possible role of antidiuretic hormone and a number of those who did discussed the actions of this hormone on water reabsorption in the kidney rather than its action on the vasculature. Some of the weaker candidates did not give equations relating key cardiovascular variables and discussed only actions of the heart or vasculature in adjusting arterial blood pressure, rather than both.

Question B2: ***Compare and contrast how animals and plants sense changes in the external environment.***

Mean mark: 62.1 %. 79 candidates.

This question was reasonably well answered. Not surprisingly all candidates chose to discuss the detection of light in both plants and animals. The stronger candidates were able to provide a detailed description of the transduction process and provide a comparison between *Drosophila* and humans. Nearly all candidates were able to discuss the activation of phytochromes in plants but only the stronger ones went on to describe the functions that this detection enabled. Some candidates failed to discuss circadian rhythms. The next most popular topic was the detection of gravity and many candidates gave a good comparison between the otoliths in animals, including hair cell transduction, with the statoliths and statocysts in plants. Less than 50% of the cohort chose to discuss the venus flytrap and/or *Mimosa pudica* (thigmotropism) but those that did were able to give a good comparison with movement/touch detection in animals. A few candidates discussed temperature sensing while others chose to discuss nutrient foraging and NRT 1.1 signalling. Even fewer discussed response to wounding e.g. insect chewing.

Question B3: ***What are the limitations of diffusion? How are these overcome?***

Mean mark: 69.0%. 157 candidates.

Overall this question was well answered and the majority of students answered to a good standard. Most students, however, did not give enough detail on the process of diffusion itself (Fick's law and/or Einstein's law, and adaptations to improve diffusion rates), instead leaning heavily onto details on bulk flow as a mechanism to overcome limitations. The best essays were balanced in terms of detail and rich in examples from different organisms, and made good points in linking the two, clearly stating that they are complementary mechanisms, not exactly mutually exclusive (which many of the weaker candidates implied). Many essays included multiple examples on mechanisms for transport or movement *outside* of diffusion and bulk flow, and often these were very well written and contextualised essays. The weaker candidates, although they could provide examples and an overall account, lacked depth and provided minimal detail and very limited examples, often the standard found in their handouts, or less, or limited their narrative to one single example, or one only kind of organism.

Question B4: ***How are membrane potentials used in signalling and transport?***

Mean mark: 56.4%. 48 candidates.

The quality of answers to this question was variable. The strongest candidates were able to give detailed accounts of mechanisms found in animals, plants and microbes. Many candidates wrote little or nothing on the origins of membrane potentials, and a number suggested that animal cell membrane potentials were created by the electrogenic effect of the Na^+/K^+-ATPase. Many descriptions of the mechanisms underlying action potentials in neurones were very basic and surprisingly few candidates commented on the functioning of voltage-gated channels. Most candidates gave reasonable or good descriptions of the actions of abscisic acid in causing stomatal closure but very few discussed stomatal opening. Many of the weaker candidates failed to address transport and appeared to have run out of time.

Question B5: ***What advantages do large organisms have over smaller ones? At what cost?***

Mean mark: 60.9 %. 34 candidates.

The best answers provided a mechanistic comparison of scaling in plants and animals, illustrated with graphs and supporting equations which were used to derive empirical relationships. These included considerations of Surface Area : Mass, heat balance, diffusion vs circulation pressures in mass flow systems, movement, mechanical support/strengthening, overall organismal energetics in terms of the costs of reproduction/longevity/seedsize, as well as visual acuity and light utilisation. Many answers were largely descriptive and were not always well-integrated between plants and animals. The most striking omissions were the modular nature of plants, relative to scaling of organs in animals in relation to body size, and phenotypic plasticity in plants relative to mobility, although some of these points are slightly peripheral to the main question. Overall, the second element of the question was more often addressed as an afterthought in all but the best answers.

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Date: June 24th 2017