ADDITIONAL READING

Winter, B., Breitenstein, C., Mooren, F. C., Voelker, K., Fobker, M., & Lechtermann, A. (2007). High impact running improves learning. *Neurobiology of Learning and Memory*, 87(4), 597–609. doi:10.1016/j.nlm.2006.11.003

Zhang, F., Lidbury, B., Schulte, J., Bridgeman, A., Yates, B., & Rodger, J. (2009). A cross-disciplinary approach to language support for first year students in the science disciplines. Paper presented at the HERDSA 2009, Charles Darwin University, Darwin.

Zhang, F., & Lidbury, B. A. (2006). It's all foreign to me: Learning through the language of genetics and molecular biology. Paper presented at the 2006 National UniServe Science Symposium: Assessment in Science Teaching and Learning, The University of Sydney, Sydney. Retrieved from <http://sydney.edu.au/>

KEY TERMS AND DEFINITIONS

Ferguson's Delta: Ferguson's delta is another whole-test statistic. It measures the discriminatory power of an entire test by investigating how broadly the total scores of a sample are distributed over the possible range. If a test is designed and employed to discriminate among students, one would like to see a broad distribution of total scores. If a test has Ferguson's delta greater than 0.9, the test is considered to offer good discrimination. (Kline, 1986).

The Item Difficulty Index (P): A measure of the difficulty of a single test question.

The Item Discrimination Index (D): A measure of the discriminatory power of each item in a test. In other words, it measures the extent to which a single test item distinguishes students who know the material well from those who do not. On a test item with a high discrimination index, students with more robust knowledge will usually answer correctly, while students whose understanding is weaker will usually get the item wrong. In contrast, a flawed test question might lead more thoughtful students to give answers that are judged wrong, while students who think less deeply give a correct answer. If a test contains many items with high discrimination indices, the test itself can be useful in separating strong students from weak students in a specific test domain.

The Point Biserial Coefficient: Sometimes referred to as the reliability index for each item is a measure of consistency of a single test item with the whole test. It reflects the correlation between students' scores on an individual item and their scores on the entire test, and is basically a form of the correlation coefficient. The point biserial coefficient has a possible range of $[-1, +1]$. If an item is highly positively correlated with the whole test, then students with high total scores are more likely to answer the item correctly than are students with low total scores. A negative value indicates that students with low overall scores were the most likely to get a particular item correct and is an indication that the particular test item is probably defective.

Chapter 6

Language Support for First Year Human Physiology and Biology

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ABSTRACT

This chapter examines student performance in Human Physiology and Biology in response to a number of interactive language-focused and career-oriented interventions that were integrated into both lecture and tutorial formats. The study took place at the University of Newcastle, Australia and involved around 1000 students on two campuses. Although it was not possible to demonstrate a clear overall improvement in student performance as a result of these interventions, the activities were viewed positively by the majority of students. Arguably, the major impact of the language and other interventions was in the level of student motivation and engagement with the course topic. Contemporary university students are highly focused on the relevance of a course to their chosen career path, suggesting that language-based teaching and learning strategies would be most effective if placed within a vocation-specific context.

INTRODUCTION

Learning the language of science is a major obstacle to many students in first year human physiology and biology. It is particularly difficult for those students who have not studied science subjects previously or recently, and consequently struggle to recognize and differentiate concepts.

These issues are exacerbated by the diversity of the student population in large first year courses in relation to background knowledge, their degree program and career path.

Students from the allied health programs (occupational therapy, speech pathology, nutrition/dietetics and podiatry) must complete first year human physiology as part of their program requirements for accreditation, but consistently perform poorly due largely to their lack of background in

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science (McCleary et al, 1999). It is obvious to those who teach human physiology that a basic understanding of the biochemical processes, cells and tissues that contribute to the functioning of human organ systems is essential in any clinical context. Many students, however, fail to recognize the relevance of physiological and biochemical processes that operate to maintain and integrate the specific organ systems that contribute to a healthy human body. Students often become overwhelmed with course content and question its relevance with comments such as "Why do I need to know all this? I just want to be a podiatrist/speech pathologist/occupational therapist etc".

The situation for students undertaking first year biology, and student attitudes and engagement with particular subject matter in biology is similarly diverse. Students are enrolled in a variety of degree programs many of which require first year biology (e.g. Psychology, BSc Biology major, Biotechnology, Environmental Science and Management and Environmental Engineering). The unit which is the focus of the current chapter provides an introduction and overview of the animal kingdom and the principles of animal function. Inevitably this introduces the student to a very large array of new and often confusing technical terms and animal names in addition to the special uses and meanings certain 'normal' English words take on in biology (e.g. model, control, significant). As with the health programs, questions of relevance to the students' specific program of study are often expressed, "Do I really need to know these funny names, etc?"

The aim of this study was to develop teaching methods and tools that increased students' ability to see the interconnectedness between language and biological problems and situations. Students were also encouraged them to develop their own techniques to deal with language issues in biology, based on the resources provided. Some of the language-oriented techniques implemented were breaking down long words by identifying prefixes and suffixes,

1. exploring the roots and origin of words,
2. matching exercises with scientific terms and definitions,
3. flashcards for vocabulary revision and
4. role playing for students to practise conveying complex scientific information to their peers and the public.

Strategies were also developed to increase the motivation for embracing the language and concepts introduced. Vocation-specific clinical examples were presented as a "Disease of the Week" package in the human physiology course to enable students to put basic physiological information in a broader context with relevance to their future career. A series of regular online assessments were also introduced to provide consistent and immediate feedback to students on their progress. In the case of the animal function unit, examples were provided throughout the lecture material of how the particular animal group or its function related to:

1. Everyday life examples (e.g. Why the life style of some animals makes them dangerous parasites, or why certain stages in development are so critical for producing a normal baby);
2. Biodiversity and the environment (e.g. Kangaroo breeding and life in the Australian arid zone), or
3. How contemporary biology was engaging with evolutionary biology and taking it beyond anatomy and fossils (e.g. The major changes in understanding of animal evolution and relationships due to molecular biology).

METHODS EMPLOYED TO SUPPORT LEARNING IN HUMAN PHYSIOLOGY

Human Physiology is a first year undergraduate subject taught over two semesters. It is arbitrarily

split into two parts (*Part 1* and *Part 2*) that run consecutively each year. Each part is delivered concurrently at two locations (Callaghan and Ourimbah, Newcastle, New South Wales (NSW), Australia) and utilize the same assessment items and criteria. Callaghan is the main campus of the University of Newcastle with an enrolment of approximately 17,000 full time student equivalents (FTSE). The Ourimbah campus is located on the central coast of NSW, approximately 100km south of the main campus. It is a multi sector campus offering university, TAFE and community college programs. There are approximately 3,000 FTSE studying at the University of Newcastle Ourimbah campus, many of whom study part-time.

Disease of the Week

Modules targeting a particular disease or condition that related to course content were introduced in 2009 via the subject Learning Management System (LMS; i.e. *Blackboard*). Each "Disease of the Week" module included a "user-friendly" introduction that provided a summary of the disease or condition, the relevance of related lecture content and the role of allied health professionals in treatment with vocation-specific references. The introduction was written in language aimed at an educated lay audience, avoiding unnecessary jargon and providing clear explanations of any technical terms. Where possible, the scientific papers that were cited in the introduction were also posted on the subject LMS to encourage students to take the next step in furthering their physiology-related language skills by reading on topics of particular interest to the student. These articles also introduced students to peer-reviewed scientific articles as a reliable source of information and as the major source of communication for new biomedical and health-related research for those working in the field.

Topics for "Disease of the Week" were generally chosen to be relatively common conditions that students may have heard of previously, with

a variety of treatment modalities relevant to the study programs of the student cohorts. For example, the role of intermediate filaments and the cytoskeleton in maintaining cell shape, stabilizing the position of the organelles within the cell and stabilizing the position of the cell with respect to other cells is demonstrated by the module on *Epidermolysis bullosa (EB)*. A mutation in the gene coding for keratin proteins in intermediate fibres of superficial skin layers can result in blistering of the skin in response to even minor trauma. Individuals with *EB* may require treatment from:

- **Dieticians:** who have an understanding of the manifestations of *EB* and its associated nutritional problems to develop a strategy to ensure nutritional status (Birge, 1995; Bello et al, 2003).
- **Physiotherapists and Occupational Therapists:** to help prevent contractures (i.e. abnormal shortening of muscle tissue) and to maintain muscle tone through the use of exercise and special splints (Bello et al., 2003)
- **Podiatrists:** who can play a role in minimizing the blistering associated with *EB* by ensuring appropriate and well-fitting footwear that provides both mobility and protection (Kahn et al, 2002).
- **Speech Pathologists:** who may assist in management of communication problems in instances where oral scarring has occurred (Bello et al, 2003).

In this example it was also pointed out that biomedical students in particular may be interested in the brief account of how *EB* was discovered to be due to a keratin defect and the contradictory results that were reported during this process (Fuchs, 1996).

Other modules included Calcium Homeostasis and Osteoporosis, Mitochondrial Disease, Cystic Fibrosis, Multiple Sclerosis, Neurotoxins, and

Spinal Cord Injury. The information presented in “Disease of the Week” was not examined.

Tutorial/PASS Activities

Learning support was provided at the Callaghan campus via a Peer Assisted Study Session (PASS) for 1 hr/week. Participation in PASS was based on students’ self selection and was voluntary. Student leaders of PASS have achieved either a Distinction or High Distinction in human physiology during the past 1-3 years. Student leaders are trained in active learning strategies and are provided with sample resources including “Mix and Match” exercises, “Fill in the Blanks”, crosswords and concept mapping exercises (see examples below). Similar activities are used in a more traditional tutorial style session at the Ourimbah campus. These sessions have not been changed substantially during the course of this study.

The “Mix and Match” (see Table 1) and “Fill in the Blanks” (see Box 1) exercises were primarily aimed at improving language comprehension of topics presented in lectures during the previous week. The activity was done in paper format in small groups during the PASS or tutorial, and answers were then shared with the class. During the latter part of the semester, crosswords were also used during PASS and tutorials to reinforce some of the more complex language and concepts associated with lectures on the nervous system. All of these activities covered key language and concepts that had to be mastered in order to pass the course, but the activities themselves did not form part of the assessment.

Online Assessments

Regular online assessments were introduced during 2009 via the subject’s LMS. Since many students are using an online LMS for the first time during this subject there was one practice quiz followed by four compulsory online assessments. Each online assessment consisted of

10 multiple choice questions that tested basic understanding of the language and concepts that had been presented during the previous 2-3 weeks. Students received feedback immediately after submission of the test including their score and the correct answer for any question that they had answered incorrectly. Each part is delivered concurrently at two locations (Callaghan and Ourimbah) and utilizes the same assessment items and criteria.

During 2008, *Human Physiology Part 1* and *Part 2* consisted of lectures with learning support provided by PASS or tutorial sessions, depending upon the campus location. 473 and 389 students participated in the unit on the Callaghan campus in semester 1 and 2 in 2009. On Ourimbah campus, 174 and 180 students participated in the unit in both semesters in 2009. Assessment consisted of two written mid-semester exams (each contributing 15% of final mark) and a final written exam (70% of final mark). Feedback to students on their progress during the semester was limited to the scores obtained on the written mid-semester exams. Although individual feedback on mid-semester exams was offered by appointment, very few students took advantage of this opportunity. During 2009, four online assessments (each contributing 5% of final mark) were introduced to both *Part 1* and *Part 2* of *Human Physiology*, in addition to a written mid-semester exam (worth 20%) and a final written exam (worth 60%). This was intended to be formative assessment to keep them on track. The “Disease of the Week” modules were incorporated into *Human Physiology Part 1* only.

IMPACT ON STUDENT PERFORMANCE IN HUMAN PHYSIOLOGY

Student data from Callaghan and Ourimbah was examined separately, as the cohorts differ in several aspects and historically perform very differently.

Table 1. Match the subject with its building blocks

Subject (“To be built”)	“Building Blocks”
1. Life (Organic Complexity)	A. Systems (eg muscle, respiratory)
2. Atoms (Stuff of the Universe)	B. Elements(eg carbon, hydrogen)
3. “DNA” / “RNA”(Design & Function)	C. Phosphate, Sugar & Nitrogen Base
4. Proteins (Form & Function)	D. Atoms
5. Lipids (Oils, Fats & Waxes)	E. Phospholipids & Proteins
6. Matter (Solids, Liquids & Gases)	F. Nucleotides
7. Organism (Worm, Moss, Tree, You)	G. Cells
8. Nucleotides (Adenine, Cytosine, ...)	H. Glycerol and Fatty acids
9. Compounds (H ₂ O; C ₆ H ₁₂ O ₆ ; CO ₂)	I. Sugar molecules
10. Cell Membranes (Life’s border)	J. ADP’s; P’s & ENERGY!
11. Sugar (Life’s chemical energy)	K. Protons, Neutrons & Electrons
12. Systems (ex. digestive, skeletal)	L. Amino acids
13. Polysaccharides (eg starch, glycogen)	M. Organs (eg heart, kidney)
14. ATPs (Energy currency of life)	N. CO ₂ & H ₂ O

Box 1. Fill in the blank

Fill in the gaps. Then summarize the information by drawing a concept map. Compare the concept maps produced by different groups.

There are two types of nucleic acids: (1) _____ which is _____ stranded and found primarily in the _____ and (2) _____ which _____ stranded and found primarily in the _____. The two strands of DNA are together by _____ bonds between complementary _____.

Nucleic acids are polymers made up of _____, that are linked together by _____ bonds. Each nucleotide consists of three components (1) a _____-containing base that can be either a _____ or a _____; (2) a _____ carbon sugar; (3) a _____ group that links the nucleotides. The sugar in RNA is _____, and in DNA is _____.

A summary of student performance in terms of grade distribution i.e. percentage and number of *High Distinction* (HD), *Distinction* (D), *Credit* (C), *Pass* (P), *Fail* (F) and *Withdrawn* (W) for *Human Physiology (Part 1)* at both campuses is shown in Table 2.

Statistical analysis using Chi-square (χ^2) indicated a significant improvement (Callaghan, $p<0.001$; Ourimbah, $p<0.0001$) in student performance in 2009 compared to 2008 at both Callaghan and Ourimbah. Whilst the overall failure rate remained stable or increased slightly, there were a higher percentage of students at both campuses that achieved a D or HD grade. There were also a greater percentage of students that withdrew

from the subject 2009 although students’ reasons for withdrawing from a course might be complex and might not be closely associated with a unit’s teaching arrangement.

Despite the shift in distribution of grades there was no significant change in the mean final mark at Callaghan (Table 3; t-test, $p=0.09$). There was however a significant increase in the mean score achieved by students at Ourimbah in 2009 (Table 2; t-test, $p<0.05$), largely due to a significant increase in the continuous assessment component of the course.

The online assessments could be completed by students at any location within a restricted time frame of availability, and as such can be regarded

Table 2. Distribution of final student grades in undergraduate human physiology (Part 1) at Callaghan and Ourimbah campuses of University of Newcastle in 2008 and 2009

	High Distinction	Distinction	Credit	Pass	Fail	Withdrawn
Callaghan						
2008 (473)	7.0 (33)	18.4 (87)	24.7 (117)	36.8 (174)	13.1 (62)	2.5 (12)
2009 (389)	10.8 (42)	19.4 (76)	23.1 (90)	30.08 (117)	16.4 (64)	6.9 (27)
Ourimbah						
2008 (174)	4.0 (7)	6.9 (12)	21.3 (37)	43.7 (76)	24.1 (42)	4.0 (7)
2009 (180)	4.4 (8)	15.0 (27)	23.3 (42)	31.67 (57)	25.5 (46)	7.8 (14)

Final grade categories: High Distinction (85-100%); Distinction (75-84%); Credit (65-74%); Pass (50-64%); Fail ($\leq 49\%$). To pass overall, a minimum of 45% was required in the end of semester formal examination.

Table 3. Mean scores obtained for assessment items and final overall total in undergraduate human physiology (Part 1) at Callaghan and Ourimbah campuses of University of Newcastle in 2008 and 2009. Assessment consisted of two written mid-semester exams in 2008; and four online tests and one written mid-semester exam in 2009

	Callaghan		Ourimbah	
	Assessment	Final	Assessment	Final
2008	60.5 $\pm$ 0.7	63.3 $\pm$ 0.7	51.6 $\pm$ 1.3	56.4 $\pm$ 1.2
2009	65.3 $\pm$ 0.7*	65.1 $\pm$ 0.8	60.4 $\pm$ 1.1*	60.4 $\pm$ 1.2*

* significantly different from previous year (t-test, $p < 0.05$)

as an open-book examination. Not surprisingly, it was found that the written mid-semester exam (completed under supervision) was more highly correlated with final grade (Callaghan, $r=0.78$; Ourimbah, $r=0.72$) than the online assessments (Callaghan, $r=0.60$; Ourimbah, $r=0.65$). The marked improvement in both assessment tasks and final grades at Ourimbah in response to regular online assessments may be partly due to increased peer-assisted learning and interaction. The student cohorts at Ourimbah are generally smaller in number and form a more cohesive group than students at Callaghan, which appeared to be enhanced further by the introduction of regular language-oriented learning tasks and assessments.

Impact of "Disease of the Week" on Failure Rates of Program Cohorts

Historically, within any one year student performance is similar in the two (arbitrarily split) parts of *Human Physiology*. This similarity is demonstrated by the 2008 failure rate data for the various program cohorts (Table 4), which do not differ significantly between *Part 1* and *Part 2* (χ^2 , $p=0.97$).

Following the introduction of online assessments as outlined above (in both *Part 1* and *Part 2*) and the "Disease of the Week" modules (in *Part 1* only) in 2009, there was a significant difference in student performance in the two parts

Table 4. Failure rates for student cohorts in undergraduate Human Physiology (Part 1 and Part 2) at the University of Newcastle in 2008 and 2009

Cohort	2008				2009			
	Part 1		Part 2		Part 1*		Part 2*	
	n	%F	n	%F	N	%F	n	%F
Physiotherapy	106	1.9	106	0.9	67	7.5	62	3.2
Biomed	82	7.3	72	9.7	87	9.2	82	13.4
Occupational Therapy	95	15.8	97	17.5	68	23.5	63	47.6
Nutrition & Dietetics	65	16.9	52	17.3	62	8.1	69	15.9
Podiatry	80	17.5	66	16.6	63	20.6	52	13.5
Exercise/Sport Science	60	21.7	53	17.0	62	21.0	53	18.9
Speech Pathology	94	22.3	60	16.7	93	23.7	62	27.4
Food science/Human Nutrition	41	24.4	35	25.7	53	30.2	47	38.3
Science	34	32.4	28	32.1	22	22.7	13	38.5
All Students	666	15.6	577	14.7	610	18.0	522	23.55

n = number of students

%F = percentage of students that failed course

of the subject (χ^2 , $p < 0.0001$). The failure rates of students from Occupational Therapy, Nutrition & Dietetics, Food Science & Human Nutrition and Speech Pathology programs were much lower in *Human Physiology Part 1* compared to *Part 2*, suggesting that the "Disease of the Week" modules found their target audience and made a significant impact on their performance. It was envisaged that students from Podiatry and Sport Science & Exercise programs may also benefit from the clinical contexts provided for the course content, however these students went against the trend and performed better in *Part 2* of the course. These modules were made available online and therefore, the number of times these modules were accessed by students from the various program cohorts would have provided useful information to interpret these differences, but was not collected on this occasion.

The differences found in effectiveness of "Disease of the Week" between cohorts may well be related to differences in their motivation to learn basic physiology and/or their learning style preferences. A study with non-science majors

found that overall motivation to learn science could be measured over five domains: *intrinsic motivation and personal relevance, self-efficacy and assessment anxiety, self-determination, career motivation and grade motivation* (Glynn et al, 2009). A belief that course content was relevant to their future career was a dominant motivating factor for both non-science (Glynn et al, 2009) and science majors (Walker, 2010). An increased perception of the relevance of basic physiology to their future career and may be a factor in the improved performance of students from Occupational Therapy, Nutrition & Dietetics, Food Science & Human Nutrition and Speech Pathology. Student learning can also be classified according to the sensory modality that is preferred: *visual, auditory, reading-writing or kinaesthetic*. Students may have either a strong single preference ("unimodal") or multiple preferences ("multimodal") for learning. Previous studies have indicated differences in learning preferences related to gender (Dobson, 2009) and career choice (Breckler et al, 2009). The "Disease of the Week" intervention was primarily a *reading-writing* activity and was

Table 5. Mean student satisfaction rating achieved for undergraduate human physiology (Part 1) at Callaghan and Ourimbah campuses of University of Newcastle in 2008 and 2009

Course Area	Student Satisfaction			
	Callaghan		Ourimbah	
	2008	2009	2008	2009
1. Improved knowledge	4.2	4.0	3.6	4.3
2. Assessment Items	3.7	3.8	3.1	4.2
3. Overall Quality	3.5	3.5	2.4	4.3

probably most effective in those students with a strong *reading-writing* learning preference.

Impact on Student Satisfaction

At the Ourimbah campus there was a significant increase in student satisfaction reported for *Human Physiology Part 1*, with respect to overall knowledge gained, relevance and effectiveness of assessment items, and overall course quality (Table 5). The same changes introduced concurrently at Callaghan resulted in no change in mean satisfaction ratings. Questions were phrased as follows:

- As a result of studying this course, I have improved my knowledge of the topics/material covered.
- The assessment items in this course supported my learning.
- Overall, I am satisfied with the quality of the course.

Student Responses: scored on a scale of 1-5 (1=Strongly Disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree).

It can be reported anecdotally however, that the number of complaints and negative comments posted on the subject LMS Discussion Board declined markedly in 2009 compared to 2008 especially on the Ourimbah campus. The total number of posts on the Discussion also declined from 43.5 posts per week in 2008 to 30 posts per week in 2009. Several unsolicited positive com-

ments were posted by students on the Discussion Board during 2009 in relation to Disease of the Week:

I'm really liking that you can apply the information that we are learning to a real life example. I've been reading the articles and finding them very interesting. Thank you.

I've been finding them very useful for applying them to review questions as examples that I've been doing, along also in my summaries.

Although mean satisfaction rating at Callaghan remained steady, chi-square analysis indicated a significant polarization of student opinion on whether they had increased their knowledge of the area, and satisfaction with the overall quality of the course. For the 2009 cohort more students responded at either the positive or negative end of the scale, whereas the 2008 students generally responded neutrally. A study of genetics students (Lidbury, in press, Chapter 4) presented evidence that innovative instructional styles can actually provide an additional disincentive to lower level students, which may also be the case here. The impact might be clearer if a longitudinal study of this group of students over a number of years. The pattern of student response to assessment items was consistent over the two years of the study.

Table 6. Biology 1002 students at The University of Newcastle in semester two, 2008

Terms	'Yes' response for confidence in %	100% understanding	Delusion index	Ranking (easiest=1, hardest=10)
Significant	44.44	33.33	1.33	9
Equation	72.22	38.89	0.54	8
Research	77.78	44.44	0.57	7
Equilibrium	66.67	50.00	0.75	6
Concentration	77.78	61.10	0.79	5
Power	44.44	66.67	1.50	4
Graph	88.89	77.78	0.88	3
Experiment	66.67	83.30	1.25	2
System	72.22	88.89	1.23	1

Note: at The University of Newcastle, one item (significant) was repeated and the item on 'model' was not included. Therefore the table shows the data for nine items rather than ten.

METHODS EMPLOYED TO SUPPORT LEARNING IN BIOLOGY

At the University of Newcastle in 2008 and 2009 there were 209 and 250 students respectively in the unit: Biol 1002: Organisms to Ecosystems. Biology 1002 is taught as four modules: Ecological and evolutionary processes; Principles of Development; Animals – Who are they and how do they live; Green machines (Plant physiology). During 2008, lecturers taught the subject matter as they had previously and students were assessed in the normal fashion. The language interventions outlined below were implemented during 2009 in the “Animals – who are they and how do they live” module only, with the three other modules in the course serving as an additional control. Assessment during 2008 and 2009 consisted of four online MCQ quizzes (worth 10% each) and a formal written exam (worth 60%) with multiple choice and short answer questions. Short answer questions required students to fill in missing words, list key words, draw and label simple diagrams or write brief 2-3 sentence paragraphs.

In 2009, in the implementation phase of the project in semester two, VotAmedia questions (Appendix B) were used during the lectures as well as online revision exercises and tutorial activities

(Appendix C). These took place over a period of three weeks out of a total of 13 weeks for the unit.

In semester two, 2008 in the subject Biology 1002, students were asked for their consent to participate in the project through the completion of Test 1 and 2 of the language surveys (Appendix A). However, only 18 students participated (Table 6). In semester two 2009, in order to increase the number of students participating, the Tests 1 and 2 of the language surveys were built in as part of the out of class non-assessable assessment items. At the end of the second non-assessable item, a number of demographic questions were asked as well as the implementation of a Biology Self-Efficacy questionnaire which was based on Baldwin, Ebert-May and Burn's Biology Self-efficacy instrument (Baldwin, Ebert-May, & Burns, 1999). In the last item of the out of class survey, they were asked to tick 'yes' or 'no' on their participation. By building test 1 and 2 items into the non-assessable assessment item, the participation rate for Test 1 and 2 of the language surveys rose to 30.4%.

During semester two, 2009, the language strategies were implemented for three weeks over four hours per week. In the second two-hour block of each week, the language exercises (Appendix D) were administered in about half an hour each week. This amounts to one and half an hour in

Table 7. Biology 1002 students at the University of Newcastle in semester two, 2009

Terms	'Yes' response for confidence in %	100% understanding	Delusion Index	Ranking (easiest=1, hardest=10)
Research	80	5	16	9
Equilibrium	47	11	4.27	8
Equation	73	15	4.87	7
System	73	24	3.04	6
Model	34	26	1.31	5
Experiment	83	40	2.08	4
Concentration	76	43	1.77	3
Graph	83	48	1.73	2
Control	87	74	1.18	1

total. These tutorial exercises were also provided to students before each week's tutorial. These exercises provided students opportunities to classify, link and reflect on the linkage of words and concepts (Table 7).

The language difficulty surveys were also distributed to first year students at the University of Newcastle and second year students at the University of Canberra in both 2008 and 2009. Since both these universities were involved in the discipline of biology, the same language difficulty questionnaire appropriate to biology was distributed.

Interactive Lecture Format

Traditional lectures are essentially a one way communication. First year students in particular, are reluctant to ask or answer questions in the lectures. To increase two way communication we used a variant on the 'clicker' style of student interaction tool during lectures. Short survey questions were integrated into each lecture at the completion of each significant unit of content (3-4 per hour) through the VotAmedia audience response system (<http://www.urvoting.com>) to gauge student understanding of lecture content and to engage the students in use of the language and discussion of the material just covered. The emphasis was not

on correct answers, but discussing why an answer or answers were correct and why an alternative was incorrect or 'less' correct. The goal was discussion, and reflection, not just assessment. There was no specialist infrastructure required for the use of VotAmedia and the lecturer was able to create, edit and assess their own questions using the site (Figure 1a). Students responded to each question via their mobile phone (at no cost), and were able to view the results immediately thus facilitating discussion (Figure 1b).

In-Lecture Tutorial Activities

Formal tutorials are not feasible in our system, but small group discussions (4-6 students) were used to complete tutorial activities such as the linking of terms and concepts within the Lecture Theatre environment. Over the course of several tutorial exercises, these activities progressed from relatively simple activities involving a single concept to the use of extensive and complex word lists associated with animal diversity (see Table 8 and Box 2).

The incremental increase in difficulty of the tutorial exercises enabled student confidence with the language to increase and encouraged students to put their points of view forward within their small groups. Reporters from each group then

Figure 1. Screen shots of the VotAmedia audience response system used during lectures in the "animals" module of biology (a) before voting and (b) after voting

Table 8. Example of one of the more complex "in-lecture" tutorials used in the animals biology module

Animal Phyla	Animals in the Phylum Class or Common Name	Body Features Seen in the Phylum*									
Arthropoda											
Nematoda											
Chordata											

Task 1: From the word list below, fill in the rows opposite the Phyla with one word that fits in the above table.
Clue: Some Phyla are very diverse and not all Classes in the Phylum will share all the same body features.
Word List: Hydra (Greek - many headed god), Medusa (Greek - snake hair god), Coral, Anthozoa (Class), Anemone, Mouth only, Nerve Net, Nervous system, Excretory system, Turbellaria (Class), Mammalia (Class), Hair, Feathers, Flatworm, Mesoderm, Acoelomate, Nematocyst, Circulatory system, Anus, Respiratory system, Cephalization, Asexual - Sexual life cycle, Trematoda (Class), Amphibia (Class), Oviparity, Reptile, Exoskeleton, Podia, Tagmata (Tagmatization), Jointed limbs, Terrestrial members, Marine/aquatic members, Mouth parts, Wings, Tracheal respiration, Euclitellata (Class), Parasites, Endothermy, Viviparity, Cephalochordata, Insecta (Class), Crustacea (Class), Cestoda (Class), Segmentation, Hydrostatic skeleton, Skin/surface respiration, Gills, Jelly Fish, Blue Bottle, Polychaeta (Class), Lungs, Amniote egg, Milk, Caenorhabditis

Box 2.

Task 2: For each of the tissue types below, indicate the germ layer(s) (i.e. ectoderm, mesoderm, endoderm) that it is derived from during embryonic development?
Tissue Types: Epithelium, Skin, Gut Lining, Lung Lining, Vaginal Lining, Muscle, Nerve Chord, Blood, Bone

contributed to whole class discussions, which provided another opportunity for the use of new language and terms to be reinforced.

Online Resources and Assessments

Practice quizzes were provided online, at weekly intervals throughout the semester for all four modules of the course. These quizzes consisted of MCQs as used previously, supplemented with mix and match exercises and gap-fill (Cloze) exercises to reinforce new language terms presented during the past week. The following is an example of the gap-fill exercises used:

Diabetes is a disease affecting more people around the world as societies become more affluent. A _____ of the disease is possible using mice that have been chemically-induced to be diabetic, or have been genetically selected to become diabetic over time. _____ into this disease requires the conduct of laboratory _____ using the mouse _____. Diabetes is a complex disease, requiring the consideration of physiological _____ that include sugar metabolism, water regulation via electrolyte _____ in blood, and the blood acid/base _____. The acid/base balance, or pH, can be described by an _____ showing the production of bicarbonate ions via the enzyme carbonic anhydrase, which helps buffer the blood pH around 7.4. Once the _____ are completed, the data can be represented in either tables or _____. Analysis is also required to decide whether the experimental results are _____ or not.

Words To Consider: Research, Experiment(s), System(s), Concentration, Equation(s), Significant, Model(s), Equilibrium, Graph(s)

There was a formative online quiz that consisted of between 40 and 60 multiple choice questions each week. Students received feedback immediately after submission of each practice quiz including their score and the correct answer for any question that they had answered incorrectly.

IMPACT OF CHANGES ON STUDENT LEARNING IN BIOLOGY

The language interventions outlined above were implemented during 2009 in the “Animals – who are they and how do they live” module only, with the three other modules in the course serving as an additional control.

Practice and Assessment Quizzes

An average of 61.2% of students completed the practice quiz each week, ranging from a low of 46.2% in week 5 of semester to peaks of 66-67% in weeks 1, 10, 11 and 12. The average score obtained in the practice quizzes ranged from 26-49% in 2009.

In 2009 students scored significantly higher in the online assessment for the “Animals” module that incorporated the language intervention than they did in the other three Biology modules (Table 7). The score obtained for “Animals” module was significantly higher in 2009 compared to 2008 (*t*-test, *p*<0.01), which was also the case for the “Ecological and Evolutionary Processes” module.

Table 9. Mean scores obtained in the online assessment for each of the biology modules during 2008 and 2009. The language intervention was incorporated into the “animals” module in 2009 only

Module	Online Assessment Quiz Score (% ± s.d.)	
	2008	2009
Ecological and evolutionary processes	66.6 ± 15.4	71.4 ± 14.3
Principles of Development	66.0 ± 16.7	55.4 ± 17.0
Animals: Who are they; how do they live	75.4 ± 20.0*	84.2 ± 18.3*
Green machines	83.2 ± 13.7*	78.7 ± 15.1

* Significantly different from other modules (*t*-test, *p*<0.001).

Table 10. Comparison of 2008 and 2009 biology 1002 cohorts at the University of Newcastle

Study Year	2008				2009			
	n = 221				n = 226			
Cohort	Language		Control		Language		Control	
Grade	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL
Number	28	193	88	133	63	163	131	95
% Total Students	13%	87%	40%	60%	28%	72%	58%	42%
Range of Marks (%)	50 - 94	0 - 48	50 - 87	19 - 49	50-100	0 - 49	50 - 82	4.4 -49
Mean Mark ± SD (%)	61.7 ± 10.1	15.6 ± 12.1	63.8 ± 8.3	37.5 ± 8.0	64.3 ± 12.3	24.6 ± 12.8	60.5 ± 8.2	39.5 ± 8.4

The “Language” intervention was incorporated into the “Animals” module of Biol 1002 in 2009 only. The other three modules, where no language intervention was introduced were used as the “Control”. Grades and marks presented are for the short answer component of the final exam only.

Performance in the online assessment for the other two modules declined in 2009, compared to 2008 (Table 9).

Performance in Final Exam

The following data assessed the impact of the interventions on performance in the short answer component of the exam only because it was the section that most critically depended on language and vocabulary (see Table 10). Analyses showed a significant improvement for the language group between 2008 and 2009 (χ^2 , *p*<0.01), but this was also found for the control modules, indicating a general improvement across the 2009 group, not an improvement only associated with the language interventions.

A closer look at the marks obtained by students reveals some interesting comparisons. The mean

score of students with a fail grade increased significantly in 2009 for the language group (24.6 *cf.* 15.6; *t*-test, *p*<0.001) but remained steady over both years in the control group (39.5 *cf.* 37.5; *t*-test, *p*>0.05). Conversely, the mean score of students that passed did not differ significantly between years for the language cohort, but increased significantly in 2009 for the controls (*t*-test, *p*=0.004).

CONCLUSION

A major limitation of both studies is that they are based on only two years of data. In both the Health and Science student cohorts there were significant variability between years, and where programs were identified, even between program cohorts from year to year. With this level of noise in the

data it is not surprising that evidence of the impact of teaching interventions was not always clear and in some cases performance was apparently worse. The study of genetics students (Lidbury, chapter 4) is based on five years of data and even with this greater amount of information a simple improvement in grades was not evident. The major impact of the language and other interventions was in the level of student motivation and engagement with the course topic.

The engagement and motivation of the different career program cohorts for the Health students is arguably an issue for future study. Similar subcohort analysis is possible for the biology students but would require changes to the study design. Anecdotal evidence would suggest contemporary university students are highly focused on the relevance of a course to their chosen career path. First year basic science courses have always found it challenging to engage the interest of students for which that discipline is not seen as core to the student's career goals. Learning tools such as, 'Disease of the Week' with subcohort specific examples, or illustrative examples of the relevance of lecture material to everyday life are sensible strategies to address this problem.

Similarly although it is difficult to provide empirical evidence of positive impacts of increased two way communication in the lecture theatre context, It is another effective strategy to promote student motivation and engagement. Anecdotal evidence from unsolicited student comments is that activities like the use of 'VotApedia' questions and discussion sessions and tutorial exercises with discussion are viewed positively by students and improve their experience in the lecture environment.

Future study should focus more on the student experience and their career aspirations and how these factors interact with the specific course or unit. Teaching interventions should arguably be assessed in terms of these outcome areas rather than in improvements in pass rates and grades.

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KEY TERMS AND DEFINITIONS

Chi-square (χ^2): The chi-square (chi, the Greek letter pronounced "kya") statistic is a nonpara-

metric statistical technique used to determine if a distribution of observed frequencies differs from the theoretical expected frequencies. Chi-square statistics use nominal (categorical) or ordinal level data, thus instead of using means and variances, this test uses frequencies.

Intrinsic motivation: refers to motivation that comes from inside an individual rather than from any external or outside rewards, such as money or grades.

Self-efficacy: has been defined in a variety of ways: as the belief that one is capable of performing in a certain manner to attain certain goals, as a

person's belief about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives.

VotApedia: an audience response system that does not require issuing clickers or need specialist infrastructure. Known users (users who have signed on and have obtained permission from Ken.Taylor@csiro.au to create surveys) can create surveys and edit the pages on this site. VotApedia is intended for co-located audiences but also works with remote audiences. Surveys are in a multiple choice question (MCQ) form. (<http://www.urvoting.com/>)

APPENDIX A: TEST 1 AND 2 OF THE LANGUAGE DIFFICULTY SURVEYS USED AT THE UNIVERSITY OF NEWCASTLE IN SEMESTER 2, 2009

Test 1

- **Question 1.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). MODEL: *Experimental models can be ideas or actual things.*
A: a microscope
B: an anatomical model
C: an experimental procedure
D: a mouse made susceptible to cancer
E: a blood specimen

Opinion scale:

- **Question 2.** Are you confident with your answer to the above question?
◦ No: I do not understand the meaning of this word.
◦ Not sure: I have some idea of the meaning of this word.
◦ Yes: I understand the meaning of this word.
- **Question 3.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). SYSTEM: *A system is many things that work together.*
A: The heart, veins and arteries
B: a motor
C: an electron
D: a protein
E: an event

Opinion scale:

- **Question 4.** Are you confident with your answer to the above question?
◦ No: I do not understand the meaning of this word.
◦ Not sure: I have some idea of the meaning of this word.
◦ Yes: I understand the meaning of this word.
- **Question 5.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). EQUILIBRIUM: *Over 5 years, the number of people leaving town was identical to the number of people arriving, leading to population equilibrium.*
A: The addition of chemical A to cells lead to an equal amount of oxygen production by these cells over 5 days of measurement.
B: The temperature of the pond water regularly changed by 10 degrees Celsius over a 100 day period of measurement.
C: the release of gas into the corner of the room soon spreads to fill the entire room.
D: The concentration of sodium (NA) in your blood changes when you drink a lot of water.

Opinion scale:

- **Question 6.** Are you confident with your answer to the above question?
◦ No: I do not understand the meaning of this word.
◦ Not sure: I have some idea of the meaning of this word.
◦ Yes: I understand the meaning of this word.
- **Question 7.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). EQUATION: *The tutor helped the student balance the equation.*
A: A statement that two things are the same.
B: A description of a reaction in terms of chemical symbols
C: A mathematical tool for calculating molecular mass.
D: A problem to solve to find the answer
E: A representation of a chemical reaction

Opinion scale:

- **Question 8.** Are you confident with your answer to the above question?
◦ No: I do not understand the meaning of this word.
◦ Not sure: I have some idea of the meaning of this word.
◦ Yes: I understand the meaning of this word.
- **Question 9.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). RESEARCH: *We carry out research to find out the answers to scientific questions.*
A: Observing the results of a series of chemical reactions
B: Testing a hypothesis by experimentation
C: Answering an exam question
D: Looking for information in the library or on-line
E: Copying information out of a textbook

Opinion scale:

- **Question 10.** Are you confident with your answer to the above question?
◦ No: I do not understand the meaning of this word.
◦ Not sure: I have some idea of the meaning of this word.
◦ Yes: I understand the meaning of this word.
- **Question 11.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). GRAPH: *The temperature was measured at 5 minute intervals and plotted on a graph.*
A: An XY plot of temperature versus time.
B: A table of numbers representing temperature and time.
C: A diagram expressing the connection between temperature and time.
D: A picture of the experiment
E: A piece of paper with lines on it.

Opinion scale:

- **Question 12.** Are you confident with your answer to the above question?
 - No: I do not understand the meaning of this word.
 - Not sure: I have some idea of the meaning of this word.
 - Yes: I understand the meaning of this word.
- **Question 13.** Tick the definitions that best fit the statement containing the key word (there can be more than one correct answer). CONTROL: An experiment can usually only be valid if it has a control or controls.
 - A: The results are carefully measured.
 - B: A trained observer is in control of the experiment
 - C: The same measurements are made on treated and non-treated groups.
 - D: Experimental animals are treated in an ethical way.
 - E: Experimental animals are not allowed to escape from their enclosure.

Opinion scale:

- **Question 14.** Are you confident with your answer to the above question?
 - No: I do not understand the meaning of this word.
 - Not sure: I have some idea of the meaning of this word.
 - Yes: I understand the meaning of this word.

Test 2

Fill in the Blank (10 points)

- **Question 1.** Diabetes is a disease affecting more people around the world as societies become more affluent. A _____ of the disease is possible using mice that have been chemically-induced to be diabetic, or have been genetically selected to become diabetic over time.
WORDS TO CONSIDER: *Research, Experiment(s), System(s), Concentration, Equation(s), Significant, Model(s), Equilibrium, Graph(s)*
 - Answer: *Model(s)*

Fill in Multiple Blanks (10 points)

- **Question 2.** (*This paragraph continues on from the sentence in the previous question*) [a] into this disease requires the conduct of laboratory [b] using the mouse [c]. Diabetes is a complex disease, requiring the consideration of physiological [d] that includes sugar metabolism, water regulation via electrolyte [e] in blood, and the blood acid/base [f]. The acid/base balance, or pH, can be described by an [g] showing the production of bicarbonate ions via the enzyme carbonic anhydrase, which helps buffer the blood pH around 7.4. Once the [h] are completed, the data can be represented in either tables or [i]. Analysis is also required to decide whether the experimental results are [j], or not.
WORDS TO CONSIDER: *Research, Experiment(s), System(s), Concentration, Equation(s), Significant, Model(s), Equilibrium, Graph(s)*

- Answer for [a]: *Research*
- Answer for [b]: *Experiment(s)*
- Answer for [c]: *Model(s)*
- Answer for [d]: *System(s)*
- Answer for [e]: *Concentration*
- Answer for [f]: *Equilibrium*
- Answer for [g]: *Equation(s)*
- Answer for [h]: *Experiment(s)*
- Answer for [i]: *Graph(s)*
- Answer for [j]: *Significant*

APPENDIX B: VOTAPEDIA QUESTIONS USED IN BIOLOGY 1002 AT THE UNIVERSITY OF NEWCASTLE

Biology clicker/votapedia questions on Animal Form and Function, written by Professor John Rodger, john.rodger@newcastle.edu.au

Some questions require multiple answers and the ticked items [✓] are the answers for the questions.

1. Monotremes don't produce milk the egg is self sufficient
 - ☐ Marsupials favour lactation over the placenta to support the growth phase of development [✓]
 - ☒ Marsupials don't have a placenta the embryo is supported only by milk
 - ☐ Marsupials lay eggs and the embryo hatches and climbs into the pouch
 - ☐ Placental mammals favour the placenta over lactation to support the growth phase of development [✓]
2. Place these membrane structures in order from the embryo outwards
 - ☐ Amnion – Yolk Sac – Allantois – Chorion [✓]
 - ☐ Allantois – Yolk Sac – Amnion – Chorion
 - ☐ Amnion – Allantois – Yolk Sac – Chorion [✓]
 - ☒ Amnion – Chorion – Yolk Sac – Shell
3. Place these Structures in their Order of Appearance in Vertebrate Evolution
 - ☐ Jaws – Limbs – Tail – Notochord – Dorsal hollow nerve cord
 - ☐ Jaws – Vertebrae – Bone – Lungs – Limbs – Amniote egg [✓]
 - ☒ Pharyngeal gill slits – Lungs – Notochord – Lactation
 - ☐ Ray fins – Gills – Tail – Feathers – Milk
4. Place Deuterostome Groups in Correct Order
 - ☐ Chordates – Vertebrates – Crainiates – tetrapods – Amphibians
 - ☒ Amniote – Vertebrate – Mammal – Bird – Craniates
 - ☐ Sarcopterygii – Actinopterygii – Vertebrates – Mammals
 - ☐ Chordates – Crainiates – Vertebrates – Tetrapods – Amniotes [✓]
5. Deuterostome chordates
 - ☒ Have aquatic larvae with gill slits
 - ☐ Share a common developmental process [✓]
 - ☐ Have a notochord and hollow nerve cord [✓]
 - ☐ Form the mouth first and have radial cleavage
6. Phylum Arthropoda, the arthropods
 - ☐ Arthropods are protostomes [✓]
 - ☐ Arthropods have smooth growth and an exoskeleton
 - ☒ Insects have a non-segmented body plan and mouth parts
 - ☐ Insects use gills to respire
 - ☐ Class Insecta and Class Crustacea are arthropods [✓]

7. Phylum Mollusca, the molluscs
 - ☐ Molluscs grow by ecdysis
 - ☐ Many molluscs use a radula to scrape food off surfaces [✓]
 - ☐ The mollusc body plan is made up of segments
 - ☒ slugs and oysters are mollusks [✓]
 - ☐ Bivalvia refers to the two valves in the mollusc heart
8. Phylum Annelida, the annelid worms
 - ☐ All annelids live underground
 - ☐ All annelids are segmented [✓]
 - ☒ Annelids have one heart
 - ☐ Annelids have circular and longitudinal muscle [✓]
 - ☐ Annelids are often parasites
9. The simplest animals
 - ☒ have a reduced coelom
 - ☐ are bilaterally symmetric
 - ☐ have a mouth only [✓]
 - ☐ have 3 body layers – triploblast
 - ☒ have 2 body layers – diploblast [✓]
10. Flatworms
 - ☐ Cestoda are free living flatworms
 - ☐ Platyhelminthes means flatworm [✓]
 - ☒ Turbellaria are free living flatworms [✓]
 - ☐ Flatworms are pseudocoelomate
 - ☐ Flatworms lack a circulatory system [✓]
11. Evolution of animals
 - ☒ Phylogeny is now based on structure of fossils and living forms
 - ☒ Molecular sequence data suggests that acoelomates gave rise to pseudocoelomates then coelomates
 - ☒ Sequence data suggests that the pseudocoelomate condition arose at least twice from coelomate ancestors [✓]
 - ☐ Nematodes are closely related to arthropods [✓]
 - ☐ All worms are more closely related to one another than other phyla
12. Sexual or asexual reproduction
 - ☒ Meiosis is a feature of sexual reproduction [✓]
 - ☐ Meiosis is a feature of asexual reproduction
 - ☐ Mitosis is a feature of sexual reproduction
 - ☐ Mitosis is a feature of asexual reproduction [✓]
 - ☒ Meiosis results in a doubling of chromosome number

13. Osmosis
 - Osmosis describes molecules moving from a site of high concentration to a site of low concentration
 - Diffusion is the process by which molecules move due to current in the water
 - Osmosis requires a selectively permeable membrane that water cannot cross
 - Osmosis requires a selectively permeable membrane that some solutes cannot cross [✓]
 - Water moving across a selectively permeable membrane to equalise water concentration is called osmosis [✓]
14. Respiration
 - Surface area to volume ratio means that very small animals can 'breathe' through their 'skin' [✓]
 - Large animals cannot control body temperature in the cold as easily as small animals
 - Water is a good source of oxygen if not stagnant
 - Fish use counter current flow in their gills to more effectively remove carbon dioxide
 - Counter current flow is only important in marine mammals
 - Very thin animals can 'breathe' through their 'skin' without gills or lungs [✓]
15. Digestion
 - Animals with the simplest form of digestion system have a mouth and anus
 - Birds use teeth to grind their food
 - Parasites often have reduced or no digestive organs [✓]
 - Mammals have specialised teeth to eat very different diets [✓]
 - Nematodes have only a mouth and no anus
16. Coeloms
 - Acoelomates have two coeloms
 - Pseudocoelomates have no coelom
 - Coelomates have the coelom between the mesoderm and endoderm
 - Coelomates have the coelom in the mesoderm [✓]
 - Coelomates have mesenteries [✓]
17. Epithelia:
 - A type of tissue [✓]
 - A cellular lining [✓]
 - Part of the mesoderm
 - Connect other tissues together
 - Regulate movement of materials [✓]
18. What is an animal?
 - Dog
 - Bird
 - Fly
 - Worm
 - All of the above [✓]

19. Cost of Nitrogen Excretion
 - All animals must excrete the waste products of the breakdown of nitrogen containing molecules like proteins and nucleic acids because they are toxic. Access to water and the cost of producing less toxic versions of the nitrogen containing waste are the two key issues for animals.
 - Ammonia is produced in terrestrial animals
 - Urea is produced by all marine or aquatic animals
 - Ammonia, Urea, Uric acid, Guanine is the ascending order of energy cost
 - All animals produce Urea
 - Guanine, Ammonia, Urea, Uric acid is the decreasing order of water cost

APPENDIX C: TUTORIAL LANGUAGE EXERCISES

1. Activity 1: body plan

Instruction to instructors:

Aim: to practice the names of different cells in the body plan of different types of animals.

Language practiced:

Procedure: Divide the class into even numbered groups. Within each 2-group, students group A gets the Task sheet. One student gets one task sheet. Each student in group B gets a definition sheet. The task of the students in group A is to walk around and talk to group B students and get the names of all the things they are looking for. You need to photocopy enough for all students. (see Tables 11 and 12)

Table 11. Task sheet

Find the:
groups of similar cells that are organized into structural units.
Find the name of the organism that have cells that cover the surface
Name of the animal group that has two types of tissue layers.
Name of the animal group that has three types of tissue layers
Find the name of the inner layer in two buds animals.
Find the name of the outer layer in two buds animals
What is the name of the layer in three buds animal which is between the outer and inner layer?

Table 12. Definition sheet

All animals have these groups of similar cells that are organised into the tightly integrated structural and functional units. My name is 'tissue'.
Sponges have a layer of tightly joined such cells that covers the surface. I am epithelium.
These animals have embryos that have two types of tissue layers. (diploblast)
These animals have embryos that have three types of tissue layers. (triploblast)
Embryonic tissues are organized in such layers. (germ layers)
This is the name of inner layers in "two buds" animals. (ectoderm)
This is the name of outer layers in "two buds" animals. (endoderm)
In "three buds" animals, there is another tissue layer between the outer and inner skin. (mesoderm)

2. Why is epithelium a particular important tissue in achieving homeostasis?

Hints for answering this question:

- Step 1: fill in the blanks in the drawing (below)
- Step 2: fill in the blanks in the sentence: 'Epi' from Greek means '____' or '____'.
- Step 3: what is epithelium (singular)/epithelia (plural)?
- Step 4: Where are they found in an animal's body?
- Step 5: Give two examples of epithelia
- Step 6: use the two examples to illustrate what the epithelia do to maintain homeostasis.

Tissue Layers

3. Explain the difference between a diploblast and a triploblast. Why was the evolution of a third embryonic tissue layer important?

Hints for answering this question:

- 'Di' means _____, 'tri' means _____.
- The third layer is known as '_____'.
 - What does the third layer enable the organism to do?
 - What does the third layer develop into?
 - What does this further development allow the organism to do?

4. Explain why cephalisation was important.

Hints for answering this question:

- Step 1: what is cephalisation?
- Step 2: Give two examples of cephalisation.
- Step 3: use the two examples to illustrate what cephalisation enables the animal to do better.

5. Provide students with a phylogeny of animals, then ask them to fill in the blanks with the following words: *Lophotrochozoa*, *protostoma*, *ecdyssozoa*, *deuterostoma*, *bilateria*, *animalia*, *deuterostome development*, *protostome development*, *triploblasty*, *bilateral symmetry*, *multicellularity*, *annelida*, *mollusca*, *nematode*, *arthropoda*, *echinodermata*, *chordata*

Aim: what is the relationship between the ‘ma’ in ‘protostoma’ and ‘me’ in protostome development?

6. Complete the following table on diversification of animals: **Instructions:** Provide each student with a table without the answers and get them in groups 3-4 to discuss this for five minutes, then let them report back their solutions. (see Tables 13 & 14)

Table 13.

Examples of animals	Types of feeders	environment	Shapes/mouthparts	Function of shapes	Movement
Worms, fish					
Hummingbirds, ticks, mosquitoes, bees					
Humans, dogs, eagles					
Clams					

Table 14. Answers

Examples of animals	Types of feeders	environment	Shapes/mouthparts	Function of shapes	Movement
Worms, fish	Deposit feeder	Surrounded by substrate such as soil, water	tubelike	Take in substrate from front, waste out behind.	Hydroskeleton?
Hummingbirds, ticks, mosquitoes, bees	Fluid feeders	Trees, flowers	Long tubular mouthparts	Piercing or reaching into food source such as nectar by suction.	
Humans, dogs, eagles	Food-mass feeders		Different types of teeth	Puncturing prey	
Clams	Suspension feeders				

7. Compare and contrast the types of mouthparts and body shapes you would expect to find in herbivorous insects that suck plant fluids from stems, bore through stems, bite leaves, and suck nectar from flowers. **Instructions:** Provide each student with a table without the answers and get them in groups 3-4 to discuss this for five minutes, then let them report back their solutions. (see Tables 15 & 16)

Table 15.

Types of insects	mouthparts	Uses of mouthparts	Body shapes	Uses of body shapes
Insects that suck fluids, e.g. mosquito				
Insects that bore into stems				
Insects that bite leaves				
Insect that suck nectar				

Table 16. Answer

Types of insects	mouthparts	Uses of mouthparts	Body shapes	Uses of body shapes
Insects that suck fluids, e.g. mosquito	Sharp and point syringe like (proboscis)	Pierce woody stems and suck out the fluid.	Have Legs or wings	Cling to the stems of the tree
Insects that bore into stems	Mouthparts that can bite and chew and a strong proboscis	To bite and chew stems to get food	Smooth/streamlined outer surface and appendages	Enable easy movement through the stem
Insects that bite leaves	Mouthparts that bite and chew		Legs and wings	Cling to the leaves while eating
Insect that suck nectar	Long proboscis that can be inserted into the flowers	To suck nectar from flowers	Eyes to sense the flower and wings	Wings to get to the flowers.

8. Explain how a hydrostatic skeleton works. Compare the types of movement that are possible with a hydrostatic skeleton to the types of movement observed in animals that lack a hydrostatic skeleton. Hints for answering this question:
- Step 1: Fill in the blanks for the drawing (below)
 - Step 2: Fill in the blanks in the sentence: ‘Hydro-’ from Greek means ‘_____’ or ‘_____’, ‘Static’ means _____. In this case, the water is not moving.
 - Step 3: By what means is the movement possible in this animal?
 - Step 4: What is the ‘coelom’?
 - Step 5: Where is the coelom found in an animal’s body?
 - Step 6: At what stage of phylogeny did the coelom first appear?
 - Step 7: Use the two examples to illustrate how the hydrostatic skeleton functions to enable movement. 1. _____ 2. _____
 - Step 8: what happens if muscles on both sides stiffen? Or one side relax and one side stiffen?

Body Cavities

9. Suppose you are walking along an ocean beach at low tide and find an animal that is unlike any you have ever seen before. How would you go about determining how the animal feeds and how it moves? How would you go about determining the major features of its body plan? Hints for consideration: Construction of animal body plan from external observation, dissection and embryo culture. (see Table 17)

Table 17. Construct a phylogenetic tree from the following body plan observations summarised below, and answer the questions embedded in the exercise

Phylogenetic Characteristic	Mode of Observation								
	External Examination			Dissection of Organism			Embryo Culture		
Bilateral Symmetry + Cephalisation	Yes	No	NA	Yes	No	NA	Yes	No	NA
	✓					✓			✓
Mouth & Anus	Yes	No	NA	Yes	No	NA	Yes	No	NA
	✓					✓			✓
Mouth first? (_____stome)							✓		
Anus first? (_____stome)								✓	
Body Cavity	Yes	No	NA	Yes	No	NA	Yes	No	NA
			✓	✓					✓
Fluid-Filled Body Cavity has Muscles & Blood Vessels on both sides	Yes	No	NA	Yes	No	NA	Yes	No	NA
			✓	✓					✓
Number of Tissue Layers? (2=_____blastic OR 3=_____blastic)?	Two	Three	NA	Two	Three	NA	Two	Three	NA
			✓	✓					✓
Spiral or Radial Cleavage	Spiral	Radial	NA	Spiral	Radial	NA	Spiral	Radial	NA
			✓			✓		✓	
Language & Definitions	(1) Which "Phylogenetic Characteristic" above can be described as a <i>coelom</i> ? (2) With <i>diploblasty</i> there was the evolution of the _____derm and _____n_____derm. With <i>triploblasty</i> , there was the addition of a _____e_____derm. (3) <i>Ceph-</i> refers to what part of the body?								

NA = Not Applicable (i.e. mode of observation cannot detect this phylogenetic characteristic).

In [Table 18], tick the appropriate boxes to construct your own representative animal at the level of Phylum. Be aware that the observations recorded in the table cannot always be detected by external examination, dissection or embryo culture, so you need to be aware of what technique is appropriate for the particular phylogenetic observation.

Table 18. + Student phylogenetic construction of their own animal

Phylogenetic Characteristic	Mode of Observation								
	External Examination			Dissection of Organism			Embryo Culture		
Bilateral Symmetry + Cephalisation	Yes	No	NA	Yes	No	NA	Yes	No	NA
Mouth & Anus	Yes	No	NA	Yes	No	NA	Yes	No	NA
Mouth first? (_____stome)									
Anus first? (_____stome)									
Body Cavity	Yes	No	NA	Yes	No	NA	Yes	No	NA
Fluid-Filled Body Cavity has Muscles & Blood Vessels on both sides	Yes	No	NA	Yes	No	NA	Yes	No	NA
Number of Tissue Layers? (2=_____blastic OR 3=_____blastic)?	Two	Three	NA	Two	Three	NA	Two	Three	NA
Spiral or Radial Cleavage	Spiral	Radial	NA	Spiral	Radial	NA	Spiral	Radial	NA
Language & Definitions (List your own here)	(1) (2) (3)								