Unpacking and validating the “integration” core concept of physiology by an Australian team

Unpacking the 'Integration' Core Concept of Physiology by an Australian team.

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ABSTRACT

Consensus was reached on seven core concepts of physiology using the Delphi method, including '*Integration*', outlined by the descriptor, 'cells, tissues, organs, and organ systems interact to create and sustain life'. This Core Concept was unpacked by a team of three Australian physiology educators into hierarchical levels, identifying five themes and ten sub-themes, up to one level deep. The unpacked core concept was then circulated amongst twenty-three experienced physiology educators for comments and to rate both level of importance and level of difficulty for each theme and sub-theme. Data were analysed using a one-way ANOVA to compare between and within themes. The main theme '*The body is organised within a hierarchy of structures, from atoms to molecules, cells, tissues, organs, and organ systems*' almost universally rated as 'Essential'. Interestingly, the main theme, also rated between 'Slightly Difficult' to 'Not Difficult', which was significantly different from all other sub-themes. There were two separate subsets of themes in relation to importance, with three themes rating between 'Essential' and 'Important', and the two other themes rating as 'Important'). Two subsets in difficulty of the main themes were also identified. While many core concepts can be taught concurrently, *Integration* requires application of prior knowledge, with expectation that learners should be able to apply concepts from cell-cell communication, homeostasis and structure and function, prior to understanding the overall Integration core concept. As such, themes from the *Integration* core concept should be taught within the endmost semesters of a Physiology program.

Keywords: Physiological Integration, Interdependence, Higher education, curriculum design, integrative physiology.

NEW & NOTEWORTHY

This article proposes the inclusion of a core concept regarding "*Integration*" into a physiology-based curricula, with the descriptor: 'cells, tissues, organs, and organ systems interact to create and sustain life'. This concept expands prior knowledge and applies physiological understanding to real-world scenarios and introduces contexts such as medications, diseases and ageing to the student learning experience. To comprehend the topics within the Integration core concept, students will need to apply learned material from earlier semesters.

INTRODUCTION

When a student embarks on a tertiary science or health-based degree program, the learning experience will vary depending on the providing institution. Different programs will embed different amounts of research, technology, hands-on learning, practical laboratories, online modules and other modes for learning within their curricula (1). This is important, as although students choose a university based upon a number of factors, such as geographical characteristics, the admissions process or school atmosphere (2), the offering of unique teaching methods or tailored curricula also influences their decision (3). As such, it is in a tertiary institution's interest to provide something different and out-of-the ordinary to attract and retain students. Unfortunately, this means that a student graduating from one program may have quite a different set of skills and experiences than a student from an alternate institution, presenting the importance of offering 'core concepts' for various disciplines. Core concepts form a recommended curriculum, which would be expected outcomes for learning within a course (4). Although universities may accommodate and assess the concepts in different ways, structuring parts of a program around core concepts provides students, employers, and community stakeholders with a clearer understanding of expected graduate knowledge within a field. However, there is no 'one size-fits all', as curricula can vary greatly between countries (5), and as such, there is benefit from identifying which core concepts are specifically important to each national community. To accomplish this, programs and concepts should be reviewed within the proposed country of implementation and focussed on specific disciplines. In Australia, nation-wide agreement was reached on seven core concepts of physiology, along with their descriptions, using the Delphi method (6). The core concepts agreed on were 1) Cell-cell Communication, 2) Cell membrane, 3) Movement of Substances, 4) Homeostasis, 5) Structure and Function, 6) Integration and 7) Physiological Adaptation. This article investigates the fundamentals of Physiology, and unpacks the core concept, "*Integration*".

Physiological integration collectively describes how cells, tissues, organs, and organ systems interact to create and sustain life. This concept can present a challenge to both students and educators as much of the underlying core knowledge from prior core concepts, such as cell-communication or homeostasis is assumed. The foundational semesters of a physiology-based degree often focus on providing students with an introductory understanding of human body functions (7), with students often approaching physiology concepts in a systems-focussed approach, or as a series of independent and unrelated phenomenon concepts (8). Teaching in the foundation years can also be somewhat didactic (9) with little encouragement for students to see the big picture around what they are learning, which can enhance achievement engagement (10). As such, while placing a focus on more applied concepts using authentic activities and experiences can ensure that graduates have a robust and clear understanding of physiology, this is best accomplished when prior learning of the fundamental core concepts has been performed. One of the key knowledge requirements for a physiology graduate is that they develop an ability to apply this foundation content to more complex real-life scenarios (11). This highlights the need for more advanced core concepts, or ones that build-upon concepts focussed on throughout foundation semesters and subjects. *Integration* is one example of this type of higher-level concept, and this article outlines the processes and presents results from its unpacking.

METHODS

To reach consensus on the core concepts of Physiology, academics teaching physiology across Australia were invited to establish these concepts by surveying a contingent of Australia-Wide physiology-based academics following a process outlined in (6). For this, a national task force was assembled and a four-phased Delphi method, a structured process used to arrive at a group opinion, was used to identify the seven core concepts associated with Physiology. Each concept was randomly assigned by the project lead to a team of three academics from the Task force to unpack into themes and sub-themes. The core concept of *Integration* was developed as part of this process (6).

Unpacking Team:

Three experienced physiology-based academics from the national task force were randomly selected to the *Integration* core concept by the project lead (KT). The unpacking team (CM, RTD, RP) themselves had a combined 68 years' experience teaching physiology and worked across three different Australian Universities. Each member had a role in the design of both physiology curricula and assessment. Unpacking was performed over several weeks and assisted by a facilitator (MT) using a method adapted from previously published work (12). Meetings were held by video conference, with online documents shared between the meetings.

Evaluation of proposed themes:

After development by the unpacking team, the proposed *Integration* themes and sub-themes were entered into a Qualtrics survey and distributed through a hyperlink to 25 physiology academics located in universities across each state in Australia, and the Australian Capital Territory. The academics were between a Senior Lecturer to Professor role, with an average of 52% teaching workload at their institution. The group held an average of 17 years' experience teaching physiology (range 7 – 31 years), and every member had a role in the design of both physiology curriculum and assessment. Nineteen participants had experience teaching physiology across multiple institutions, and all participants had first-hand experience with lectures, tutorials and practical sessions.

Survey participants were asked to rate the themes and sub-themes on a 5-point Likert scale for level of importance for the students to understand (1=Essential, 2=Important, 3=Moderately Important, 4=Slightly Important and 5=Not Important) and level of difficulty for students (1=Very Difficult, 2= Difficult, 3=Moderately Difficult, 4=Slightly Difficult and 5=Not Difficult).

Statistical Analyses

Descriptive statistics are used to report mean ± standard deviation and median and interquartile range. Survey responses were analysed with a one-way ANOVA to compare between and within concept responses using SPSS software (v26, IBM, New York, USA). Correlations between responses was performed using Prism (v9, Graphpad, San Diego, USA) and the Spearman's assessment for significance.

Ethical Approval

Ethics for the study was approved by the Victoria University Human Research Ethics Committee (HRE20-164).

RESULTS

Survey results

Physiology academics from 21 separate institutions from six Australian states and one of two territories provided responses to the survey. Participants assessed the items for the perceived importance and difficulty, while also providing commentary regarding the themes and sub-themes. Written comments were received for Theme 1 (4 comments), Theme 2 (5 comments), Theme 3 (5 comments), Theme 4 (8 comments), Theme 5 (5 comments), as well as other general feedback (3 comments). Due to the low number of written responses, no formal thematic analysis wasperformed. However, this feedback was helpful in guiding the discussion at the following ‘unpacking group’ meeting. For example, written feedback for sub-theme 1.2 was “students may not really understand what ‘within and between structural levels’ means”. The written feedback guided the team’s discussion around the appropriateness of each theme’s wording, and stimulated the group to consider alternative terminology or phrasing that could be used to present this concept. A group vote was undertaken to reach final consensus, and in some cases, wording was left as in the original, and in other cases there were minor agreed-upon amendments. Table 1 outlines examples of feedback received under each theme.

Table 1: Sample participant comments regarding each overarching theme (including all sub-themes) provided during the survey phase of the unpacking process.

Theme	Comment

1	*"This is important general knowledge for a science student but is not covered in my unit"*
2	*"It could be helpful to define autonomic and somatic in subsections"*
3	*"Immune threats are not something that is covered in physiology units at my institution, though they are covered extensively elsewhere"*
4	*"4.2 and 4.3 are important overall but not in line with the focus of physiology units I teach, which focus on physiology rather than pathophysiology"*
5	*"I think that regulation of growth is important at all levels - cellular, tissue, organ, and organ system level"*

Importance of the theme and sub-theme

Survey participants also rated each theme and sub-theme regarding the perceived importance of the item (Table 2). All themes and sub-themes were consistently rated as Essential or Important (both mean and median results) with sub-themes related to the imbalance of the system and its widespread effects slightly less important than others (Figure 1).

Table 2: Level of importance for students to understand as rated by Task Force members. (1=Essential, 2=Important, 3=Moderately Important, 4=Slightly Important and 5=Not Important. SD = standard deviation, n= number of respondents who rated that theme/sub-theme).

***Integration* Core Concept**	**Rated importance**			
	Mean	**SD**	**Median**	**n**
1. The body is organised within a hierarchy of structures, from atoms to molecules, cells, tissues, organs, and organ systems.	1.04	0.21	1.00	23
1.1 The body differentiates into cells, tissues, organs, and organ systems from embryonic tissues and stem cells.	1.78	1.13	1.00	23
1.2 Individual cell functions can impact whole tissues, organs, organ systems and the organism due to integration within and between structural levels.	1.52	0.73	1.00	23

2. The function of tissues, organs, organ systems, and the organism involves integration and coordination of processes occurring at the various levels of structural organisation.	1.35	0.57	1.00	23
2.1 Communication between systems is performed through various signalling pathways (e.g. chemical, electrical) to achieve integration.	1.17	0.39	1.00	23
2.2 Coordination between systems is important, and may be facilitated, for example, through autonomic and somatic responses.	1.52	0.67	1.00	23
3. The integration and coordination of processes occurring in response to external and internal stimuli are necessary for survival.	1.39	0.58	1.00	23
3.1 Some stimuli require a rapid response with multiple mechanisms working together (i.e, reflexes, polysynaptic and diverging signals) to bring about an integrated response.	1.83	0.94	2.00	23
3.2 Effective homeostasis requires integrations between multiple organ system responses (e.g., thermoregulation, blood pressure).	1.48	0.67	1.00	23
3.3 The body must defend against infections and respond to immune threats through its structural organisation and coordination of cellular mechanisms.	1.91	0.90	2.00	23
4. Normal integrative processes can be impacted by an imbalance at any level of the system and have widespread effects.	2.05	0.84	2.00	22
4.1 Medications and pharmaceuticals can imbalance, or assist to balance, the overall system's function.	2.50	1.10	2.00	22
4.2 Diseases (e.g., diabetes, hypertension, cancer) can impact multiple organ systems and integrated functions.	2.09	0.87	2.00	22
4.3 The actions of the individual can impact the internal environment, resulting in a failure to coordinate (e.g., stress, malnutrition, sedentary lifestyle).	2.19	0.75	2.00	21
5. Growth must be regulated and coordinated at a systemic level (e.g., puberty, ageing).	2.05	0.86	2.00	21

Statistical assessment of ratings for importance.

A one-way ANOVA with Tukey post-test was performed to assess significant differences between the ratings of importance for the themes. Although rated important overall, Theme 4 was reported as less important than Themes 1, 2 and 3 ($p < 0.001$ for all). Theme 5 was also considered significantly less important than concepts 1 ($p = 0.36$) and 2 (0.007). When analysing the specific sub-themes, Theme 1.1 was rated the most important. This individual sub-theme was considered significantly more important than sub-themes 3.2 ($p = 0.046$), 3.4 ($p = 0.013$), 4.1 ($p = 0.003$), 4.1 ($p < 0.001$), 4.2 ($p < 0.001$), 4.3 ($p = 0.001$), 4.4 ($p < 0.001$) and Theme 5 ($p = 0.004$).

Difficulty of the theme and sub-theme

Survey participants also rated each theme and sub-theme in regard to the perceived difficulty of the item (Table 3). All themes and sub-themes were in the median rating range of not difficult to moderately difficult with Theme 5 identified as the most difficult.

Statistical assessment of ratings for difficulty

A one-way ANOVA with Tukey post-test was performed to assess significant differences between the ratings of difficulty for the themes. Theme 1 was significantly less difficult than Theme 2 ($p = 0.041$), 3 ($p = 0.001$), 4 ($p = 0.002$) and 5 ($p = 0.001$). No other significant differences were found between the various concepts. Upon sub-theme analysis, based upon statistical differences, the least difficult item was 1.1. This sub-theme was found to be significantly less difficult than 1.3 ($p = 0.014$), 2.1 ($p = 0.004$), 2.2 ($p = 0.026$), 2.3 ($p = 0.002$), 3.2 ($p < 0.001$), 3.3 ($p < 0.001$), 3.4 ($p < 0.001$), 4.1 ($p = 0.001$), 4.2 ($p = 0.04$), 4.3 ($p < 0.001$), 4.4 ($p = 0.001$), and 5.1 ($p < 0.001$). The most difficult item on the list was Theme 5, although this was only significantly more difficult than 1.1 (Figure 1).

Table 3: Level of difficulty for students to understand as rated by Task Force members. (1=Very Difficult, 2= Difficult, 3=Moderately Difficult, 4=Slightly Difficult and 5=Not Difficult. SD = standard deviation. n= number of respondents who rated that theme/sub-theme).

Integration Core Concept	Mean	SD	Median	n
1. The body is organised within a hierarchy of structures, from atoms to molecules, cells, tissues, organs, and organ systems.	4.35	0.65	4.00	23
1.1 The body differentiates into cells, tissues, organs, and organ systems from embryonic tissues and stem cells.	3.55	0.96	4.00	23
1.2 Individual cell functions can impact whole tissues, organs, organ systems and the organism due to integration within and between structural levels.	3.43	0.84	3.00	23
2. The function of tissues, organs, organ systems, and the organism involves integration and coordination of processes occurring at the various levels of structural organisation.	3.35	0.83	3.00	23
2.1 Communication between systems is performed through various signalling pathways (e.g. chemical, electrical) to achieve integration.	3.43	0.90	3.00	23
2.2 Coordination between systems is important, and may be facilitated, for example, through autonomic and somatic responses.	3.26	0.92	3.00	23
3. The integration and coordination of processes occurring in response to external and internal stimuli are necessary for survival.	3.70	0.76	4.00	23
3.1 Some stimuli require a rapid response with multiple mechanisms working together (i.e, reflexes, polysynaptic and diverging signals) to bring about an integrated response.	3.00	0.80	3.00	23
3.2 Effective homeostasis requires integrations between multiple organ system responses (e.g., thermoregulation, blood pressure).	3.04	0.93	3.00	23
3.3 The body must defend against infections and respond to immune threats through its structural organisation and coordination of cellular mechanisms.	2.96	0.88	3.00	23
4. Normal integrative processes can be impacted by an imbalance at any level of the system and have widespread effects.	3.18	0.66	3.00	22
4.1 Medications and pharmaceuticals can imbalance, or assist to balance, the overall system’s function.	3.27	0.83	3.00	22

4.2 Diseases (e.g., diabetes, hypertension, cancer) can impact multiple organ systems and integrated functions.	3.14	0.94	3.00	22
4.3 The actions of the individual can impact the internal environment, resulting in a failure to coordinate (e.g., stress, malnutrition, sedentary lifestyle).	3.19	0.81	3.00	21
5. Growth must be regulated and coordinated at a systemic level (e.g., puberty, ageing).	2.86	0.79	3.00	21

Figure 1

Comparing importance and difficulty

There was a small but significant negative correlation between the ratings for importance and the ratings for difficulty. Overall, themes and sub-themes that were considered more important, were also perceived as less difficult (r = -2.056, r^2 = 0.0423, p = 0.0002, n = 327 pairs). When assessing only the overarching themes (#1, #2, #3, #4, #5), there was a significant and nearly moderate degree of correlation (r = -2.934, r^2 = 0.0861, p=0.002, n=109 pairs). Correlating responses for sub-themes only (1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3) demonstrated a similar trend, where perceptions of importance were inversely correlated to perceptions of difficulty (r = -0.1494, r^2 = 0.0223, p = 0.027, n = 218 pairs).

DISCUSSION

In keeping with the philosophy of reflection and renewal in teaching, there have been calls for reform in physiology education throughout the world, most notably in the United States of America (12). This study responds to this call by addressing and unpacking ‘Integration’, one of the 7 physiological core concepts identified for the Australian curricula. The themes and sub-themes presented are intended to provide a framework to guide curriculum development. Institutions and educators are encouraged to edit, alter or revise these as needed to suit their desired outcomes.

To understand '*Integration*' as a core concept, students often need to build upon foundational learning and teachings from previous semesters. Each of the themes and sub-themes associated with *Integration* were rated Essential or Important by the survey respondents. This highlights the expectation that a physiology curriculum extends beyond the initial foundational knowledge and that a physiology graduate is required to demonstrate higher order thinking (13). It also means that a student who has progressed through the course by rote-learning concepts and only acquired a basic recall knowledge, would be unlikely to meet the expectations of a physiology graduate (11). For example, while students will have learnt about homeostasis earlier in their degree, *Integration* extends this to require an application to comprehend scenarios where integration is affected, whether through stressors, external stimuli or dysfunction. Importantly, homeostatic control in one system could be at the expense of another in the short-term, leading to (mal)adaptation, another important higher order thinking core concept (6). In addition, although students would have a robust knowledge on the structural organisation, *Integration* themes require a consideration of how individual elements influence the organism as a whole. This is a new, broader and conceptual way of thinking to what students may have been used to in earlier semesters of their degree (8) and enables them to become critical thinkers, an important graduate attribute (14).

If structured well, the concepts within *Integration* will be instrumental in expediting a robust physiological knowledge in graduates. When learning outcomes were mapped from 160 subjects across physiology majors online, from 18 Australian universities, the core concept of 'Interdependence' was the 3rd most often mapped manually, and 2nd by software context analysis, (Structure and Function was the most common) (6). Surveys consistently place Interdependence

(Cells, tissues, organs, and organ systems interact with one another [are dependent on the function of one another] to sustain life) within the "top five" core concepts across a physiology curriculum (15, 16). Although the Australian task force decided the term "*Integration*" was a better fit for this core concept during the Delphi process (6), it fits within the same scope and content as this classification in the United States system.

There is not necessarily a substantial amount of 'new' content to learn within the core concept of *Integration*, as the themes surround conceptualisation and application to real-world scenarios. The introduction of diseases, such as Type 2 diabetes mellitus, provides students with insights into how normal systems can be disrupted by pathological changes. In addition, discussing the influence of pharmaceuticals to target organ pathophysiology provides an understanding of how normal function can be restored. Taking the foundational knowledge of physiology, students will be required to have more cognitive processing to ensure they demonstrate the higher levels of Blooms taxonomy; namely evaluate and create (17). As such, it was not surprising that the themes and sub-themes were rated "moderately difficult" or "slightly difficult", with none highlighted as specifically challenging for student learning.

Although much of physiology is thought to be challenging or 'hard' (18-20), higher-level concepts such as *Integration* do not necessarily need to present any new challenges, but instead, provide students with opportunities to use prior knowledge in an effective way and develop their critical thinking skills. In order to enable students to consolidate the information, educators may wish to diverge from traditional and didactic teaching methods and utilise more engaging ways to scaffold learning. Physiology teaching can successfully engage student learning using techniques such as flipped classrooms (21), immersive technology (22), simulations (23), gamification (24), interactive lesson formats (25, 26), relevent content delivery (27) and assisted self-directed learning (28). These techniques can be utilised to scaffold the learning of *Integration* as a core concept in physiology. It was interesting to observe a small but significant inverse correlation between perceived importance and the grouped concept difficulty. This may be due to the understanding that more 'core' concepts are simpler and foundational. As such, the higher importance may relate to an increased simplicity in the item, with more difficult concepts considered slightly more specialised.

One key component arising out of the method to unpack the *Integration* core concept was the recommendation to focus on specific scenarios or examples. Rather than integrate too much pathophysiology when teaching about how disease in general influences integration, it appears useful to stick to specific exemplars to avoid overwhelming the students. To facilitate this, our team has provided examples within the sub-themes to direct and assist any curricula development. These suggestions are for guidance, and not 'required learning' as such, but it is envisioned that educators would not extend the required learning beyond a few specific examples. This allows the focus on physiology to be applied to various scenarios without directing students into pathology-based learning. This suggestion also extends to teaching related to pharmaceuticals, with no requirement to formally cover any pharmacology-based instruction. Puberty, ageing, stress and malnutrition could be used as a means of providing higher order understanding of the concepts associated with *Integration*.

Physiology is an integrative discipline in biology (29). For academics wishing to structure curricula to meet the *Integration* Core Concept, it would be advantageous to involve a multidisciplinary team in the initial planning stages. For example, although advanced microbiology or immunology concepts are not usually assessed in physiology, students would be expected to draw on some foundational knowledge from these areas in order to fully understand the influence of infection (Theme 3.3). This is reiterated in the 4.1 and 4.2 sub-themes, relating to pathology or pharmacology content, where foundational knowledge of the underlying disorder or therapeutics is needed to assess the influence on the organism's physiology. As such, a multidisciplinary approach to teaching this content can greatly assist in the development of curricula surrounding *Integration*. Overall, *Integration* should be viewed as a capstone core concept which enables students to consolidate and apply knowledge, integrating key physiological and scientific concepts. This core concept also ensures that graduates enhance their employability skills as they have demonstrated critical thinking and the ability to integrate and apply knowledge.

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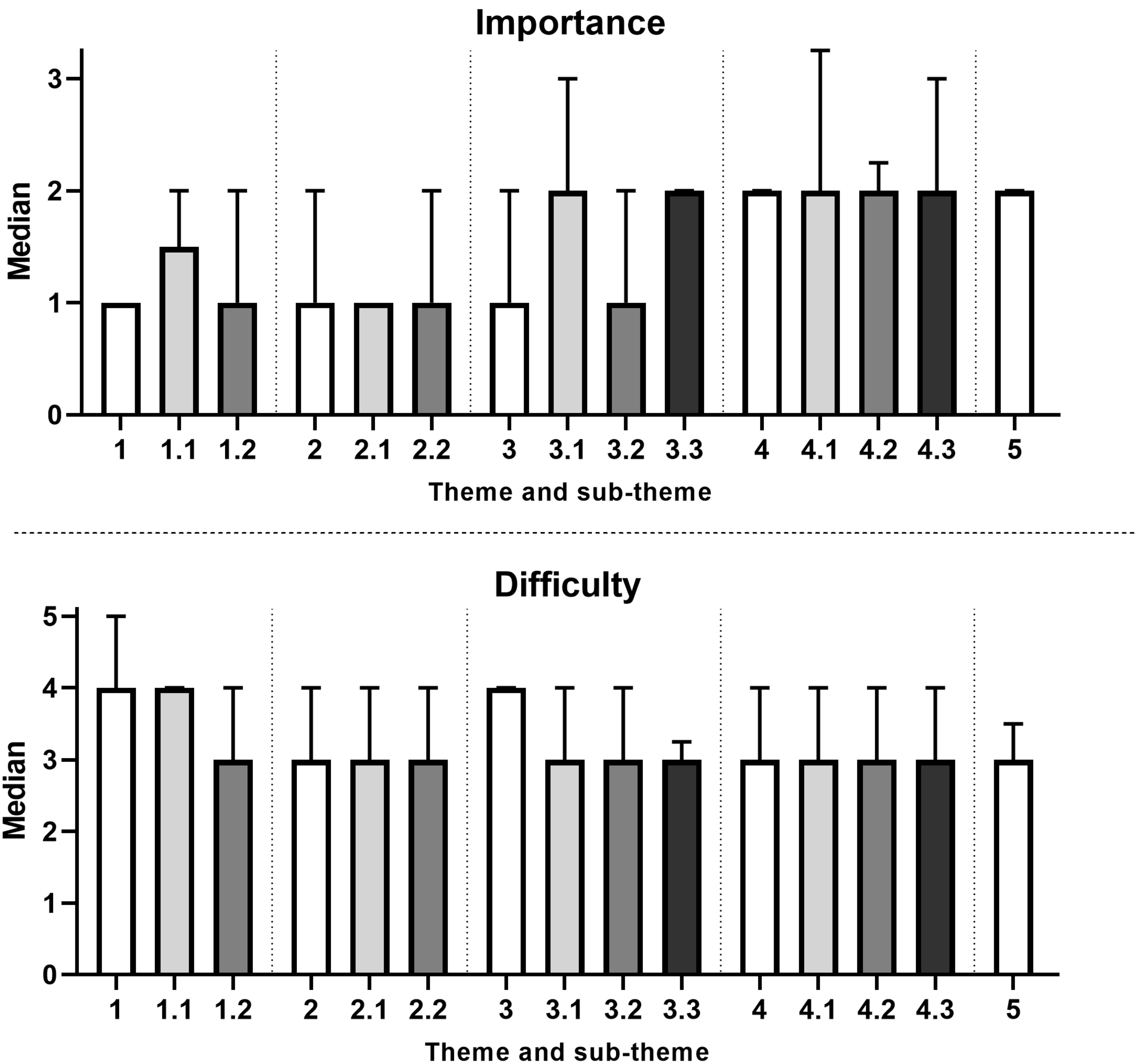
LEGENDS

Figure 1: Median ± Interquartile range results from the Task Force Members regarding the Importance (1=Essential, 2=Important, 3=Moderately Important, 4=Slightly Important and 5=Not Important) and difficulty (1=Very Difficult, 2= Difficult, 3=Moderately Difficult, 4=Slightly Difficult and 5=Not Difficult) for each theme and sub-theme for Integration.



Importance
Median
0
1
2
3
1
1.1
1.2
2
2.1
2.2
3
3.1
3.2
3.3
4
4.1
4.2
4.3
5
Theme and sub-theme
Difficulty
Median
0
1
2
3
4
5
1
1.1
1.2
2
2.1
2.2
3
3.1
3.2
3.3
4
4.1
4.2
4.3
5
Theme and sub-theme

Table 1: Level of importance for students to understand as rated by Task Force members. (1=Essential, 2=Important, 3=Moderately Important, 4=Slightly Important and 5=Not Important. SD = standard deviation, n= number of respondents who rated that theme/sub-theme).

***Integration* Core Concept**	**Level of importance**			
	Mean	**SD**	**Median**	**n**
1. The body is organised within a hierarchy of structures, from atoms to molecules, cells, tissues, organs, and organ systems.	1.04	0.21	1.00	23
1.1 The body differentiates into cells, tissues, organs, and organ systems from embryonic tissues and stem cells.	1.78	1.13	1.00	23
1.2 Individual cell functions can impact whole tissues, organs, organ systems and the organism due to integration within and between structural levels.	1.52	0.73	1.00	23
2. The function of tissues, organs, organ systems, and the organism involves integration and coordination of processes occurring at the various levels of structural organisation.	1.35	0.57	1.00	23
2.1 Communication between systems is performed through various signalling pathways (e.g. chemical, electrical) to achieve integration.	1.17	0.39	1.00	23
2.2 Coordination between systems is important, and may be facilitated, for example, through autonomic and somatic responses.	1.52	0.67	1.00	23
3. The integration and coordination of processes occurring in response to external and internal stimuli are necessary for survival.	1.39	0.58	1.00	23
3.1 Some stimuli require a rapid response with multiple mechanisms working together (i.e, reflexes, polysynaptic and diverging signals) to bring about an integrated response.	1.83	0.94	2.00	23
3.2 Effective homeostasis requires integrations between multiple organ system responses (e.g., thermoregulation, blood pressure).	1.48	0.67	1.00	23
3.3 The body must defend against infections and respond to immune threats through its structural organisation and coordination of cellular mechanisms.	1.91	0.90	2.00	23
4. Normal integrative processes can be impacted by an imbalance at any level of the system and have widespread effects.	2.05	0.84	2.00	22
4.1 Medications and pharmaceuticals can imbalance, or assist to balance, the overall system's function.	2.50	1.10	2.00	22
4.2 Diseases (e.g., diabetes, hypertension, cancer) can impact multiple organ systems and integrated functions.	2.09	0.87	2.00	22
4.3 The actions of the individual can impact the internal environment, resulting in a failure to coordinate (e.g., stress, malnutrition, sedentary lifestyle).	2.19	0.75	2.00	21
5. Growth must be regulated and coordinated at a systemic level (e.g., puberty, ageing).	2.05	0.86	2.00	21

Table 2: Level of difficulty for students to understand as rated by Task Force members. (1=Very Difficult, 2= Difficult, 3=Moderately Difficult, 4=Slightly Difficult and 5=Not Difficult. SD = standard deviation. n= number of respondents who rated that theme/sub-theme).

Integration Core Concept	**Mean**	**SD**	**Median**	**n**
1. The body is organised within a hierarchy of structures, from atoms to molecules, cells, tissues, organs, and organ systems.	4.35	0.65	4.00	23
1.1 The body differentiates into cells, tissues, organs, and organ systems from embryonic tissues and stem cells.	3.55	0.96	4.00	23
1.2 Individual cell functions can impact whole tissues, organs, organ systems and the organism due to integration within and between structural levels.	3.43	0.84	3.00	23
2. The function of tissues, organs, organ systems, and the organism involves integration and coordination of processes occurring at the various levels of structural organisation.	3.35	0.83	3.00	23
2.1 Communication between systems is performed through various signalling pathways (e.g. chemical, electrical) to achieve integration.	3.43	0.90	3.00	23
2.2 Coordination between systems is important, and may be facilitated, for example, through autonomic and somatic responses.	3.26	0.92	3.00	23
3. The integration and coordination of processes occurring in response to external and internal stimuli are necessary for survival.	3.70	0.76	4.00	23
3.1 Some stimuli require a rapid response with multiple mechanisms working together (i.e, reflexes, polysynaptic and diverging signals) to bring about an integrated response.	3.00	0.80	3.00	23
3.2 Effective homeostasis requires integrations between multiple organ system responses (e.g., thermoregulation, blood pressure).	3.04	0.93	3.00	23
3.3 The body must defend against infections and respond to immune threats through its structural organisation and coordination of cellular mechanisms.	2.96	0.88	3.00	23
4. Normal integrative processes can be impacted by an imbalance at any level of the system and have widespread effects.	3.18	0.66	3.00	22
4.1 Medications and pharmaceuticals can imbalance, or assist to balance, the overall system's function.	3.27	0.83	3.00	22
4.2 Diseases (e.g., diabetes, hypertension, cancer) can impact multiple organ systems and integrated functions.	3.14	0.94	3.00	22
4.3 The actions of the individual can impact the internal environment, resulting in a failure to coordinate (e.g., stress, malnutrition, sedentary lifestyle).	3.19	0.81	3.00	21
5. Growth must be regulated and coordinated at a systemic level (e.g., puberty, ageing).	2.86	0.79	3.00	21

Table 3: Sample participant comments regarding each overarching theme (including all sub-themes) provided during the survey phase of the unpacking process.

Theme	Comment
1	*"This is important general knowledge for a science student but is not covered in my unit"*
2	*"It could be helpful to define autonomic and somatic in subsections"*
3	*"Immune threats are not something that is covered in physiology units at my institution, though they are covered extensively elsewhere"*
4	*"4.2 and 4.3 are important overall but not in line with the focus of physiology units I teach, which focus on physiology rather than pathophysiology"*
5	*"I think that regulation of growth is important at all levels - cellular, tissue, organ, and organ system level"*