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**Disclaimer:** While all module information are provided accurate by the respective module coordinator(s), students are responsible to confirm the information with relevant administrator(s) or module coordinator(s) due to the possible changes and updates in the modules.
Message from Head of the Department

At the Department of Biological Sciences (DBS) in NUS, we will take our undergraduate students on an exciting education journey to learn about life, the human condition, and the natural world. Equipped with the state-of-the-art technologies and facilities coupled with next-generation resources and expertise, we will enable our students to learn about the complex and dynamic biological world from the environmental and ecological levels to the organismal, cellular and molecular levels. Students will gain access to a wealth of knowledge brought to you by experienced faculties who will teach you what we know and co-discover with you what we have yet to know. There will be ample learning opportunities and we wish to help you plan your journey ahead with us.

This Life Sciences Module Handbook (volume 1) contains detail information of the level 1000 and 2000 modules relevant to first-year students who plan to embark on their education journey with us. Whether you plan to be a ‘versatilist’, an ‘integrator’, or a ‘deep specialist’ in the College of Humanities and Sciences (CHS) curriculum, we have the modules to help you become one. These level 1000 and 2000 modules will be important stepping stones to the higher level 3000 and 4000 modules that will eventually empower you with disciplinary knowledge and skills when you graduate with Life Sciences as Major or Minor.

In addition to informing you about the modules that we are teaching, we are also interested in how you will be learning from us. This Life Sciences Module Handbook has been designed to inform you on the active learning activities that we are employing in our modules to achieve the learning outcomes. Active learning activities will require you to participate in the learning process where you have to put in efforts to build understanding and construct knowledge in your mind beyond merely acquiring information. This handbook will prime you for active learning.

We are not only committed to your learning, but also interested in preparing you for your professional development, be it joining the workforce or pursuing further studies. This Life Sciences Module Handbook has been designed to inform you on the opportunities to develop Graduate Employability Skills and Attributes (GESAs) in our modules. GESAs are generic, applicable across disciplines, and transferable to multiple settings from academic, work, to various life contexts. Make the best of the opportunities to develop GESA with us!

DBS is therefore not just committed to educating and equipping our students with disciplinary knowledge and skills, but also holistically as individuals who will contribute to society. We care for your present journey with us and we also have your future in mind. On behalf of DBS, I wish your education journey with us to be deeply enriching, greatly rewarding and to have a long sustaining positive effects into forging a brighter future!

Professor Yu Hao
Head of the Department of Biological Sciences,
Faculty of Science, National University of Singapore,
July 2021
An Overview of the Life Sciences Module Handbook

There are three volumes for the Life Sciences Module Handbook:

- Volume 1 - Life Sciences Modules (LSM) 1000 and LSM 2000 modules
- Volume 2 - LSM 3000 modules
- Volume 3 - LSM 4000 modules

Volume 2 and 3 will be available in subsequent year.

The modules are arranged according to an increasing module code number. You can quickly access the modules by searching the module code using the search function (‘Ctrl and F’ keys) in PDF.

There are nine sections in each of the module description and they can be summarized into the following five parts:

<table>
<thead>
<tr>
<th>Section</th>
<th>Module Section</th>
<th>What information does this Section contain?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 5</td>
<td>Module Essential Information</td>
<td>This section includes Module Description, Module Prerequisites, Instructional Methods, Assessment Modes, and Contact Information of the module coordinator and co-teachers.</td>
</tr>
<tr>
<td>6</td>
<td>Module Content and Syllabus</td>
<td>Detailed module information on what you will be learning</td>
</tr>
<tr>
<td>7</td>
<td>Learning Activities used in the Module</td>
<td>A list of the diverse active learning activities adopted by the teaching team in the module, and a description of how these learning activities will help to achieve module learning outcomes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>As various active learning instructional methods have been adopted in the LSM modules, some tips to prepare students to participate effectively in these active learning activities are provided in the ‘Active Learning’ section in the front matter of this LSM Module Handbook (page xii to xvi).</td>
</tr>
<tr>
<td>8</td>
<td>Learning outcomes (including both knowledge development and cognitive skills and generic skills and attributes)</td>
<td>Besides knowledge construction in each module, the cognitive and generic skills are highlighted here. Students will know which listed generic skills they would have more opportunities to learn in the module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Please refer to ‘Graduate Employability Skills and Attributes’ in the front matter of this LSM Module Handbook to learn about the ‘what, why, where/when and how’ these skills and attributes can be developed within the module (page vi to xi).</td>
</tr>
<tr>
<td>9</td>
<td>Recommended reading list</td>
<td>A reading list that could include text books, references, relevant articles and resources for the module are indicated.</td>
</tr>
</tbody>
</table>
The Value of Academic Integrity in Learning in the University

The National University of Singapore (NUS) is a supportive and inclusive learning space for every individual. As you embark on your academic journey as a member of the NUS community, upholding academic integrity and honesty is expected to be an important guiding principle. But what exactly is considered to be academic dishonesty? According to the “Academic, Professional and Personal Integrity” principle in the NUS Code of Conduct, it is defined as any misrepresentation with the intent to deceive or failure to acknowledge the source or falsification of information or inaccuracy of statements or cheating at examinations/tests or inappropriate use of resources” with nine items which are considered to be academic dishonesty acts (Figure 1). The implications of academic dishonesty are severe, ranging from failure in the particular assessment to expulsion from the university.

**Figure 1.** Academic dishonesty acts [Source: Academic Integrity Essentials, 2021 NUS Libraries https://libguides.nus.edu.sg/c.php?g=916984&p=6831854]

Here is the list of common forms of academic dishonesty and their respective examples:

- **Hiring ghostwriters** - paying others to do your work or outsourcing your work to others.

- **Fabricating and falsifying information, data, sources of citations** – making up or changing information or data with the intention to deceive, mislead or misrepresent.
• **Cheating at exams/tests** – this includes copying, referring to or relying on unauthorized materials or sources, during a test or exams. For more information on the online exams, check out the resources for Proctoring exam information for students and Examplify exam.

• **Copying homework or lab results** - Obtaining and using the works of a senior/peer who had previously completed this module.

• **Colluding with classmates in tests, assignments or take-home exams** - Cooperation with classmates is allowed for group assignment, but for individual assignment, it is considered to be collusion. Students should undertake the responsibility of individual assignments by themselves, as collusion could result in work similarity. This could be deemed as an act of academic dishonesty and eventually result in disciplinary action.

• **Buying, selling or distributing teaching materials online** - The teaching materials are protected by copyright and only for personal study use, so there should not be sales of these materials. Such activities will be deemed as a violation of the NUS Student Code of Conduct and NUS IP Policy.

• **Plagiarism in any form** - This is a common form of academic dishonesty and it often means presenting the work of others as your own without consent/acknowledgment. This can be easily overcome by citing the work appropriating and paraphrasing the points.

• **Copyright infringement in any form** - Copyright protection is automatic so permission is required from the user before reproducing or distribution of work such as photos, videos, music, journal articles, text, films, etc. Besides getting permission granted, you can also use free-use online content and attribute accurately.

• **Inappropriate use of library e-resources** - The NUS library’s e-resources contains a diverse array of information and can only be used by current NUS staff and students for learning/teaching/research purposes.

If you are unsure of what counts as academic dishonesty, do approach and consult the teaching staff or use the online resources listed here to find out more and to avoid them. At the end of the day, having academic integrity and honesty benefits you as this allows you to have authentic learning and for others to trust the work that you produce.

“**You’re looking for three things, generally, in a person. Intelligence, energy, and integrity. And if they don’t have the last one, don’t even bother with the first two.**” Quote from Warren Buffett

**Resources:**

NUS Office of Student Affairs website

Academic Integrity guide on NUS Libraries
Graduate Employability Skills and Attributes (GESAs) and You

1. What are GESAs and what have GESAs got to do with you?

While there is no single definition, GESAs can be viewed as the abilities and personal traits that employers would want in a fresh graduate whom they are employing. GESAs are also referred as generic ‘work-ready or job-ready skills’.

Characteristically, GESAs are generic as they are applicable horizontally across disciplines, hence not discipline-specific. GESAs are required vertically across different professional roles from entry level up to higher executive levels although they may differ in the degree of competency. GESAs are transferable to multiple settings from academic, workplace to various life contexts.

GESAs can be broadly categorized into:

   a. **Fundamental skills** such as literacy, numeracy, digital, and information skills.
   b. **Cognitive or thinking skills** such as analytical thinking, critical thinking, problem-solving skills, creative thinking, interdisciplinary thinking and cognitive flexibility.
   c. **Intrapersonal skills and attributes** such as time management, planning and organizational skills, self-efficacy, adaptability, emotional intelligence, and integrity.
   d. **Interpersonal or soft skills** such as communication skills, collaboration and teamwork, leadership and people skills.

**Important Note:** Do not fret and be overwhelmed by the list. While these are skills and attributes that you would want to gain some levels of competency when you graduate, you will not likely to master them as they are part of life-long learning. However, it is important that you are aware of GESAs and know that there are opportunities in your undergraduate training to develop them, and there are instructional support and frameworks to help you develop them.

2. Why are GESAs important to you?

GESAs are important to you because of the following:

   a. **They are generic and you can use them** across disciplines although you will still need to contextualize the application within a discipline and purpose. This means you can apply thinking skills such as analytical and critical thinking framework into your academic pursuits within the context of the disciplinary knowledge, principles and operations. If it involves interdisciplinary thinking, you will need to know the strengths and limitations of different disciplinary thinking in the context of the issue and purpose.
   b. **They are transferable** to multiple settings which means that you can learn from one setting and apply it to another setting. For example, you can learn and apply collaboration skills and teamwork in an academic setting while doing a group project with your peers, and transfer the principles of good collaboration and teamwork to a neighbourhood community project, and eventually to your future workplace.
   c. **They are important for your continuous education and life-long learning.** As GESAs are generic and transferable, they are highly useful for our continuous learning in different domains and roles that you will be working on and taking on as you grow professionally and personally.
   d. **They will prepare you for the workforce** and possibly enhance your ‘employability’ as employers perceive that graduates with such skills and attributes will be able to adapt better
in workplace, perform better in work tasks and progress better in their professional
development. Employers often lament that fresh graduates lack GESA. Therefore, you either
gain some competencies in a ‘learning-friendly’ academic environment or you will have to
learn it the ‘hard’ way in a harsher working environment later.

Important Note: You must see the above reasons as relevant and important so that **you are**
motivated to play an active role in learning and developing GESA. If you **have the right motivation**, you are at a **good start** to develop GESA during your undergraduate training and beyond.

3. What are the challenges in teaching and learning GESA?

Fundamental skills and disciplinary skills can be taught stepwise and systematically while their
learning outcomes are measurable hence the abilities can be evaluated and graded more objectively.
However, GESA such as thinking, intrapersonal and interpersonal skills are difficult to teach
conventionally and their learning outcomes are not easily measured while their evaluation can be
subjective (unless they are carefully designed and evaluated according to an established standard).

It is therefore not surprising that these skills, while important, are usually not taught explicitly in
many curricula (with the exception of specific soft skillsets in certain professional courses) and being
generic would mean that these skills do not belong to any discipline. Educators who are proficient in
their own discipline are usually not train to teach these skills while others question if these skills can
even be taught. Some educators expect students to pick up and develop these skills by themselves
while performing the learning tasks in their modules. However, this can be a ‘catch-22’ situation! For
example, students are required to think critically for an assignment and are expected to pick up
critical thinking by themselves. On the other hand, students may not be aware of the need to do so,
and if they have not been exposed to critical thinking, students do not know how to pick up critical
thinking skill by themselves. In turn, some students who feel that they need to be taught in order to
learn may perform below the expectation of the educator and are perceived as not thinking
critically. This will leave both sides feeling unsatisfied of the learning outcomes at the least, while
others may feel frustrated.

Important Note: You must **be aware of these challenges** of teaching and learning GESA so that you
can **take charge on your side and play active roles** in developing these skills and attributes. While
GESA may be difficult to teach, they can be learned and developed. This Life Sciences Module
Handbook has been designed to support the learning of GESA and we will provide you with
additional instructional resources to help you develop GESA. Read on below!

4. How do you overcome the challenges of learning GESA? When and where can you learn
GESA?

Teaching these GESA in standalone modules/classes will usually not work well as skills require
practice and practice is best done in an immersive and authentic environment through experiential
learning. Therefore, one approach is to embed the development of these skills within a module’s
learning activities and assignments together with content learning. However, the learning of
disciplinary content will tend to take the centre of attention and students may not be aware that
these skills are to be developed as part of the learning process and learning outcome of the module
itself. Students may not know when and where these skills are required in the modules, and even if
they know the requirement, they may not know how to develop them. Therefore, we have taken
actions to narrow, even though not fully close, these gaps, but will further need your active roles to overcome these challenges as outline in the Table 1 below.

**Table 1. Our Roles and Your Roles in Overcoming Challenges in Developing GESA**

<table>
<thead>
<tr>
<th>Potential Challenges</th>
<th>Our Roles &amp; Your Roles for Possible Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. What and Why?</strong></td>
<td></td>
</tr>
<tr>
<td>Students may not know what GESA are, and why they are important; therefore, lack understanding and motivation to learn/develop them.</td>
<td></td>
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<tr>
<td>Our Roles: Explain what these skills and attributes are and why they are important for students, especially for freshman, in this LSM Module Handbook and in DBS learning workshop for students. Your Roles: Understand what are GESA and why they are important to you, and be motivated to take charge and play an active role in developing them.</td>
<td></td>
</tr>
<tr>
<td><strong>II. When or Where?</strong></td>
<td></td>
</tr>
<tr>
<td>Students may not know when/where they are supposed to learn these generic skills hence did not consciously learn and practice them effectively when/where required in the module.</td>
<td></td>
</tr>
<tr>
<td>Our Roles: Provide explicit information on GESA that are taught and developed as learning outcomes in this LSM Module Handbook. Some examples of when/where e.g. learning activities/exercises are described in the in this LSM Module Handbook. Your Roles: Check with the educator when/where specific GESA are required in the learning activities/assignments which are developed as part of the learning objectives/outcomes in the modules. Play an active role and be deliberate in learning and practicing them when performing the learning task or activity.</td>
<td></td>
</tr>
<tr>
<td><strong>III. How?</strong></td>
<td></td>
</tr>
<tr>
<td>Students may not know how to learn and develop GESA skills effectively in specific exercises/activities in their module.</td>
<td></td>
</tr>
<tr>
<td>Our Roles: Provide general instruction and resources on how some of these skills could be developed in this LSM Module Handbook, and Transferable Knowledge and Skills (TKS) booklets (refer to point-5 below), and in the DBS learning workshop. Your Roles: Refer to LSM Module Handbook, TKS booklets and companion practice worksheets to adapt and practice GESA in your current context (refer to detail to point-5 below). Also, check out other resources on GESA that are available on the internet.</td>
<td></td>
</tr>
</tbody>
</table>

# This Table is modified from Lam and Ip (2018). Equipping our undergraduates with essential generic skills: Why, What, When and How? Asian Journal of the Scholarship of Teaching and Learning, 8(2), 235-248.

In addition to embedding the development of GESA into modules, work-integrated learning (e.g. internships) and inquiry-based learning (e.g. research projects) can provide excellent opportunities to develop GESA where you get to work with practitioners within the community of practice. It is in the workplace, in a research laboratory or out in the field working within the community that you will find a lot of opportunities to practice your thinking, intrapersonal and interpersonal skills. Even so, you will still need to know how to develop, adapt, and practice them in these authentic learning environments. This is where and when some additional resources can act as instructional support to help you develop and practice GESA.

**Important Note:** While there are challenges in learning and developing GESA (the bad news!), they can be overcome and your active roles are crucial (the good news!). We can create opportunities and resources as instructional support to develop GESA but they are only good if you would make the best use of these opportunities and resources to develop GESA as part of your personal growth and professional development even as you prepare yourself to join the workforce or to continue with your academic pursuit.
5. How can you adopt, practice and develop GESA?

There are plenty of opportunities for you to develop GESA in the Life Sciences curriculum and to help you make the best of these opportunities, we have designed this LSM Module Handbook and provide you with Transferable Knowledge and Skills (TKS) booklets (Figure 2) as resources to act as instructional support for developing GESA. The TKS booklet series and its companion practice worksheets are made available in OTH738 (DBS Learning Resources for Students) on the LumiNUS and access are granted through the registration of DBS Learning Workshop. This LSM Module Handbook will indicate to you the opportunities for learning and developing specific GESA for the modules that you are going to take. The TKS booklet series and its companion practice worksheets will provide you instructional support on the available frameworks and principles for important GESA so that you have a starting point to adopt them with modification, practice, and develop these GESA in your specific contexts. ‘To adopt them with modification’ suggests that you have to embrace and internalize the principles but modify, adapt and apply the framework to your context. ‘To practice’ means that you will have to repeatedly try, test, and evaluate to improve on it. ‘To develop’ emphasizes that it will be improved and built based on repeated trials over time. Therefore, you need to put in efforts, be patient and persevere to develop GESA.

![Nine Booklets & Companion Practice Worksheets in three series](image)

**Figure 2.** Transferable Knowledge and Skills Booklets. These booklets and their companion practice worksheets are resources intended to act as instructional support to prime the development of GESA. Students are strongly encouraged to refer to the reference list of resources embedded at the end of each booklet and other resources to learn more about developing GESA.

Here is a general guideline on how you can play the active and crucial roles of developing GESA:

i. To find out the opportunities for developing GESA in a module that you are taking, refer to the LSM Module Handbook. For every module description, section 8 will highlight the learning outcomes that include ‘good’ to ‘very good’ opportunities for you to learn certain skills including GESA. Section 7 will highlight some of the learning activities that will contribute to the learning outcomes that include GESA. Take note of the type of learning activities (section 7) and the learning outcomes with respect to specific GESA (section 8). If
not sure, check with the instructor on a learning activity and its corresponding learning outcomes that includes GESA.

ii. Once you know the learning activity/task (it can be an assignment or a project) and the GESA required, refer to the Transferable Knowledge and Skills (TKS) Booklets or other relevant resources for the specific GESA. Also, refer to ‘Active Learning Strategies for Students’ in this Handbook for some of the GESA required for certain Learning Activities (page xii to xvi).

iii. There are nine TKS booklets with their respective companion worksheets that are designed in the following three series to provide you with instructional support to develop GESA:

   a. Refer to the **Cognitive Skills Series** if it is concerning learning and thinking skills. These skills can include **self-regulated learning**, **strategic learning mind set**, **reflective thinking**, **note-taking**, **speed reading**, **analytical and critical thinking**, **information skills**, **creative thinking**, **problem solving and decision making skills**. This series will be helpful for both personal and your academic development where you can apply to the learning of disciplinary knowledge and skills.

   b. Refer to the **Intrapersonal Skills Series** if it is concerning personal skills and attributes to initiate and maintain effective function in multiple contexts. These skills and attributes can include **self-motivation**, **emotional intelligence**, **stress management**, **time management**, **planning and organizational skills**. This series will be useful to plan, organize and manage your daily activities including both personal and academic commitments while maintaining mental health and a balance life.

   c. Refer to the **Interpersonal Skills Series** if it is concerning soft skills, working and communicating with people. These skills can include **collaboration**, **teamwork**, **leadership**, **practical communication**, **people skills**, and **managing conflict and difficult conversation**. This series will be useful when you need to collaborate with your peers for group or teamwork or when working with people outside your usual circle such as in an internship workplace or in a research laboratory.

iv. Go through the available frameworks or general principles highlighted for that specific GESA. There are usually multiple frameworks and principles for a specific GESA. As an example, for critical thinking, there are ‘5Ws+1H’, ‘8 elements of a thought’, ‘6 Thinking Hats’, and each would have its strengths and limitations. The ‘5Ws+1H’ can be good for studying and learning certain content, ‘8 elements of a thought’ is good for analysing, critiquing, and improving content, while ‘6 Thinking Hats’ is good for decision making in pragmatic and real world context. Compare the different frameworks and principles to see which apply better to your context. Refer to some of the examples and contexts provided in the booklet, if available.

v. After you have decided on adopting one of the frameworks, use the companion worksheet to help you plan, modify the framework as needed, apply it, and monitor its outcome. The companion worksheets have all the frameworks in the booklets and they are in Word document format so that you can type and work on these worksheets using the available framework. By using the worksheets, employ the following learning cycle:

   a. Understand the principles of the framework and modify as needed to apply to your context and know the goal you wish to achieve.
b. Plan how you will want to try and test out the framework in your context to achieve the goal. Have some indicators of progress so that you can track your progress.

c. Execute your plan by trying and testing it out in your context.

d. Monitor the development and progress by tracking the indicators or by seeking feedback from relevant sources, where and when appropriate.

e. Evaluate on the outcome and reflect on how you can modify and improve on practicing these skills; and this completes one learning cycle.

f. Reinitiate the learning cycle from step ‘b’ using an improved framework that is more suited to your needs [Note that this learning cycle is similar to ‘self-regulated learning’ described in the Learning skills booklet].

**Important Note:** As in all forms of skills, **practice is necessary** to gain competency and practice implies repeated exercises with increasing or varying challenges so that improvement can be made. Having access and reading the resources will not help you to develop GESA, not until and unless you apply and practice them over time. Do **adopt a learning attitude with growth mind set** and make developing GESA as an adventure and a part of your personal growth so that it will enrich your undergraduate training and even the years beyond!

6. How can you use your GESA competency for your professional development?

The following suggestions can help you use your GESA development and competency to your advantage for your professional development:

a. **Map your GESA development and competency** based on your personal plan when taking different modules throughout your undergraduate training. Take note of the GESA experience and your competency in both academic and personal settings.

b. For GESA that you evaluate as having lower competency, you can consider referring to more resources for that specific GESA, and apply one that suits you to item 5 above.

c. By the time you are in your final year and ready to graduate, if you have been consciously mapping your GESA development and practicing them purposefully, you would have **gain a good sense of your GESA competency**.

d. In your employment search or application for further studies, do not hesitate to **state your GESA competency and how you have developed them**. Highlight those GESA, for example time management, planning and organization skills, problem solving skills, collaboration and teamwork skills, especially if they are relevant and useful to your position of interest.

e. During interviews, **prepare yourself to articulate** and give examples on how you have gained specific GESA competency and how they will be relevant and useful in the position of interest that you are applying. Although you are unlikely to be at a mastery level for a specific GESA, you want to convey your awareness, experience, and diligence in developing its competency in the past and also in your future professional setting.

**Important Note:** You can only do item 6(d) and (e) effectively if you have done 6(a) and (b) consistently during your undergraduate training. However, **it is never too early nor too late to start developing your GESA competency**. Start today and make GESA as part of the rewarding journey!
Active Learning Strategies for Students

As learning occurs in the learner’s mind, active learning is about having your mind being fully engaged in thinking and in participating in the learning process. Learning is not about having an experience (e.g. attending a lecture) or being exposed to or acquiring certain information (e.g. listening, notetaking or reading) where we can go through the motions and yet not learned. Learning is about making sense and meaning out of the experience or information in relation to what you already know or have in mind. If the experience or information does not add on to or change what you already know, then you have not learned anything. Learning therefore requires you to connect, (re)-interpret, and (re)-integrate ideas, information or experience into your existing mental framework so that you can build understanding, construct knowledge, and even learn new skills. The depth and the impact of your learning can provide you with new insights, change your perception, attitude or behavior, and even gain competency in a skill. Hence, your active role in learning is imperative.

Compared to traditional lecturing and passive notetaking, active learning strategies are more effective in engaging students to build understanding and promote knowledge construction in the student’s mind. To fully engage students in learning, our experienced faculties have incorporated some active learning activities into their modules. You may find this information in the learning activity section of the module description.

Below are some common active learning activities practiced in Life Sciences modules. We would like to share some tips to help you to prepare and participate in these activities so that you can experience active learning and benefit from these learning activities.

1) Self-Assessment/Quiz

Self-assessment is usually intended for formative learning so that you can assess your own performance while you learn. Self-assessment can make you more aware of what you know and do not know regarding a topic so that you can be more responsive and improve on your learning. While the example here is about ‘self-assessment’ activity provided by an instructor, note that you can also initiate your own self-assessment activity which can help you to become an independent and reflective life-long learner. Below are some tips to prepare you for self-assessment:

- Study the topics/material before the self-assessment activity. Give yourself enough time to study and take the self-assessment/quiz.
- Know the learning objective and the learning outcome of the intended self-assessment quiz. Is it to help you remember the concepts or test your memory? Is it to help you understand concepts or test your understanding? Is it to teach you how to apply the concepts or test your application of the concepts?
- After the self-assessment, treat the outcome as a constructive but limited feedback to your proficiency on the subject tested. Depending on the learning objective and outcome of the questions that you performed well or performed poorly, you will find out whether if you are remembering, understanding or applying the concepts correctly or wrongly. Do not rest on
your laurels if you have done well. If you have done poorly, do not be discouraged but identify the problem, whether if it is not remembering, misconception and misapplication.

- If needed, check with the instructor or your peers to correct the mistakes.
- Reflect on how to improve your performance in the next self-assessment.
- You can use TKS booklets *Learning Skills* for self-regulated learning with a strategic use of resources and mindset, for connecting ideas and critical reading, *Self-motivation and Emotional Intelligence* for responding to outcome and initiating improvement.

2) Group Discussion

In group discussion, students will be asked to discuss their thoughts based on an assigned reading, video, or problem/question provided by the instructor. Group discussion could also be integrated with other learning activities, e.g. case studies, problem-based learning, group projects, etc. Below are some tips to help you to prepare and perform well in group discussion:

- Prepare on the topic by viewing or reading the relevant materials before discussion. If the instructor has provided discussion questions and points, go through them.
- List down the facts (what are known) and the implications to the topic.
- List down the unknowns and the potential implications to the topic.
- Raise relevant questions with respect to the topic and offer possible answers and solutions.
- During the discussion, be open minded and be a good listener to understand another viewpoint. Do support or add onto the other’s points, and agree to disagree respectfully. However, do not interrupt others in the middle. When you get a chance to speak, express and articulate your points as clearly as possible.
- If require to represent and share your group points in the class, be bold to speak clearly so that others can hear and understand you.
- Reflect and review what you have learned from your peers.
- You can refer to TKS booklets on *Learning skills* for reflective thinking, critical reading, and connecting ideas and *Practical Communication skills* for active listening and question in group discussion.

3) Peer-learning (including Group Project and Presentation, Peer-review and Peer feedback)

Peer learning is a type of collaborative learning. Students will work in pairs or small groups to discuss concepts or find solutions to problems or achieve a goal that require report writing and presentation. Students teach each other by addressing misunderstandings and clarifying misconceptions. Students from different groups may review and provide feedback to each other work be it report or presentation. Below are some tips to prepare you for peer learning:

- Peer learning is based on mutual experience, so keep your mind open, and work collaboratively with your peers.
- Explain your ideas to your peers clearly and freely, and participate in discussion actively, so that everyone gets to provide their contribution.
Agree to disagree respectfully and learn to negotiate a win-win solution, and if not possible, learn to vote for consensus to make a decision in order to achieve the common goal of the learning activity or project.

Support each other on learning tasks, in terms of abilities and emotional support to achieve the common goal(s) for the best of the team.

Be factual and fair when it comes to peer review, learn from others’ strengths as well as weaknesses.

Provide constructive feedback to your peers and do not condemn or insult on a personal level. Be aware that you practice higher-level thinking, oral/written communication, and responsibility during the peer feedback process.

You can use TKS booklets *Time Management and Organizational Skills* for managing project work, *Leadership, Collaboration and Teamwork* for working with peers, *Problem-solving and Creative Thinking for Decision-making Skills* for solving problem and making decision in a group, and *Practical Communication skills* for negotiation and feedback, and *Handling Difficult Conversation, Conflict Resolution and People Skills* in case of conflict and uncooperative team members.

### 4) Case Study with possible Role-Playing or Debate

In case study, the instructor uses real-world examples that can involve individuals, communities, industries, events, or geographical location, to prompt you to integrate theoretical concepts to real-world situations. This may include role playing of different stakeholders involved in a specific case and/or debate for certain controversial case. You may prepare for case study in the following steps:

- Read the material (case study) given, ask 5Ws + 1H questions.
- Understand the context and the complexity of the case and the theoretical concept(s) that will be discussed.
- Consider other related concepts, search and review other relevant articles, try to consider different viewpoints (especially if it involves different stakeholders or conflicting ideas) and articulate them.
- If it involves group discussion, participate actively in it and express your view point in the class/forum (see group discussion). If it involves Role-playing, be open-minded to imagine yourself playing a specific role with certain task/interest and be bold to act out and have fun. If it involves a debate, research and list down opposing viewpoints (for and against, pros and cons, strengths and limitations, etc.), strategize and articulate them.
- Engage in active listening (receive, understand, evaluate, remember, respond)
- Reflect after the case study, role-playing or debate regarding what you have learned and how it has changed your perspective, response, or decision-making if you were to encounter similar cases in future.
- You can use TKS booklets *Learning Skills* for critical reading of articles, notetaking for connecting ideas, *Analytical and Critical Thinking Skills* for analyzing content, *Problem-solving and Creative Thinking for Decision-making Skills* in respond to specific cases, and *Practical Communication skills* for group discussion.
5) Experiential Learning (Laboratory Works and Field Trips)

Laboratory works and field trips are the two major experiential learning activities in the life science curriculum. They provide you an immersive and authentic environment to learn disciplinary skills that will connect you with the theoretical concepts taught in class. To maximize your learning experience, you may prepare yourself following the suggestions below:

- Read and understand the learning objectives and/or learning outcomes of the lab practical/field trips.
- Read through relevant lecture materials and understand the concepts that will be applied in the practical session.
- Read the practical (laboratory/field) protocol carefully and understand the steps that you need to follow including safety measures. Think through each of the protocol steps and ask yourself why they are necessary. Note down your responses.
- Take note of any questions that you want to ask the teaching staff (TA or lecturer) especially if you do not understand the steps taken in the protocol. Interact with group members or Teaching Assistant (TA).
- Take your own notes (pen & paper are the best!) as you collect the data or samples. Understand the strengths and limitations of the approach taken.
- Perform the necessary analysis by applying the concepts taught in the practical. Interpret and question your findings. Be deliberate in making the connections between theory and practice.
- Don’t be shy to ask questions during the class or even after class. Revisit the notes after the practical session and ask the teaching staff any questions via email, if needed.
- You can use TKS booklets Learning Skills for critical reading and notetaking, Analytical and Critical Thinking Skills for analyzing information, Practical Communication skills for active listening and questioning, and writing effective emails, and Leadership, Collaboration and Teamwork for working with peers.

6) Problem-based Learning

Problem-based learning (PBL) is a student-centered approach in which students learn about a subject by working in groups to solve a problem and solving the problem becomes the motivation to learning. The problem is usually complex, requiring interdisciplinary approach, or involving multiple stakeholders and likely to be open-ended. You will practice critical thinking, teamwork, oral/written communication, leadership, researching and information literacy, and problem solving skills in PBL. To participate effectively in PBL, you may prepare yourself following the steps below:

- Structure the problem by considering the multiple factors including the goal, barriers or obstacles to achieve the goal, factors influencing the barriers including different stakeholders’ viewpoints.
- List down and examine the facts and what you already know about the background issues related to the problem.
- List down what you do not know, identify what you need to learn more, and where to acquire the information.
● Structure all the information in relation to how they act as barriers and obstacles to achieving a goal.
● Brainstorm with your peers and discuss on the possible ways to address, remove or reduce each of the barriers or obstacles with the aim achieving the goal or solving the problem.
● Present your findings in class discussion, get feedback from peers and the instructor.
● Reflect after the PBL exercise regarding what you have learned and how it has change your perspective or decision-making if you were to encounter similar problem.
● You can use TKS booklets Learning Skills for critical reading of articles, notetaking for connecting ideas, Analytical and Critical Thinking Skills for analyzing content, Problem-solving and Creative Thinking for Decision-making Skills to solve the problem, and Practical Communication skills for group discussion.

7) Inquiry-based learning

Inquiry-based learning (IBL) involves students using an investigative process to discover concepts for themselves. After the instructor identifies an idea or concept for mastery, a question is posed that requires students to make observations, pose hypotheses, and speculate on conclusions. Then students will share their thoughts and tie the activity back to the main idea/concept. Depending on time and resources, this can be further extended to a research-based learning where students actually conduct experiment to test the hypothesis, collect data, analyse and evaluate them before concluding based on the evidence. In IBL, students will practice critical thinking, time management, information gathering, filtering and synthesizing, communication skills etc. Below are the common steps you can prepare yourself for IBL:

● Students explore the topic/theme, or scenario introduced by the instructor.
● Instructor or students can pose relevant questions related to the topic, make predictions, and hypothesize.
● With instructor’s support, students take the initiative to conduct research (e.g. information gathering by literature reading, data collection by experiment or survey, evidence collection etc.) to test their hypotheses.
● Based on collected information and data, students will evaluate and draw conclusions to answer their initial questions. Depending on the findings, new questions and hypotheses can be developed for another round of inquiry-based learning.
● Present findings in the class, share your results with peers, and reflect.
● You can use TKS booklets Learning Skills for critical reading and connecting ideas, Problem-solving and Creative Thinking for Decision-making Skills for framing research question and hypothesis, Analytical and Critical Thinking Skills for information research and analyzing content, and Practical Communication skills for questioning, and Leadership, Collaboration and Teamwork if you are working with peers or in groups.
Module Information

Essential Information
Content and Syllabus
Active Learning Activities
Learning Outcomes with Graduate Employability Skills and Attributes
Reading List

[Disclaimer: While all the module information is provided accurate by the respective module coordinator(s), students are responsible to confirm the information with relevant administrator(s) or module coordinator(s) due to the possible changes and updates in the modules that are not reflected in this Handbook.]
# Module Information

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSM1111</td>
<td>Biological Challenges and Opportunities for Humankind</td>
<td>1 &amp; 2</td>
<td>4</td>
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</tbody>
</table>

## Module Description

Designed as a gateway for the Life Sciences Major, this module explores biological challenges faced by humankind today and how solutions are developed. Instead of focusing on one topic, we will use examples from evolution, ageing, food security, climate change and pandemics to discuss global issues. How distinct approaches from multiple disciplines of Biology contribute to problem solving. Students will learn scientific inquiry skills and basic concepts in genetics, cell biology, ecology, and evolutionary biology through authentic problem solving. (88 words)

The module will consist of four sections:
1) Introduction to biological complexity
2) Climate change and food security
3) Pandemics
4) Ageing

## Eligibility and requirements

**Prerequisites (prior knowledge required):** GCE 'A' Level or H2 Biology or equivalent, or LSM1301

**Corequisites:** NIL

**Precluded modules (if any):** NIL

## Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Blended Learning
3) Inquiry-based or Research

## Assessment modes

The following assessments will be employed:
1) Class quizzes: 30%
2) Homework assignments: 20%
3) Daily journal submissions: 20%
4) Final (video) project: 30%

**Total for CA:** 100%
Contact information for Module Coordinator and other instructors

Prof. Antónia Monteiro  
(Module Coordinator, Sem 1)  
Office: S2 level 1  
Phone number: 97551591  
Email: antonia.monteiro@nus.edu.sg  

Dr. Wu Jinlu  
(Module Coordinator, Sem 2)  
Office: S1A level 4  
Phone number: 65168476, 93609830  
Email: dbswjl@nus.edu.sg  

Dr. Xue Shifeng (Co-lecturer, Sem 1)  
Email: dbsxues@nus.edu.sg  

Dr. Ng Ngan Kee (Co-lecturer, Sem 2)  
Email: ngankee@nus.edu.sg  

Course content and syllabus

These topics are tentative, and subject to change

1) Introduction to the module  
2) The major transitions in evolution  
3) Mutations and genomic increases in complexity  
4) Principles of natural selection acting on small and large populations  
5) How populations become species  
6) Principles of development and gene regulatory networks (stem cells)  
7) Biodiversity and its importance  
8) The sixth extinction – caused by climate change (Lian Pin)  
9) Plasticity and adaptations to climate change  
10) The effect of climate change on food security  
11) Current status of food production in Singapore  
12) Future of food production and food security  
13) Outbreaks, epidemics, pandemics  
14) Emergence and evolution of viruses  
15) Pandemic response  
16) Vaccines, therapeutics, medical products  
17) Problems associated with ageing  
18) Evolution of ageing  
19) Mechanism of ageing  
20) Animal models of ageing  
21) Ageing intervention

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  
2) Critical Reading & Critique  
3) Games  
4) Group/Individual Presentation  
5) Group/Individual Project  
6) Inquiry-based Learning  
7) Interactive Lecture  
8) Peer-Learning  
9) Problem-based Learning  
10) Self-Assessment or Quiz
• Reading before class will help students engage with the material and prepare them for subsequent critical evaluations and discussions.
• Interactive teaching sessions, will provide students opportunities to analyse and evaluate information, and help them present well-reasoned arguments
• Daily writing will help them construct their own knowledge through critical and integrative thinking.
• Students will be encouraged to identify real-world problems on their own, seek information, and analyse possible solutions to those problems. They will become more engaged with the world they live in.

### Intended Learning Outcomes

#### Knowledge development

Upon completion of this module, students are expected to
1. describe some of the top challenges that humanity has faced in the past, is facing in the present, and will likely face in the future.
2. explain fundamental biology concepts behind these challenges
3. elaborate connections between these challenges and other subjects outside the life sciences
4. become engaged in the integration of multiple disciplines for problem solving
5. evaluate the pros and cons of the distinct biological approaches for tackling the challenges.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

<table>
<thead>
<tr>
<th>Very Good/Good Opportunities</th>
<th>Good/Average Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Remember: Recognize, Recall &amp; Know</td>
<td>1) Apply: Use, Execute &amp; Implement</td>
</tr>
<tr>
<td>2) Understand: Question, Connect &amp; Explain</td>
<td>2) Verbal/oral Communication</td>
</tr>
<tr>
<td>3) Evaluate: Review, Check &amp; Critique</td>
<td>3) Digital &amp; Information Literacy</td>
</tr>
<tr>
<td>Quantitative Thinking</td>
<td>4) Planning, Organizing &amp; Management skills</td>
</tr>
<tr>
<td>Written Communication</td>
<td>5) Adaptability &amp; Learnability</td>
</tr>
<tr>
<td>5) Interdisciplinary Thinking</td>
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<td>6) Creative Thinking</td>
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<tr>
<td>7) Problem-solving &amp; Decision-making</td>
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<td>8) Collaboration &amp; Teamwork</td>
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<td>9) Ethics Awareness</td>
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<td>10) Self-Efficacy</td>
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<tr>
<td>11) Resilience</td>
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</tbody>
</table>

### Required and/or recommended readings

This list is not complete and not final, but features a representative for some topics.
- David Attenborough: A Life on Our Planet (available on Netflix)
- Richard Preston: The hot zone
<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSM1301</td>
<td>General Biology</td>
<td>1 &amp; 2</td>
<td>4</td>
</tr>
</tbody>
</table>

**Module Description**

This introductory module explores the scientific study of life, at successive levels of organisation. The module begins with the chemistry of life and the smallest unit of life, the cell, which form the basis for energy and life. The inheritance of traits will also be discussed and the field of biotechnology, including its applications and associated ethical issues, will be explored. Diversity of life on earth will be discussed in the context of evolution and ecology. How organisms maintain their internal constancy and the organisation of major organ systems will also be explored. The focus of the module is the introduction of the unifying concepts of biology and how the concepts affect everyday life.

**Eligibility and requirements**

Prerequisites (prior knowledge required): NIL  
Corequisites: NIL  
Precluded modules (if any): GCE A-Level or H2 Biology, or equivalents

**Instructional methods**

The following instructional methods will be employed:  
1) Lecture  
2) Tutorial  
3) Blended Learning  
4) Laboratory (Dry/Wet)  
5) Expedition/Site/Field visit

**Assessment modes**

The following assessments will be employed:  
**Semester 1:**  
1) In-Class Quizzes – 10%  
2) Lab-based, Tutorial-based, Fieldtrip-based – 70%  
3) Test – 20%  

**Semester 2:**  
1) Post-class Quizzes – 10%  
2) Lab-based, Tutorial-based, Fieldtrip-based – 50%  
3) Tests – 40%
Contact information for Module Coordinator and other instructors

**Semester 1:**

Assoc. Prof. Seow Teck Keong (Module Coordinator)
Office: College of Alice and Peter Tan,
University Town, B1-50
Phone number: 65162695
Email: teckeong@nus.edu.sg

Dr. Zeehan Jaafar (Co-lecturer)
Office: Department of Biological Sciences,
S1A 04-06
Phone number: 65162858
Email: jaafarz@nus.edu.sg

**Semester 2:**

Dr. Nalini Puniamoorthy (Module Coordinator)
Phone number: Department of Biological Sciences, S3 04-13
Telephone: 65162852
Email: nalini@nus.edu.sg

Dr. Maxine Allayne Darlene Mowe (Co-lecturer)
Office: Department of Biological Sciences,
S2-04
Phone number: 65161614
Email: dbsmadm@nus.edu.sg

Course content and syllabus

Science of Biology

Chemistry of Life

Cell Structure and Function
Size of a cell. Biological membranes. Structures and functions of prokaryotic and eukaryotic cells.

Energy and Life

DNA and Heredity
Genetic material. DNA structure and replication. DNA sequencing. Mitosis and meiosis.

Gene Expression
Central dogma of molecular biology. RNA molecules and genetic code. Transcription, translation and mutations. Regulation of gene expression in prokaryotic and eukaryotic cells.

Biotechnology
Genetically modified organisms - bacteria, plants and animals. DNA profiling. Genetic screening and gene therapy. Environmental, safety and ethical issues.
Evolution

Biodiversity
Species concepts. Identification, naming and classifying of organisms. Constructing and interpreting cladograms.

Plant Form and Function

Animal Form and Function
Major animal groups. Animal tissues and selected organ systems. Homeostasis.

Ecology

Learning activities
The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Expedition/Field Trip/Site Visit
2) Group Discussion or Discussion Forum
3) Inquiry-based Learning
4) Interactive Lecture
5) Laboratory Activities (Wet/Dry)
6) Peer-Learning
7) Self-Assessment or Quiz


Group Discussion or Discussion Forum – Remember, Understand, Apply, Analyse, Evaluate, Create – Written Communication, Verbal/Oral Communication, Analytical & Critical Thinking, Interdisciplinary Thinking, Creative Thinking, Problem-solving & Decision-making, Collaboration & Teamwork, Ethics Awareness, Self-Efficacy, Adaptability & Learnability

Interactive Lecture – Remember, Understand, Apply, Analyse, Evaluate – Written Communication, Verbal/Oral Communication, Digital & Information Literacy, Analytical & Critical Thinking, Quantitative Thinking, Interdisciplinary Thinking, Creative Thinking, Problem-solving & Decision-making, Collaboration & Teamwork, Self-Efficacy, Adaptability & Learnability

Laboratory Activities (Wet/Dry) – Remember, Understand, Apply, Analyse, Evaluate – Written Communication, Verbal/Oral Communication, Digital & Information Literacy, Analytical & Critical Thinking, Quantitative Thinking, Interdisciplinary Thinking, Creative Thinking, Problem-solving & Decision-making, Collaboration & Teamwork, Planning, Organising & Management skills, Ethics Awareness, Self-Efficacy, Adaptability & Learnability, Resilience


Self-Assessment or Quiz – Remember, Understand, Apply, Analyse, Evaluate, Create – Written Communication, Verbal/Oral Communication, Digital & Information Literacy, Analytical & Critical Thinking, Quantitative Thinking, Interdisciplinary Thinking, Creative Thinking, Problem-solving & Decision-making, Collaboration & Teamwork, Self-Efficacy, Adaptability & Learnability, Resilience

**Intended Learning Outcomes**

**Knowledge development**

At end of module, students should be able to:
1. Describe concept of life functions from cells to tissues to organs to systems
2. Define basic terminologies and concepts in biology
3. Explain basic biological processes and diversity of life
4. Relate knowledge acquired to everyday life, which includes dealing with common day controversies between science and society

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

<table>
<thead>
<tr>
<th>Very Good Opportunities</th>
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</tr>
</thead>
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<tr>
<td>2) Understand: Question, Connect &amp; Explain</td>
<td>2) Interdisciplinary Thinking</td>
</tr>
<tr>
<td>3) Apply: Use, Execute &amp; Implement</td>
<td>3) Collaboration &amp; Teamwork</td>
</tr>
<tr>
<td>4) Analyze: Differentiate, Organize &amp; Attribute</td>
<td>4) Self-Efficacy</td>
</tr>
<tr>
<td>5) Evaluate: Review, Check &amp; Critique</td>
<td>5) Resilience</td>
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<tr>
<td>6) Written Communication</td>
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<tr>
<td>7) Analytical &amp; Critical Thinking</td>
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<tr>
<td>Required and/or recommended readings</td>
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Module Information

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
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</thead>
<tbody>
<tr>
<td>LSM1303</td>
<td>Animal Behaviour</td>
<td>2</td>
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</table>

Module Description

Understanding animal behaviour awakens the individual to the complexity of daily phenomenon in the animal kingdom - how animals live and survive in their environment. Much of this occurs around us every day and everywhere we go. But the city-dweller lives in increasing isolation of animals and understands little of the world around them.

This module will highlight behaviours such as learning, sociality, territoriality, predation and defense, courtship and communication, with examples from across animal diversity. How behaviors have evolved to fit specific ecological conditions will be examined.

Students will gain understanding of and empathy for animals, appreciate the value of scientific approach to animal care, human-animal conflict and conservation, and a better insight into our own behavior.

Eligibility and requirements

Prerequisites (prior knowledge required): NIL
Corequisites: NIL
Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Tutorial
3) Blended Learning
4) Laboratory (Dry/Wet)
5) Expedition/Site/Field visit
6) Inquiry-based or Research

Assessment modes

The following assessments will be employed:
1) Writing (various forms) = 25%
2) Presentations = 35%
3) Quizzes = 10%
4) Final Examination = 30%

Contact information for Module Coordinator and other instructors

Mr N. Sivasothi (Module Coordinator)
Email: sivasothi@nus.edu.sg
@otterman on Telegram
**Course content and syllabus**

- Wildlife in Singapore & Learning Outcomes
- Diversity, Ethology & Ethics; How to observe animal behaviour?
- Innate Behaviour & Learning
- Living in Groups I & II
- Foraging
- Territoriality I & II
- Human - Animal Interactions
- Communication I & II
- Courtship & Mating
- Animal Welfare

**Learning activities**

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

| 1 | Case Studies, Expedition/Field Trip/Site Visit | 8 | Laboratory Activities (Wet/Dry) |
| 2 | Games | 9 | Peer Review and Feedback (including Group Review & Feedback) |
| 3 | Group/Individual Presentation | 10 | Problem-based Learning |
| 4 | Group/Individual Project | 11 | Self-Assessment or Quiz |
| 5 | Inquiry-based Learning | 12 | Student Generated Questions |
| 6 | Interactive Lecture |

1. Understand how animal behaviour functions in the natural world
2. Understand the evolving ethics of animal welfare
3. Evaluate the complexity of human-wildlife interactions
   - Lecture, Lab, Tutorial
4. Conduct field work safely [risk assessment, field attire and safety, spatial awareness]
5. Formulate a design to observe and quantify wild animals in the natural environment
6. Implement the scientific method to ask a question, measure, and compare in the field
7. Present a scientific report (coherent, concise and evidence-based) as a group
   - Project Work

**Intended Learning Outcomes**

**Knowledge development**

The student will be able to...

**Domain knowledge**

1. Understand how animal behaviour functions in the natural world
2. Understand the evolving ethics of animal welfare
3. Evaluate the complexity of human-wildlife interactions
Field and academic skills
4. Conduct field work safely [risk assessment, field attire and safety, spatial awareness]
5. Formulate a design to observe and quantify wild animals in the natural environment
6. Implement the scientific method to ask a question, measure, and compare in the field
7. Present a scientific report (coherent, concise and evidence-based) as a group

**This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:**

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<thead>
<tr>
<th>Very Good Opportunities</th>
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<td>1) Apply: Use, Execute &amp; Implement</td>
<td>1) Understand: Question, Connect &amp; Explain</td>
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<tr>
<td>2) Create: Ideate, Plan, Generate &amp; Produce</td>
<td>2) Analyze: Differentiate, Organize &amp; Attribute</td>
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<td>8) Problem-solving &amp; Decision-making</td>
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<td>9) Collaboration &amp; Teamwork</td>
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<td>10) Planning, Organizing &amp; Management skills</td>
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<td>11) Adaptability &amp; Learnability</td>
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<tr>
<td>12) Resilience</td>
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<tr>
<td>Other skills: Spatial awareness</td>
<td>Other skills: Spatial awareness</td>
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</tbody>
</table>

**Required and/or recommended readings**


Weekly short readings and videos in LumiNUS Learning Flow.
**Module Information**

<table>
<thead>
<tr>
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<th>Semester</th>
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<tbody>
<tr>
<td>LSM1307</td>
<td>Waste and Our Environment</td>
<td>1</td>
<td>4</td>
</tr>
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</table>

**Module Description**

All organisms generate waste in one form or another. Earth has a high human population with wasteful habits and mostly poor waste management practices. This module concentrates on solid wastes which are often ignored as they are dirty, often invisible and people assumed that they will disappear in time. The syllabus starts from fossilized waste to those generated from modern day living. It reveals the immense quantities of waste generated from food production, households, to industrial waste and how these wastes impact the environment and ultimately our health and that of the planet’s. Various options will be explored to manage waste better, to ensure environmental sustainability and to create business opportunities on waste management. The purpose of the module is to create awareness on the urgent situation about waste generated locally and globally. Students will learn that certain organisms can treat waste effectively, but most are harmed. Life science program teaches students about life and how humans interact with the environment thus this module is timely and highly relevant.

**Eligibility and requirements**

- Prerequisites (prior knowledge required): NIL
- Corequisites: NIL
- Precluded modules (if any): GEK1515

**Instructional methods**

The following instructional methods will be employed:

1) Lecture
2) Tutorial
3) Guest lectures

**Assessment modes**

The following assessments will be employed:

1) Personal introduction assignment: 2%
2) Outreach assignment: 32%
3) Class attendance: 6% (0.25% for attendance per lecture, applicable to 24 lectures online) Attendance will be taken on e-platform
4) Weekly record of waste generated from Week 3 to Week 12: 10%
5) Critique of Waste to applications: 15%
6) Final exam: 35%
Contact information for Module Coordinator and other instructors

Dr. Amy Choong Mei Fun (Module Coordinator)
Office: S2, 4th floor
Phone number: 65162707
Email: dbscmfa@nus.edu.sg

Course content and syllabus

1. Introduction to waste, sources and magnitude of the problem and possibilities of reusing and converting waste to useful resources.
2. Nature reuses waste: Microbes and other organisms will decompose all organic wastes. Learn about the sequence of events during decomposition of plants, animals, including our human bodies.
3. Waste tells us how our ancestors lived: Fossilized wastes inform us what prehistoric life forms existed and what the animals fed on. Learn how our ancestors lived from their wastes and how as we modernize, we also become more wasteful.
4. Biodegradable, laboratory wastes, synthetic and non-biodegradable wastes: wastes from farms, forestry, horticulture, industries.
5. Agricultural wastes and how they are reused: how agricultural wastes come about and why the need to manage properly.
7. The issue with plastics, generation, recycling and reusing.
8. Guest lectures from industries that deal with food waste, plastic wastes.
9. Obtain raw materials from the ground via mining to construction of buildings. Learn about the process of mining, from clearing forest, digging, extracting ores using acids to transporting and waste products generated from mining and construction.
10. Electronic waste: sources, manufacturing, recycling processes and the harm done to the environment when using cheap labor and unsound practices.
11. End-of-life industries: what happens to old cars, rails and planes. Where do they go to die or get recycled.
12. Illegal dumping, landfill vs incineration: learn how illegal dumping occur, what happen to the waste in dumps, landfills and after incineration.
13. Sustainable fashion: Fast fashion releases 10% of global carbon emissions and generate 20% of waste water. This lecture tracks garment production to its disposal.
14. International trade in waste and recycling: if there is no value to the waste, there will be no recycling.
15. Waste impact on ecosystem services: how waste impact provisioning, supporting, cultural and regulating services.
16. How habitats such as forests are affected by waste: how forest dwellers and native people suffer from waste.
17. Biotechnology of waste: using microbes and fungi to bioremediate or ycoremediate.
18. The way forward: wastes are difficult to avoid, they need to be better managed and potentially income-generating.
Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies
2) Critical Reading & Critique
3) Group/Individual Presentation
4) Report/Essay Writing
5) Self-Assessment or Quiz

Case studies: students document their own waste generation and reflect on their own waste and how they can do better.

Critical reading & critique: after each lecture, each student reflects and critique the type of waste and whether the issue is handled well.

Group/individual presentation: students are grouped to design posters to reach out to members of the public on Singapore's waste management practices. The aim is to help them clarify their own conceptual understanding and be able to communicate to others to minimize waste generation. They have to find audiences to present their posters or messages to. They will face rejection so they will learn resilience, quick thinking, problem solving on the spot. They need to plan how to meet as a group, how to carry out the whole outreach exercise so they will learn time management.

Essay writing: reflection essay on the whole outreach exercise, working with group members, interacting with members of the public. Critique how much green washing there are in various companies.

Self-assessment or quiz: check own understandings on lecture topics.

Intended Learning Outcomes

Knowledge development

After taking this module, students will be able to:

1. communicate to an audience what is the waste situation and management practices of Singapore.

2. design posters to clarify and reinforce what they had learnt.

3. list different types of waste, polluting chemicals, expound their impacts, connect the waste generation to environmental and health impacts.

4. improve their communication skills, powers of persuasion, empathy and being good listeners.
5. Expound how organisms such as bacteria and fungi can be used to treat wastes that are persistent and difficult to treat.

6. Appreciate the seriousness of waste issues.

7. Recognise that industries and policies do try to tackle the waste issues but everyone else too have the responsibility to minimize waste generation and to dispose of waste properly.

**This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:**

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<td>5) Create: Ideate, Plan, Generate &amp; Produce</td>
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<td>6) Verbal/Oral Communication</td>
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<td>17) Resilience</td>
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**Required and/or recommended readings**

Recommended readings:

Webpages and articles provided in each lecture. A few listed below:
- [https://www.unescap.org/sites/default/files/1.%20The%20waste%20crisis.pdf](https://www.unescap.org/sites/default/files/1.%20The%20waste%20crisis.pdf)

- Threat of plastic pollution to seabirds is global, pervasive, and increasing. PNAS 2015 112 (#8)11899-11904.
Module Information

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<th>Module Title</th>
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<tbody>
<tr>
<td>LSM2105</td>
<td>Molecular Genetics</td>
<td>1 &amp; 2</td>
<td>4</td>
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</table>

Module Description

This module forms one of the key tenets of biology - the heredity process and principles. It covers topics on (i) the patterns of inheritance, (ii) the molecular properties of genes and chromosomes, (iii) transcription and translation, (iv) genetic methods and technology, and (v) genetic analysis of individuals and populations. This will include an in-depth understanding of mendelian patterns of inheritance and variations that could occur due to multiple alleles, lethal genes, chromosomal variations, linkage, gene interaction and other genetic phenomena. Emphasis is placed on the understanding of the underlying molecular and biochemical basis of inheritance. Quantitative and population genetics will also be discussed with the emphasis of understanding the processes and forces in nature that promote genetic changes. Modern and current topics on molecular methods and new genetic technologies plus model organisms will also be introduced.

Eligibility and requirements

Prerequisites (prior knowledge required): GCE 'A' Level or H2 Biology or equivalent, or LSM1301 or LSM1301X

Corequisites: NIL

Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Tutorial
3) Blended Learning

Assessment modes

The following assessments will be employed:
1) Critical Reading and Critique = 10% (part of Continual Assessment)
2) Progress and Assessment Quizzes = 10% (part of Continual Assessment)
3) Peer-wise Assessment = 5%
4) Analytical, Quantitative, and Critical Thinking Continual Assessment Tests = 35%
5) Final Examination = 40%

Contact information for Module Coordinator and other instructors

Assoc. Prof. CHEW Fook Tim (Module Coordinator)
Email: dbscft@nus.edu.sg

Dr. WU Jinlu (Lecturer)  Ms. LOW Yi Lian (Instructor)
Assoc. Prof. Cynthia HE (Lecturer) Ms. Sylvia LAW (Instructor)
Assoc. Prof. LIOU Yih-Cherng (Lecturer)
**Course content and syllabus**

(1) Introduction; Overview of Genetics and Chromosome in Eukaryotes  
(2) Cellular Division: Mitosis and Meiosis; Non-Disjunction and Polyploidy  
(3) Chromosome in Prokaryotes, Genetic Transfer and Mapping Analysis in Microorganisms  
(4) Chromosome Compaction, Structure, Organization  
(5) Chromatin Remodeling and Gene Expression  
(6) Chromosome Recombination  
Continual Assessment 1 (on Topics 1-6)

(7) Molecular structure of DNA and RNA; DNA Replication  
(8) Gene Transcription and RNA Processing  
(9) Translation of mRNA  
(10) Molecular genetic methods (genetic screening, recombinant and transgenic technologies, RNAi, reporter tagging etc.)  
(11) New genetic technology (genome editing, next generation sequencing, omics)  
(12) Model organisms in genetic studies  
Continual Assessment 2 (on Topics 7-12)

(13) Mendelian Genetics – Terminologies, Mendelian Laws  
(14) Mendelian Genetics – Sex Linkage, Modes of Inheritance, Pedigree Analysis, Penetration, Expressivity, Pleiotropy  
(15) Variations to Mendelian Genetics – Multiple Alleles, Epistasis  
(16) Variations to Mendelian Genetics – Lethal Genes, Linkage  
(17) Population Genetics – Hardy Weinberg Equilibrium, Allele Frequencies, Non-random Mating  
(18) Population Genetics – Mutation and Selection Forces, Maintenance of Genetic Polymorphism  
(19) Quantitative Genetics – Statistical Description of Quantitative Traits  
(20) Quantitative Genetics – Polygenic Inheritance, Heritability, Breeding, Heterosis  
Continual Assessment 3 (on Topics 13 onwards)

**Learning activities**

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  
2) Critical Reading & Critique  
3) Group Discussion or Discussion Forum  
4) Peer-Learning  
5) Peer Review and Feedback (including Group Review & Feedback)  
6) Self-Assessment or Quiz
Applications of case-studies and scenarios (via tutorial questions, problem-based lecture question and answers, and critical reading of key research papers) are the mainstay of the module learning activities with the intent to analytical and critical thinking, quantitative decision making, and hypothesis testing. This will be embedded throughout all the key topics and application across fields as well e.g., the application of biochemistry concepts as well as ecological phenomena in the overall heredity processes and biological phenomena.

**Intended Learning Outcomes**

**Knowledge development**

At the base level, students are expected to learn and re-learn the basic concepts of heredity, get used to the terminologies, basic language and concepts of modern genetics, and learn them in context of time, space, history and context of the environment.

At the next level, the learners are expected to begin to apply these concepts to both seen and unseen scenarios, learn to observe phenomena, hypothesize the potential underlying mechanisms and test these assumptions based on the principles and concepts built within this module.

At the higher level, the learners are expected to not only apply, but begin to analyze and evaluate possible observations, and begin to potentially create and generate new ideas (or hypothesis) or ways to produce new understanding, products, or services.

**This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:**

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</tbody>
</table>

**Required and/or recommended readings**

1) Specific suggested readings of research articles (vary semester to semester).
3) D. S. Falconer & T.F.C. Mackay. Introduction to Quantitative Genetics. Longman
## Module Information

<table>
<thead>
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<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
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<tbody>
<tr>
<td>LSM2106</td>
<td>Fundamental Biochemistry</td>
<td>1 &amp; 2</td>
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</table>

### Module Description

This module provides and lays a rigorous foundation in current concepts in biochemistry. These fundamental concepts form the basis of almost all recent advances in biological and the biomedical sciences. Biomolecular structures and functions (including protein, carbohydrates, lipid and nucleotides) and how these biomolecules play roles in biological processes including cellular biocatalyst and metabolism will be introduced and discussed. e-practical sessions provide experience in data interpretation and learning of basic laboratory techniques.

### Eligibility and requirements

**Prerequisites (prior knowledge required):** GCE ‘A’ Level or H2 Biology or equivalent, or LSM1301 or LSM1301FC or LSM1301X  
**Corequisites:** NIL  
**Precluded modules (if any):** NIL

### Instructional methods

The following instructional methods will be employed:  
1) Lecture  
2) Tutorial  
3) Blended Learning  
4) Laboratory (Dry/Wet)

### Assessment modes

The following assessments will be employed:  
1) Two Continuous Assessment (Open book; comprising modified Multiple-Choice Questions with justifications of choice + Short Answer Questions) = 40%  
2) Final Semestral Exam (Open book with modified Multiple Choice Questions with justification of choice + Short Answer Questions) = 60%

### Contact information for Module Coordinator and other instructors

Assoc. Prof. DENG Lih Wen (Module Coordinator, Sem 1)  
Office: MD7#04-07  
Phone number: 65161239  
Email: bchdlw@nus.edu.sg

Assoc. Prof. Too Heng-Phon (Module Coordinator, Sem 2)  
Office: MD7#04-09  
Phone number: 65163687  
Email: bchtoohp@nus.edu.sg
Co-Lecturers in Semester 1:

Assoc. Prof. Marie-Veronique Clement
Office: MD7#04-05
Phone number: 65167985
Email: bchmvc@nus.edu.sg

Assoc. Prof. Henry Mok
Office: S3-03-01d
Phone number: 65162967
Email: dbsmokh@nus.edu.sg

Co-Lecturers in Semester 2:

Dr. Long Yun Chau
Office: MD7#03-06
Phone number: 66012084
Email: bchlongy@nus.edu.sg

Dr. Adrian Kee Keong TEO
Office: 61 Biopolis Drive, Proteos, #06-07,
Singapore 138673
Phone number: 65869641
Email: bchtkka@nus.edu.sg; ateo@imcb.a-star.edu.sg

Course content and syllabus

Topics

I. Fundamental Forces & Chemicals in cells
(Water, Acid/Bases, Buffer, Non-Covalent Forces, H-bonds, Amphiphiles, Methods of analyses)

II. Structures & Functions of Cellular Proteins
(Amino Acid Structures & Properties, Protein Biosynthesis, Shape & Structure of Proteins, Domains & Motifs, Protein Families; Post-Translational Modifications, Folding and Dynamics of Proteins in Cellular Compartments)

III. Cellular Enzymes
(Forms & Functions of Enzymes, Enzymatic Kinetics, Cellular and Pharmacological Inhibitors, Regulation of Enzyme Activity, Cellular Oxygenation)

IV. Cellular Metabolism
(Structures & Functions of Carbohydrates, Mitochondria & Bioenergetics, Integrating Catabolism & Anabolism in Cellular Energy Production, Oxidative and Non-Oxidative Metabolism, System approach to the Organization & Regulation of Metabolic Pathways, Signal Transduction)

V. Cellular Membranes & Nucleic Acids
(Structures & Functions of Lipids, Cellular Membrane and Membrane Transport, Structures & Functions of Nucleic Acids, DNA Replication, Repair and Manipulation)
**Learning activities**

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  
2) Concept Mapping  
3) Critical Reading & Critique  
4) Games  
5) Group Discussion or Discussion Forum  
6) Inquiry-based Learning  
7) Interactive Lecture  
8) Laboratory Activities (Wet/Dry)  
9) Problem-based Learning  
10) Student Generated Questions

Students are expected to undertake learning processes to achieve the following outcomes:
1. understand the principles for macromolecules and the key biological processes that are related to the contents of the course;  
2. apply their understanding of these concepts through thinking, analyzing and evaluating critically how biomolecules function and regulate in biological processes;  
3. integrate their knowledge from different topics in the course and different disciplines to make relevant connections to support their ideas or reasoning;  
4. appreciate how hands-on practical sessions and basic laboratory techniques are relevant to the applications in biotechnology and medical sciences.

**Intended Learning Outcomes**

**Knowledge development**

Students will learn the following:

a) How the structure and functions of biological macromolecules (protein, carbohydrate, lipid and nucleotides) play critical roles in human health and disease;  
b) How these macromolecules are identified, purified and studied;  
c) How fundamental chemical forces affect forms and functions of proteins and the molecular consequences of errors in protein structures;  
d) How enzymes accelerate the rate of reactions;  
e) How enzymes activity is characterized and regulated;  
f) How cellular and biochemical processes are regulated as a system;  
g) How biomolecules integrate in cellular function.

The student is expected to develop the skills to communicate sufficient details of biochemistry in answering discussion questions in exams, on specific problem(s) as assigned in tutorials, and during discussions in class and review sessions.
This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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Required and/or recommended readings

Recommended reading:
by Charles Grisham; Reginald H. Garrett

Supplementary reading:
By Donald Voet; Judith G Voet
### Module Information

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<tbody>
<tr>
<td>LSM2107</td>
<td>Evolutionary Biology</td>
<td>1 &amp; 2</td>
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#### Module Description

Evolutionary biology covers the history of life on our planet and the processes that produced the multiple life forms of Earth. It plays an essential role in the study of Life Sciences, with evolution being regarded as a critical principle theme running throughout an undergraduate life sciences curriculum in numerous top tier universities across the globe (e.g.: Harvard, MIT, Oxford etc.). The ideas involved bring together the spectrum of diverse disciplines in Life Sciences from cell and molecular biology to biomedical sciences as well as the environmental studies and ecology. Students will learn concepts in evolutionary biology which would form a basis in the foundation level of the Life Sciences Major on which students build up their understanding and from which students filter into the different disciplines.

Specific topics include: the origins of life, the eukaryotic cell, and multicellularity; the generation of genetic variation and the sorting of that variation through random processes and through natural and sexual selection; the origin of new traits, new life histories, and new species; the origins of sex, sociality, and altruism; the evolution of humans; and applications of evolutionary biology to solving modern-day problems.

#### Eligibility and requirements

**Prerequisites (prior knowledge required):** GCE 'A' Level or H2 Biology or equivalent, or LSM1301

**Corequisites:** NIL

**Precluded modules (if any):** NIL

#### Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Blended Learning

#### Assessment modes

The following assessments will be employed:
1) Pre-lecture quizzes = 20%
2) Take-home assignments = 20%
3) Midterm examination = 30%
4) Final Examination = 30%
Contact information for Module Coordinator and other instructors

Dr. Nalini Puniamoorthy (Module Coordinator, Sem 1)
Office: S4 Level 3-13
Phone number: 65162852
Email: nalini@nus.edu.sg

Dr. John Ascher (Module Coordinator, Sem 1)
Office: S4 Level 3-11
Phone number: 65161683
Email: dbsajs@nus.edu.sg

Maxine Allayne Darlene Mowe (Co-lecturer)
Office: S2 Level 4
Phone number: 65161614
Email: dbsmadm@nus.edu.sg

Course content and syllabus

Week 1: What is Evolution? What is the evidence for evolution?

Week 2: How did life evolve? How do variations come about?

Week 3: How do variations get fixed in populations via random processes? How do variations get fixed in populations via Natural Selection?

Week 4: What is the outcome of Natural Selection? What is Artificial selection, and how do we use it in our lives?

Week 5: How does evolution lead to variation in Life Histories? How does the environment determine phenotypes?

Week 6: How do we connect genotypes to phenotypes? What are the major transitions in Evolution?

Week 7: How do we reconstruct species relationships and interpret phylogenies?

Week 8: What are species? How does speciation occur?

Week 9: Why sex? What is sexual selection?

Week 10: What is evolutionary genomics? What is evo-devo and how do novel traits originate?

Week 11: What is coevolution? What is convergent evolution?

Week 12: How does sociality and altruism evolve? How did humans evolve?

Week 13: How does evolution affect our lives?
Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes (ILO)’ below:

1) Case Studies 6) Interactive Lecture
2) Concept Mapping 7) Peer-Learning
3) Critical Reading & Critique 8) Problem-based Learning
4) Group Discussion or Discussion Forum 9) Self-Assessment or Quiz
5) Inquiry-based Learning 10) Student Generated Questions

- Pre-lecture videos and e-tutorials (ILO 1)
- Pre-lecture quizzes (ILO 1)
- In-class Polleverywhere (ILO 1-5)
- In-class Q&A (ILO 1-5)
- Post-class non-graded questions (ILO 1-4)
- Post-class discussion forum (ILO 2-5)
- Take-home assignments (ILO 1-5)
- Midterm and final examinations (ILO 1-5)

Intended Learning Outcomes

Knowledge development

The purpose of the university curriculum is to take the students beyond the pre-university academic training and to train students to apply concepts from the textbook to empirical evidence based learning.

Intended Learning Outcomes (ILO) i.e. in this course, students should be able:

1) To comprehend complex theoretical concepts accompanied by case study examples (E.g. how changes in seed types can select for changes in beak shape among Darwin’s finches)

2) To recognise key processes that drive evolutionary changes (E.g. Mechanisms of mutation, drift, selection, gene flow that meditate allele changes in populations)

3) To reconstruct evolutionary relationships (E.g. Interpret phylogenies, trace evolution across spatio-temporal scales)
(4) To estimate the influence of genetic and environmental components in variation (E.g. Phenotypic plasticity and linkage disequilibrium)

(5) To apply evolutionary concepts to real world challenges (E.g. Using emerging genomics techniques to study host-parasite coevolution in view of disease management)

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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Required and/or recommended readings

Textbook

Evolution
Carl T. Bergstrom, University of Washington,
Lee Alan Dugatkin, University of Louisville.

Supplementary papers (that vary with semesters highlighting relevant research)
E.g.:
## Module Information

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<tbody>
<tr>
<td>LSM2191</td>
<td>Laboratory Techniques in Life Sciences</td>
<td>1 &amp; 2</td>
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</table>

### Module Description

This module introduces the theory and practical applications of techniques used in molecular biology and protein biochemistry. Knowledge in recombinant DNA techniques, such as RNA isolation, reverse transcription, polymerase chain reaction, recombinant DNA construction and recombinant protein expression; and in protein purification, such as liquid chromatography, polyacrylamide gel electrophoresis and western blotting, will be integrated with laboratory practice.

### Eligibility and requirements

**Prerequisites (prior knowledge required):** LSM2105 or LSM2106  
**Corequisites:** NIL  
**Precluded modules (if any):** NIL

### Instructional methods

The following instructional methods will be employed:  
1) Lecture  
2) Tutorial  
3) Laboratory (Dry/Wet)

### Assessment modes

The following assessments will be employed:  
1) Writing Report = 60%  
2) Final Examination = 40%

Note, these weightages are subject to periodic review and therefore may change.

### Contact information for Module Coordinator and other instructors

Assoc. Prof. Lu Gan (Module Coordinator, Sem 1)  
Email: [lu@anaphase.org](mailto:lu@anaphase.org)

Assoc. Prof. Norbert Lehming (Module Coordinator, Sem 2)  
Email: [micln@nus.edu.sg](mailto:micln@nus.edu.sg)

Assoc. Prof. Maxey C.M. Chung (Module Coordinator, Sem 2)  
Email: [bchcm@nus.edu.sg](mailto:bchcm@nus.edu.sg)
Course content and syllabus

The entire module involves a real-world exploration of the central dogma: DNA; RNA; Protein; Function. The students will also learn how the Nobel-prize-winning discovery of the exception to the central dogma, reverse transcription, is used as an essential tool in modern biotechnological research. Using the lactate dehydrogenase system and starting with only mouse tissue, students will convert RNA to DNA. They will then use a popular cloning system to create new DNA molecules that are amenable to production and purification of enzymes. These transformation and overexpression experiments will help students get a concrete grasp of the DNA; RNA; protein information flow. The students will cement their theoretical knowledge of enzymology by observing enzyme catalysis, which further reveals the nature of the invisible proteins they have purified.

In addition to these real-world lab skills, students will learn fundamental sequence analysis skills, using popular web-based and locally installed software. They will see how nearly any DNA molecule can be manipulated at base-pair accuracy and how these DNA molecules are used in advanced fundamental and applied research.

Finally, the students will be exposed to case studies. These studies relate molecular structures and their expected phenotypes of these molecules. By understanding the biological molecules as concrete entities, the students will see how modern science uses existing knowledge to predict future experimental results.

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Group Discussion or Discussion Forum
2) Group/Individual Project
3) Problem-based Learning
4) Laboratory Activities (Wet/Dry)
5) Hands-on Technology
6) Report/Essay Writing

Modern biotechnology is a highly collaborative and fast-paced enterprise. Well-executed biotech projects can have world-changing results, as recently demonstrated by the record-breaking conception, development, testing, and commercialization of the mRNA-based COVID vaccines. To achieve this level of success, scientists must learn to carry out fundamental experiments in the wet lab, then connect the observed data with invisible biological molecules. However, in science, it is not enough to be a pair of hands at the bench. Science requires accurate and concise communication of hypotheses, experimental design, results, and the greater context and ramifications of the results. This communication, which is done in the form a report, will add extreme value when it explains what the next steps of a research project are, either in improving a result or in obtaining a new result. It is expected that students will use these skills in undergraduate research, such as UROPS and FYPs to further cement their connections between the theory and experiments.
Intended Learning Outcomes

Knowledge development

By the end of the module, the student will have learned how to:
1. Isolate mRNA from tissue and amplify one specific gene.
2. Clone a gene into a bacterial expression plasmid.
3. Express and purify an enzyme from a bacterial over-expression system.

In addition, the student is expected to become proficient in analysis:
1. Measurement of both nucleic acid and protein molecule yields and sizes.
2. Measure enzyme activities.
3. Detect minute quantities of a specific protein by western blot.
4. Troubleshoot unexpected results.
5. Propose alternative experimental strategies and methods.

Finally, the students will learn how to communicate a science project in clear and concise writing.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

<table>
<thead>
<tr>
<th>Very Good Opportunities</th>
<th>Good Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Understand: Question, Connect &amp; Explain</td>
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<tr>
<td>2) Apply: Use, Execute &amp; Implement</td>
<td>2) Create: Ideate, Plan, Generate &amp; Produce</td>
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<td>3) Quantitative Thinking</td>
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<td>4) Creative Thinking</td>
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<td>5) Self-Efficacy</td>
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<td>6) Problem-solving &amp; Decision-making</td>
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<td>7) Collaboration &amp; Teamwork</td>
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<tr>
<td>8) Planning, Organizing &amp; Management skills</td>
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<td>9) Adaptability &amp; Learnability</td>
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<tr>
<td>10) Resilience</td>
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</tbody>
</table>

Required and/or recommended readings

Note, the following online learning materials will be updated as needed or when a better version is found.

VIDEOS
Before entering the wetlab, learn how to use a micropipette:
https://www.youtube.com/watch?v=uEy_NGDfo_8&spfreload=1
Principles of PCR (JoVE)

DNA / molecular biology experiments
Practical 1A
RNA Extraction Tutorial
https://www.youtube.com/watch?v=MgNicWbANkA

Simplified RT – Reverse Transcription Animation
https://www.youtube.com/watch?v=0MJIbrS4fbQ

How to use Nanodrop
https://www.youtube.com/watch?v=ZodxBlyKvQ

How to design primer for cloning
https://www.youtube.com/watch?v=-Gx08NJLwc

Practical 1B
How to prepare an agarose gel for DNA electrophoresis (Labtricks)
https://www.youtube.com/watch?v=2UQIoYhOowM

Practical 2
Detailed explanation of an expression vector’s features
https://www.embl.de/pepcore/pepcore_services/cloning/choice_vector/ecoli/vectorfeatures/

Practical 3
Linear regression using MS Excel
https://www.youtube.com/watch?v=L_a8Z0BVjyM

Linear regression using Google sheets
https://www.youtube.com/watch?v=sz7cZ92xWn0

Practical 4
How to use BLAST (for nucleic acids)
https://www.youtube.com/watch?v=rIK-5joOlyU

How to use BLAST (for proteins)
https://www.youtube.com/watch?v=HXEpBnUbAMo

Interpreting BLAST results
https://www.youtube.com/watch?v=fqcmhI34HAE

Protein experiments – These videos demonstrate the principles of LSM2191’s protein experiments. Our equipment setup and parameters are different from those portrayed here, so don’t take every part of these videos literally. Some of these videos are extra,
meaning that we won’t actually be doing, for example, Gel filtration chromatography. However, you should try to understand these concepts because they are used routinely for protein biochemistry. The details of some of these experiments are in PDF documents (zipped on LumiNUS). Please study the included figures carefully.

Practical 5:
Bacterial cell culture (awesomesaucesable)
https://www.youtube.com/watch?v=C-x_QmUZSMg

How to make a buffer (MIT OpenCourseWare)
https://www.youtube.com/watch?v=HZFIdpThd-s
* Note that some online videos show improper technique. Good buffers are key to all subsequent experiments!

Another video with good technique (Bionetwork):
https://www.youtube.com/watch?v=S6bgIeM5wSQ

Practical 6 & 7:
Affinity chromatography (GE life sciences)
https://www.youtube.com/watch?v=FUAQKjKT99Y

Bonus: the following videos show purification methods not covered in the practicals

Gel filtration / size exclusion chromatography (GE life sciences)
https://www.youtube.com/watch?v=oV5VB5kO3tQ

Ion exchange chromatography (IEC/IEX) (GE life sciences)
https://www.youtube.com/watch?v=q3fMqgT1do8

Hydrophobic interaction chromatography (HIC) (GE life sciences)
https://www.youtube.com/watch?v=v6SPK6ZovgA


Practical 7:
How to pour an acrylamide gel (Labtricks)
https://www.youtube.com/watch?v=EDi_n_0NiF4]

Practical 8:
Western Blot, semi-dry transfer (Thermo)
https://www.youtube.com/watch?v=7SVHqK_mFtQ

Western Blot, wet transfer (BioRad)
https://www.youtube.com/watch?v=VgAuZ6dBOfs
## Module Information

<table>
<thead>
<tr>
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<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
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</thead>
<tbody>
<tr>
<td>LSM2212</td>
<td>Human Anatomy</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

### Module Description

This module provides a basic introduction to human structure and function, comprising gross anatomy integrated with microscopic anatomy. Histological organization of the primary tissues: epithelial, connective, muscular, and nervous tissues will be covered. The clinical relevance of the anatomical structures will also be discussed.

### Eligibility and requirements

- **Prerequisites (prior knowledge required):** GCE 'A' Level or H2 Biology or equivalent, or LSM1301
- **Corequisites:** NIL
- **Precluded modules (if any):** NIL

### Instructional methods

The following instructional methods will be employed:

1) Lecture
2) Laboratory (Dry/Wet)

### Assessment modes

The following tentative assessments will be employed:

1) Continual assessment: 40%
2) Final examination: 60%

### Contact information for Module Coordinator and other instructors

- **Dr. Hu Qidong (Module Coordinator)**
  Email: anthq@nus.edu.sg

- **Mr. Yeo Yeu Jie Eugene (Administrative officer)**
  Email: antyyje@nus.edu.sg

- **Dr. Satish R.L (Co-lecturer)**
  Email: antsrl@nus.edu.sg

- **Dr. Ang Eng Tat (Co-lecturer)**
  Email: antaet@nus.edu.sg
Course content and syllabus

1. Cells and Tissues of the Body
2. Musculoskeletal System
3. Respiratory System
4. Cardiovascular System
5. Digestive System
6. Blood
7. Urinary System
8. Reproductive System
9. Immune System
10. Endocrine System
11. Nervous system

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies
2) Critical Reading & Critique
3) Interactive Lecture
4) Laboratory Activities (Wet/Dry)
5) Problem-based Learning
6) Report/Essay Writing

1. The lectures will focus on the anatomy of organ systems and the relevance to physiological and pathological processes. During and after the lectures, the students will apply the anatomical knowledge to analyze relevant clinical cases.

2. The practical lab (digital) will involve the use of human specimens to consolidate the knowledge taught in the lectures.

Intended Learning Outcomes

Knowledge development

1. The students are expected to learn the basic structures and functions of the human organ systems.
2. The students are expected to learn the histological/microscopic features of primary human tissues, including epithelial, connective, nervous and muscular tissues.
3. The students are expected to appreciate the clinical relevance of anatomy in exemplary diseases.
This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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<td>1) Apply: Use, Execute &amp; Implement</td>
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<tr>
<td>2) Understand: Question, Connect &amp; Explain</td>
<td>2) Written Communication</td>
</tr>
<tr>
<td>3) Analytical &amp; Critical Thinking</td>
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<tr>
<td>5) Problem-solving &amp; Decision-making</td>
<td>5) Creative Thinking</td>
</tr>
<tr>
<td>6) Ethics Awareness</td>
<td>6) Planning, Organizing &amp; Management skills</td>
</tr>
<tr>
<td>7) Resilience</td>
<td>7) Self-Efficacy</td>
</tr>
<tr>
<td></td>
<td>8) Adaptability &amp; Learnability</td>
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</tbody>
</table>

Required and/or recommended readings

Human Anatomy by Frederic H Martini (Edition 8 and newer) is recommended.
Module Information

<table>
<thead>
<tr>
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<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
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<tbody>
<tr>
<td>LSM2231</td>
<td>General Physiology</td>
<td>1</td>
<td>4</td>
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</table>

**Module Description**

This module deals with “General Physiology” and its theme is “Biological Transducers and Energy Transformation”. This module will stress on the application of thermodynamics to physiological processes in both plants and animals. Six types of energy will be dealt with: (1) the transformation of light energy to chemical energy by plants, (2) the transformation of chemical energy to chemical potential energy of ions and water across bio-membranes, (3) the transformation of chemical potential energy to electrical energy by plasmalemma with special emphasis on neurons, (4) the transformation of chemical energy to mechanical energy during animal locomotion, and (5) and the production and release of heat during energy transformation.

**Eligibility and requirements**

Prerequisites (prior knowledge required): GCE `A’ Level or H2 Biology or equivalent, or LSM1301 or LSM1301X

Corequisites: NIL

Precluded modules (if any): NIL

**Instructional methods**

The following instructional methods will be employed:
1) Lecture
2) Tutorial
3) Laboratory (Dry/Wet)

**Assessment modes**

The following assessments will be employed:
1) **Formative Quizzes** = 4%
2) **CA1** = 20%
3) **CA2** = 16%
4) **Final examination** = 60%

**Contact information for Module Coordinator and other instructors**

Prof. IP Yuen Kwong  
(Module Coordinator)  
Office: Blk S1A, 5th floor, Rm 05-22  
Phone number: 65162702  
Email: dbsipyk@nus.edu.sg

Prof. Prakash Kumar  
Office: Blk S1A, 7th floor, Rm 07-09  
Phone number: 65162859  
Email: prakash.kumar@nus.edu.sg
## Course content and syllabus

**Plant section:**
- a. Photosynthesis: from light to chemical energy
- b. Water and solute transport
- c. Water flux in plants

**Animal section:**
- a. Vital characteristics, energy and thermodynamics
- b. Feeding and digestion: energy from the sun versus energy from the center of Earth
- c. From chemical energy to chemical potential energy: transport across plasma membrane
- d. From chemical potential energy to electrical potential energy: electrical signals and neurons
- e. From chemical energy to mechanical energy: (a) cytoskeletons and motor proteins; (b) skeletal muscle and locomotion
- f. From chemical energy to heat: heat production and body temperature

## Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  
2) Concept Mapping  
3) Critical Reading & Critique  
4) Laboratory Activities (Wet/Dry)  
5) Self-Assessment or Quiz  
6) Student Generated Questions

- a. Students will need to integrate physiology with physics and biochemistry.
- b. Students will need to go through reading assignments to develop reading skills.
- c. Students will be challenged to critically evaluate what they have learned through quiz so that they can practice "unlearn and relearn” and develop analytical and evaluation thinking skills.
- d. Students will have to generate concept maps so that they can make connections between concepts to construct knowledge.
- e. Students will work in groups in tutorials and practicals so that they can develop communication skills.
- f. Students will learn from case study to develop thinking skills in application and analysis.
- g. Students will need to do experiments to develop finger skills, analytical skills and problem-solving skills.
h. Students will have access to past years’ Q&As so that they can practice independent learning.

### Intended Learning Outcomes

#### Knowledge development

After taking this module, students will:

1. Know the basic physiological processes occurring in plants and animals.

2. Understand how these basic physiological processes are integrated in plants and animals to enable them to live in a variety of environment.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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<td>3) Analyze: Differentiate, Organize &amp; Attribute</td>
<td>3) Digital &amp; Information Literacy</td>
</tr>
<tr>
<td>4) Evaluate: Review, Check and Critique</td>
<td>4) Adaptability &amp; Learnability</td>
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<td>5) Analytical &amp; Critical Thinking</td>
<td>5) Resilience</td>
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<td>6) Quantitative Thinking</td>
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<td>7) Interdisciplinary Thinking</td>
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</table>

#### Required and/or recommended readings

**Plant section:**

Relevant chapters in the following reference book:


**Animal section:**

There are recommended readings for each lesson (provided in the PowerPoint slides) and practical (provided in the practical manual). Most of them are short articles available in the internet and some are journal articles. They are labelled with a star-system (one to three stars), with three stars being the most important.
# Module Information

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSM2233</td>
<td>Cell Biology</td>
<td>1 &amp; 2</td>
<td>4</td>
</tr>
</tbody>
</table>

## Module Description

This course provides a comprehensive understanding of sub-cellular structures, functions and interactions in unicellular and multi-cellular systems, with a focus on cellular processes, their inter-relationships and contribution to human health and diseases. Students will be introduced to the current concepts of intercellular and intracellular signaling, the molecular basis of cell proliferation, the cell cycle and apoptosis. The emphasis will be on gaining skills to acquire scientific knowledge independently and apply concepts to critically analyse experimental data. Students will also be exposed to techniques and approaches to scientific research.

## Eligibility and requirements

Prerequisites (prior knowledge required): GCE ‘A’ Level or H2 Biology or equivalent, or LSM1301

Corequisites: NIL

Precluded modules (if any): NIL

## Instructional methods

The following instructional methods will be employed:

1) Lecture
2) Tutorial
3) Blended Learning
4) Individual and collaborative assignments; in-class exercises to practice analytical and critical thinking skills (Perusall; MS teams; in-class quizzes using Learning Catalytics and other platforms)

## Assessment modes

The following assessments will be employed:

1) Individual and team-based quizzes = 20%
2) Individual and team-based assignments = 20%
3) CA = 20%
4) Final exam = 40%

## Contact information for Module Coordinator and other instructors

Assoc. Prof. Yeong Foong May (Module Coordinator, Sem 1)
Office: MD4 Level 1 (YFM)
Phone number: 65168866
Email: bchyfm@nus.edu.sg
**Course content and syllabus**

- Cell biology concepts related to and applied to human diseases (Parkinson's disease, Diabetes, Cancer, Infectious disease)
- Scientific approaches to solving cell biology-related problems: introducing cell biology related techniques, experimental design and data analysis and interpretation, with the ultimate goal for students to be able to understand research papers independently.

**Learning activities**

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1. Critical Reading & Critique
2. Group Discussion or Discussion Forum
3. Group/Individual Project
4. Inquiry-based Learning
5. Interactive Lecture
6. Peer-Learning,
7. Problem-based Learning
8. Self-Assessment or Quiz
9. Individual and collaborative assignments; in-class exercises to practice analytical and critical thinking skills (Perusall; MS teams; in-class quizzes using Learning Catalytics and other platforms)

**Intended Learning Outcomes**

**Knowledge development**

Students are expected to achieve the following learning outcomes:

- To be able to explain fundamental cell biology concepts
-to be able to explain scientific data obtained using cell biology related experimental methods
- to be able to design experiments to answer cell biology related research questions
- to understand a research paper and explain how conclusions were obtained
- to be able to work collaboratively

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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<thead>
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<th>Very Good Opportunities</th>
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</table>

**Required and/or recommended readings**

Required readings: recent topical research articles

Optional readings: General cell biology textbooks, depending on background level
Module Information

## Module Code
LSM2234

## Module Title
Introduction to Quantitative Biology

### Semester
2

### Mod. Credits
4

### Module Description
Over the past 30 years, there has been an explosion in the amount of quantitative biological data. This is due to advances in imaging, genetics, and sequencing. This module introduces methods necessary for understanding and analysing such quantitative biological data. We use systems from across biology, from photosynthesis to human sleep cycles, to demonstrate the power and applicability of these approaches. We introduce the mathematical and physical concepts necessary through the course. This module is suitable for all Life Sciences students regardless of background in the physical sciences.

### Eligibility and requirements

**Prerequisites (prior knowledge required):** GCE 'A' Level or H2 Biology or equivalent, or LSM1301

**Corequisites:** NIL

**Precluded modules (if any):** NIL

### Instructional methods
The following instructional methods will be employed:
1) Tutorial
2) Blended Learning

### Assessment modes
Assessment is done through continuous assessment. There is no final exam. Due to the flipped classroom format, attendance of tutorials is required and contributes towards the final grade.

The following assessments will be employed:
1) 10% tutorial participation
2) 20% essay (15% for final essay, 5% for peer review of classmate essay)
3) 20% CA test after mid-term break
4) 20% CA test in week 13
5) 30% Weekly problem sets (10 in total, not set in Week 1 or in weeks with CA tests). Each set consists of 3-5 questions and solutions are to be handed in during the following week.

### Contact information for Module Coordinator and other instructors
Prof. Thorsten Wohland (Module Coordinator)
Office: S1A-2-12
Phone number: 65161248
Email: twohland@nus.edu.sg
Course content and syllabus

The course has four general themes:
1. Numbers, scales, probabilities and calculations in biology (weeks 1-4)
2. Application of thermodynamics to biology (weeks 4-8)
3. Chemical kinetics and transport in biological systems (weeks 8-11)
4. Channels and electrostatics (weeks 11-13)

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Interactive Lecture
2) Peer Review and Feedback (including Group Review & Feedback)
3) Problem-based Learning
4) Report/Essay Writing
5) Self-Assessment or Quiz

This module will be held in a flipped classroom mode. There will be video lectures of short duration (typically 5-15 min) and reading material set the week before tutorials will be held. During the week there will be two tutorial time slots. Students will have the opportunity to clarify questions with the lecturers regarding the content in the video lectures and reading material. During each class, there will be problem questions that will be solved within groups, with help from the lecturers. These questions focus on applying the material learned and check student understanding in an interactive manner.

Intended Learning Outcomes

Knowledge development

This module introduces important basic physical concepts in biology. It aims at providing students with a quantitative biophysical skill-set to apply to biological processes, and is suitable for all Life Sciences students regardless of background in the physical sciences. It also develops estimation skills and intuition about biological systems.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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Required and/or recommended readings

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<tr>
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<td><strong>Semester</strong></td>
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<tr>
<td><strong>Mod. Credits</strong></td>
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</table>

**Module Description**

Students will be introduced to the concepts, tools and techniques of bioinformatics, a field of immense importance for understanding molecular evolution, individualised medicine, and data-intensive biology. The module includes a conceptual framework for modern bioinformatics, an introduction to key bioinformatics topics such as databases and software, sequence analysis, pairwise alignment, multiple sequence alignment, sequence database searches, and probe-based methods, molecular phylogenetics, genomic analysis and personal genomics. Concepts emphasised in the lectures are complemented by hands-on inquiry using bioinformatics tools in the practical sessions. Students will achieve highly valued skills as biological researchers with basic competence in computational and bioinformatics techniques, with an option to learn more advanced skills in upper level modules.

**Eligibility and requirements**

Prerequisites (prior knowledge required): GCE `A’ Level or H2 Biology or equivalent, or LSM1301

Corequisites: NIL

Precluded modules (if any): NIL

**Instructional methods**

The following instructional methods will be employed:

1) Lecture
2) Tutorial
3) Blended Learning
4) Laboratory (Dry/Wet)
5) Inquiry-based or Research

**Assessment modes**

The following assessments will be employed:

1) Problem sets: 6, using problem-based learning, 10% each = 60%
2) Quizzes: 2, 15% each = 30%
3) Tutorial work/participation = 10%

**Contact information for Module Coordinator and other instructors**

Prof. Greg Tucker-Kellogg (Module Coordinator)
Office: S3 Level 1
Phone number: 65164740
email: greg_t-k@nus.edu.sg
Course content and syllabus

Course content is organised into six topics

1. Bioinformatics databases (finding information, finding links between information sources, data integrity, genomic annotation, etc.) Fundamental concepts in biological information are covered here

2. Pairwise sequence alignment. Here we cover the most fundamental algorithms of bioinformatics, as well as introduce concepts in probability and statistics that will be used throughout the module.

3. BLAST. This learning unit is named after the most widely used algorithm for sequence database search. We cover BLAST and its variants as well as more advanced methods for sequence database search, using a variety of problems and applications.

4. Multiple Sequence Alignment. This learning unit provides the bridge between previous topics and phylogenetics, and brings in more quantitative thinking and data literacy concepts.

5. Phylogenetics. Here we use all of the topics above to consider the history of life, and how biological sequence information can be used to infer evolutionary history. We cover applications in species history and forensic science.

6. Genome-wide analysis. We return to genome browsers, introduced in topic 1, with the tools covered through the semester, and take a deeper dive into the power of genomic information.

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies 6) Interactive Lecture
2) Group Discussion or Discussion Forum 7) Laboratory Activities (Wet/Dry)
3) Group/Individual Project 8) Problem-based Learning
4) Hands-on Technology 9) Self-Assessment or Quiz
5) Inquiry-based Learning 10) Student Generated Questions

The module is organised as a largely flipped learning experience. Videos are provided for students ahead of time, and each lecture session will be largely interactive, with student work on problems and conceptual challenges. Students will be asked to provide questions on the material for discussion, and students will be challenged at the beginning of each lecture with formative questions about concepts from the pre-lecture material.

The interactive lecture sessions differ from the interactive practicals in two important ways. The first is emphasis: student work during lectures sessions will deepen
understanding of concepts. These might be algorithmic concepts, statistical concepts, or ontological concepts (e.g., “what is a gene in terms of genomic information”). Practicals (dry labs) will be, well practical: they will use case studies, hands-on technology and problem-based learning to give students experience in real problem solving using bioinformatics approaches. The second is assessment: the lecture/tutorial sessions will count towards assessment as participation; while problem sets associated with the practical sessions will be assessed individually.

**Intended Learning Outcomes**

**Knowledge development**

Students will learn how to find, access, and use biological data from public databases for their own projects. Students will understand different methods for and applications of sequence analysis, including sequence alignment, databases searches including varieties of BLAST, and basic phylogenetic analysis. Students will learn how to use genomic databases and genome browsers for a variety of applications. Students will consider how genomic information intersects with privacy issues in modern society.

There is no programming requirement for students taking this module. However, students with experience in programming (using either R or Python) will be provided with an opportunity to use programming-based approaches to further their own depth of understanding and analysis skills.

**This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:**

<table>
<thead>
<tr>
<th>Very Good Opportunities</th>
<th>Good Opportunities</th>
</tr>
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<tbody>
<tr>
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<td>9) Self-Efficacy</td>
<td></td>
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<tr>
<td>10) Adaptability &amp; Learnability</td>
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</tbody>
</table>

**Required and/or recommended readings**

1. Bioinformatics and Functional Genomics, Jonathan Pevsner, 3rd ed. 2015. We will use the first section of this book
2. Practical Bioinformatics, Michael Agostino. This is not a required reading, but is useful
   Additional articles and reading resources are provided with each learning unit on LumiNUS.
Module Information

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSM2251</td>
<td>Ecology and the Environment</td>
<td>1 &amp; 2</td>
<td>4</td>
</tr>
</tbody>
</table>

**Module Description**

LSM2251 is an introductory module introduces students to the science of ecology and its role in understanding environmental processes. It addresses both major concepts and their real-world applications. Topics will include models in ecology, ecosystems of the world, organisms in their environment, life history strategies, population biology, ecological interactions, and community ecology. This module is a prerequisite for ecology modules in Level 3 and 4.

**Eligibility and requirements**

Prerequisites (prior knowledge required): GCE `A’ Level or H2 Biology or equivalent, or LSM1301 General Biology

Corequisites: NIL

Precluded modules (if any): NIL

**Instructional methods**

The following instructional methods will be employed:
1) Lecture
2) Tutorial
3) Blended Learning
4) Expedition/Site/Field visit
5) Inquiry-based or Research

**Assessment modes**

The following assessments will be employed:
I – 5% Introductory Exercises
   CA1: 2.5% Personal statement, two pages max
   CA2: 2.5% Map Exercise

II – 15% Pulau Ubin report (group work)
   CA3: 10% Pulau Ubin report, 6 pages maximum, excluding abstract and appendices
   CA4: 5% Pulau Ubin corrected report

III – 40% Ecological Observations in Singapore (group work)
   CA5: 5% Project Abstract
   CA6: 30% Group Oral Presentation
   CA7: 5% Group Oral Presentation slides PDF

IV – 10% Lecture Quizzes (individual x 4)

V – 30% Exam (individual; MCQ + Short Answers)
Contact information for Module Coordinator and other instructors

Mr N. Sivasothi  
(Module Coordinator, Sem 1)  
Email: sivasothi@nus.edu.sg  
@otterman on Telegram

Dr. Maxine Allayne Darlene Mowe  
(Module Coordinator, Sem 2)  
Office: S2-04  
Phone number: 65161416  
Email: dbsadm@nus.edu.sg

Course content and syllabus

1. What is Ecology? – the specific nature of this branch of science, wildlife and ecosystems in Singapore.
2. The Physical & Aquatic Environments – the diversity of these environments and their underpinning mechanisms.
3. Individual Ecology – physiological and behavioural adaptations to the environment, evolution and extinction.
4. Population ecology – how populations are distributed, life history variation, growth and dynamics (births, deaths, immigration and emigration).
5. Species Ecology – how species interact with their own and other species: niche, competition, predation, parasitism, disease and mutualism.
6. Community Ecology - about diversity and abundance of all species in an ecosystem, how they are structured, respond to disturbance and change (succession).
7. Ecosystem Ecology – energy flow, primary production, trophic levels, carbon and nutrient cycling.

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  
2) Expedition/Field Trip/Site Visit  
3) Games  
4) Group/Individual Presentation  
5) Group/Individual Project  
6) Interactive Lecture  
7) Laboratory Activities (Wet/Dry)  
8) Problem-based Learning  
9) Report/Essay Writing  
10) Self-Assessment or Quiz

Personal Growth

1. Reflect on their growth objectives as an undergraduate – first lecture; personal statement (CA); lecturer’s example; TAs feedback; reflection (discussion in practical); and end of module.
2. Enhance their effective network of peers – first lecture; structured introduction of peers in first lab; students check-in with TAs; post-symposium reflections
3. Summarise their skill set as a science student (career intelligence) – first lecture; post-symposium reflections
### Domain knowledge
4. Recognise common wildlife species and the ecosystems they inhabit in Singapore – active learning exercises (lab); Pulau Ubin preparatory prac (tutorial) and field trip; examples every lecture; independent ecology group project.
5. Differentiate the fundamental ecological mechanisms of the natural world – 13 lectures; quiz.
6. Apply the scientific method to pose and answer an ecological question in the natural world – Pulau Ubin group project (directed); independent ecology group project (structured).

### Academic training
7. Write and orally present a scientific report – Pulau Ubin group project (directed; with detailed feedback); independent ecology group project (structured; with tutorials with feedback for design, analysis and presentation).
8. Plan a group project and conduct field work safely – Pulau Ubin group project (directed); independent ecology group project (structured).
9. Apply the scientific method to identify questions in a complex system – lectures; Ecological Scenarios Tutorial.

### Intended Learning Outcomes

#### Knowledge development

Students will be able to...

#### Personal Growth
1. Reflect on their growth objectives as an undergraduate.
2. Enhance their effective network of peers.
3. Summarise their skill set as a science student (career intelligence).

#### Domain knowledge
4. Recognise common wildlife species and the ecosystems they inhabit in Singapore.
5. Differentiate the fundamental ecological mechanisms of the natural world.
6. Apply the scientific method to pose and answer an ecological question in the natural world.

#### Academic training
7. Write and orally present a scientific report.
8. Plan a group project and conduct field work safely.
9. Apply the scientific method to identify questions in a complex system.
This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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<td>6) Creative Thinking</td>
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<td>7) Quantitative Thinking</td>
<td>7) Adaptability &amp; Learnability</td>
</tr>
<tr>
<td>8) Problem-solving &amp; Decision-making</td>
<td>8) Resilience</td>
</tr>
<tr>
<td>9) Collaboration &amp; Teamwork</td>
<td>Other skill: Spatial Awareness</td>
</tr>
<tr>
<td>10) Planning, Organizing &amp; Management skills</td>
<td></td>
</tr>
</tbody>
</table>

**Required and/or recommended readings**

Relevant chapters in either

OR Elements of ecology, by Thomas M. Smith & Robert Leo Smith (2015)

LumiNUS Learning Flow: weekly scientific articles (max 2) and videos (max 3)
## Module Information

<table>
<thead>
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<th>Module Title</th>
<th>Semester</th>
<th>Mod. Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSM2252</td>
<td>Biodiversity</td>
<td>1 &amp; 2</td>
<td>4</td>
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</tbody>
</table>

### Module Description

This foundation module is required for all students intending to pursue a specialisation in Environmental Biology in the NUS Life Sciences undergraduate programme. It is also open to undergraduates with a fundamental background in biology and interested in the natural world.

The student will be introduced to classification and the characteristics of major groups of living organisms within the three domain system of microbial, plant and animal diversity. Students will learn the characteristics of major taxa, their evolutionary relationships and fundamental similarities and differences through lectures, readings, an examination of laboratory and museum specimens and field trips.

Students will learn to prepare for a field trip, be introduced to some tropical ecosystems and their characteristic communities by visiting a terrestrial and marine ecosystem in Singapore.

Students will also practice effective structured verbal communication, and learn to write an academic essay.

### Eligibility and requirements

Prerequisites (prior knowledge required): GCE `A’ Level or H2 Biology or equivalent, or LSM1301 General Biology

Corequisites: NIL

Precluded modules (if any): NIL

### Instructional methods

The following instructional methods will be employed:

1) Lecture
2) Tutorial
3) Blended Learning
4) Laboratory (Dry/Wet)
5) Expedition/Site/Field visit

### Assessment modes

The following assessments will be employed:

1) Post-Field Trip tests = 12.5%
2) Quizzes = 22.5%
3) Essays = 15%
4) Practical Exam = 20%
5) Final Exam = 30%
Contact information for Module Coordinator and other instructors

Mr N. Sivasothi
(Module Coordinator, Sem 1)
Email: sivasothi@nus.edu.sg
@otterman on Telegram

Dr Ng Ngan Kee
(Module Coordinator, Sem 2)
Office: S2, Level 4
Phone number: 66011091
Email: dbsngnk@nus.edu.sg

Course content and syllabus

Introduction, Systematics & Conservation
Introduction; Learning Outcomes & Methods
Classification & Systematics
The Sixth Extinction & Conservation of Biodiversity
The Kent Ridge and LKCNHM Practicals (how to work in the field)

Botany
Botany 1: Archaea, Cyanobacteria, Algae
Botany 2: Non-vascular and vascular seedless plants
Botany 3: Vascular seed plants: Gymnosperms & Angiosperms (Part 1)
Botany 4: Angiosperms (Part 2) & Fungi

Zoology lectures
Introduction & Tree of Life
Zoology 1: Non-photosynthetic Protists, Trends in the Animal Kingdom
Zoology 2: Animal Phyla trends; Parazoa and Radiata (Porifera, Cnidaria & Ctenophora)
Zoology 3: Protostomes 1 Lophotrochozoa (Platyhelminthes & Annelida)
Zoology 4: Protosomes 2 Ecdysozoa I (Mollusca, Nematoda, Tardigrada)
Zoology 5: Protosomes 3 Ecdysozoa II (Arthropoda & Onychophora)
Zoology 6: Deuterostomes 1 (Echinodermata, Hemichordata, Protochordata)
Zoology 7: Deuterostomes 2 (Vertebrates I: Fishes & Amphibia);
Deuterostomes 3 (Vertebrates II: Reptiles including Birds & Mammals)

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Expedition/Field Trip/Site Visit
2) Group/Individual Presentation
3) Inquiry-based Learning
4) Interactive Lecture
5) Laboratory Activities (Wet/Dry)
6) Report/Essay Writing
7) Self-Assessment or Quiz
8) Student Generated Questions
1. Establish a network of academic friends/acquaintances from the module.
   - emphasis in first lecture and practical, randomised groups, peer introduction and inter-dependence during field work.

2. Define biodiversity, and recognise its scope.
3. Categorise and differentiate major groups of living organisms within the Tree of Life.
4. Discover where organisms are distributed within tropical ecosystems.
5. Evaluate the identity of novel organisms.
6. Explain the need for conserving biodiversity.
   - lesson design through lecture, labs, field work, tutorials and quizzes.

7. Prepare themselves to field work in terrestrial and inter-tidal environments.
   - emphasis in first lecture and practical, survey

8. Write a coherent, precise evidence-based essay, with appropriate use of tables and figures, and cite effectively.
   - CA, essay with detailed feedback, tutorial and self-analysis survey

**Intended Learning Outcomes**

**Knowledge development**

The student will be able to...

**Personal**
1. Establish a network of academic friends/acquaintances from the module.

**Domain knowledge**
2. Define biodiversity, and recognise its scope.
3. Categorise and differentiate major groups of living organisms within the Tree of Life.
4. Discover where organisms are distributed within tropical ecosystems.
5. Evaluate the identity of novel organisms.
6. Explain the need for conserving biodiversity.

**Academic skills**
7. Prepare themselves to field work in terrestrial and inter-tidal environments.
8. Write a coherent, precise evidence-based essay, with appropriate use of tables and figures, and cite effectively.
This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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<td>2) Verbal/Oral Communication</td>
</tr>
<tr>
<td>3) Analyze: Differentiate, Organize &amp; Attribute</td>
<td>3) Analytical &amp; Critical Thinking</td>
</tr>
<tr>
<td>4) Written Communication</td>
<td>4) Ethics Awareness</td>
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<tr>
<td>5) Creative Thinking</td>
<td>5) Self-Efficacy</td>
</tr>
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<td>6) Problem-solving &amp; Decision-making</td>
<td>6) Resilience</td>
</tr>
<tr>
<td>7) Collaboration &amp; Teamwork</td>
<td>Other skill: Situational awareness</td>
</tr>
<tr>
<td>8) Planning, Organizing &amp; Management skills</td>
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</table>

**Required and/or recommended readings**

Chapters in books
Animal Diversity, by Hickman et al
Stern's Introductory Plant Biology
Module Information

<table>
<thead>
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<th>Module Title</th>
<th>Semester</th>
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</thead>
<tbody>
<tr>
<td>LSM2253</td>
<td>Applied data analysis in ecology and evolution</td>
<td>2</td>
<td>4</td>
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</tbody>
</table>

Module Description

Managing, analyzing, interpreting and displaying data to support decision making has become a fundamental skill for environmental biology. This module will train students with the skills and knowledge to design and perform data analysis on typical problems in the areas of ecology, conservation and environmental sustainability. Students will learn the R language with an emphasis on spatial data, on-the-ground ecological data collection and geographic information systems. Students will use the collected spatial data to support environmental impact assessment and sustainability reporting.

Eligibility and requirements

Prerequisites (prior knowledge required): GCE 'A' Level or H2 Mathematics/Further Mathematics or equivalent, or MA1301 or MA1301X or ST1232 or LSM1111 or ENV110

Corequisites: NIL

Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Tutorial
3) Laboratory (Dry/Wet)
4) Inquiry-based or Research

Assessment modes

The following assessments will be employed:
1) Test 1 = 25%
2) Test 2 = 25%
3) Environmental impact assessment group project = 28%
4) Sustainability reporting group project = 12%
5) Presentation = 10%

Contact information for Module Coordinator and other instructors

Assoc. Prof. L. Roman Carrasco (Module Coordinator)
Office: S3 Level 1
Email: dbsctlr@nus.edu.sg
## Course content and syllabus

Introduction to R.
Experimental design in ecology and evolution.
Linear and multiple regression.
ANOVA, ANCOVA.
Data visualization with R.
Generalized linear models.
Spatial data management and analysis (GIS).
Generalized least squares.
Linear mixed-effects models (LMEs)
Generalized linear mixed-effects models (GLMMs).
Multivariate statistics.

## Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  
2) Expedition/Field Trip/Site Visit  
3) Group/Individual Presentation  
4) Group/Individual Project  
5) Hands-on Technology  
6) Inquiry-based Learning  
7) Interactive Lecture  
8) Laboratory Activities (Wet/Dry)  
9) Problem-based Learning  
10) Report/Essay Writing

The module uses interactive lectures with the computer in which the students practice the contents being explained real time.

Practicals follow lectures in which students solve data analysis problems while being assisted.

Group project allows for real problems and uncertainty to be faced as a group.

## Intended Learning Outcomes

### Knowledge development

1. Master the R programming language.
2. Read and manage most common data formats in ecology.
3. Develop professional data graphics skills.
4. Select, by looking at the data, which type of analysis is the most suitable.
5. Fit models to data and perform model selection.
6. Check model diagnostics.
7. Make predictions with models.
8. Perform geographic information systems operations with R.
9. Learn to design fieldwork data collection and experiments.
This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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<tr>
<td>10) Resilience</td>
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</tbody>
</table>

Required and/or recommended readings

Zuur et al. (2009) Mixed effects models and extensions in ecology with R.
Module Information

Module Code  | Module Title               | Semester | Mod. Credits |
-------------|-----------------------------|----------|--------------|
LSM2254      | Fundamentals of Plant Biology| 2        | 4            |

Module Description

This module introduces students to contemporary plant biology. It focuses on the flowering plants (angiosperms), one of the most successful plant groups that sustains all life on earth, and examines how they are organized, grow, and respond to the environment and the fundamental molecular and genetic basis involved. A major theme that the module will highlight is that plant growth is highly dynamic – plants control growth and development through integrating intrinsic and external signals to best adapt to the changing surroundings. The concepts and techniques of gene manipulation for studying plants, as well as their applications in plant biotechnology, will also be discussed. This module can be taken on its own as a general introduction to modern plant biology or as a foundation module for more specialized plant- or genetic-based modules in Level 3000 and 4000.

Eligibility and requirements

Prerequisites (prior knowledge required): LSM2105 or LSM2106
Corequisites: NIL
Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Tutorial
3) Laboratory (Dry/Wet)

Assessment modes

The following assessments will be employed:
1) Writing Report = 30%
2) CA (Mid-term) = 30%
3) Final Examination = 40%

Contact information for Module Coordinator and other instructors

Dr. Lau On Sun (Module Coordinator)
Office: S1A #07-08
Phone number: 65167068
Email: onsunlau@nus.edu.sg
Course content and syllabus

1. Importance of plants
2. Plant structure, growth and development
3. Unique aspects of plant cells and tissues
4. The model plant Arabidopsis & molecular techniques to study plants
5. Sensing the environment
   • Light perception and transduction
   • Responses to pathogens
6. Coordinating growth through plant hormones
   • Diversity, with a focus on auxin, ABA and ethylene
   • Perception, signaling and action
7. Plant Biotechnology and genetic engineering

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Laboratory Activities (Wet/Dry)
2) Report/Essay Writing

Laboratory Activities (Wet)
The lab activities complement and draw connections to the content covered in lectures and students will gain hands-on experience in basic plant molecular biology techniques and approaches. Through active participation, the activities help deepen the knowledge covered in the module and improve understanding. It also provides an opportunity to apply the knowledge in a laboratory setting. The laboratory activities will also help strengthen collaboration and teamwork, planning and management skills and resilience.

Report/Essay Writing
Students are required to submit a report based on the results of the lab activities. This process of data preparation and report writing will not only further deepen students’ understanding of the module content but also promote their cognitive abilities in organizing, reviewing, and creating. This activity also develops skills in written communication, digital & information literacy (e.g. image analyses and figure preparation), analytical & critical thinking, problem-solving, and planning and organizing.

Intended Learning Outcomes

Knowledge development

At the end of the module, students will be able to:
- Describe the basic structure, growth and development of plants in relation to their life strategies
- Identify unique aspects of plant cells and tissues
- Explain the roles of model species in the study of plant processes
- Explain how plants sense and respond to environmental stimuli
- Describe how plants use hormones to coordinate growth
- Discuss the technology behind genetically modified plants and its application
- Select appropriate techniques to address questions in plant science

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

<table>
<thead>
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</tr>
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<tbody>
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Required and/or recommended readings

Recommended readings:
## Module Information

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<tbody>
<tr>
<td>LSM2288/9</td>
<td>Basic Undergraduate Research Opportunities Programme in Science (Life Sciences)</td>
<td>1 &amp; 2</td>
<td>4 or 8</td>
</tr>
</tbody>
</table>

### Module Description

This programme allows students to engage actively in research, discussions, intellectual communications and other creative activities. By complementing the conventional classroom learning, UROPS places students at the frontiers of scientific research. Through the typical phases of doing research, students are able to enhance their knowledge in the latest development of science and technology; acquire special communication and presentation skills; experience creative thinking; interact and forge closer ties with the established scientists and members of their groups. The experience students gain upon completion of the project will assist them in the preparation for future careers and postgraduate training.

### Eligibility and requirements

**Prerequisites (prior knowledge required):** students must have completed at least one semester of study at point of application and attained a CAP of 3.00 or higher

**Corequisites:** NIL

**Precluded modules (if any):** NIL

### Instructional methods

The following instructional methods will be employed:

1) Inquiry-based or Research

### Assessment modes

The following assessments will be employed:

1) Report and presentation = 100%

### Contact information for Module Coordinator and other instructors

Dr. Huang Danwei (Module Coordinator)
Office: Blk S3 Level 4
Phone number: 65162696
Email: huangdanwei@nus.edu.sg

### Course content and syllabus

Research
Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Critical Reading & Critique
2) Group/Individual Presentation
3) Group/Individual Project
4) Inquiry-based Learning
5) Problem-based Learning
6) Report/Essay Writing
7) Laboratory Activities (Wet/Dry)

Intended Learning Outcomes

Knowledge development

1. Provide unique opportunity to work with faculty and research staff, and to experience the challenges and benefits of pursuing an independent research project.

2. Complement conventional classroom learning, and to place students at the frontiers of scientific research.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

<table>
<thead>
<tr>
<th>Very Good Opportunities</th>
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<tbody>
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<tbody>
<tr>
<td>LSM2291</td>
<td>Fundamental Techniques in Microbiology</td>
<td>1 &amp; 2</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Module Description

This module gives an overview of microbial diversity, the biological properties of microbes, methods and approaches in the study of microbiology. At the end of the module, students should have fundamental knowledge of microbiology, including tools in the study of cells and microbes and the awareness of biosafety, and students should be excited by the microbial world and wishing to know more.

#### Eligibility and requirements

**Prerequisites (prior knowledge required):** GCE `A’ Level or H2 Biology or equivalent, or LSM1301  
**Corequisites:** NIL  
**Precluded modules (if any):** NIL

#### Instructional methods

The following instructional methods will be employed:  
1) Lecture  
2) Laboratory (Dry/Wet)

#### Assessment modes

The following assessments will be employed:  
1) CA1 = 30%  
2) CA2 = 40%  
3) Lab report = 30%

#### Contact information for Module Coordinator and other instructors

<table>
<thead>
<tr>
<th>Name</th>
<th>(Module Coordinator, Sem)</th>
<th>Office</th>
<th>Phone number</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. John Chen</td>
<td>(Sem 1)</td>
<td>MD4, Level 3</td>
<td>66015208</td>
<td><a href="mailto:miccjy@nus.edu.sg">miccjy@nus.edu.sg</a></td>
</tr>
<tr>
<td>Assoc. Prof. Justin Chu</td>
<td>(Sem 2)</td>
<td>MD4, Level 5</td>
<td>65163278</td>
<td><a href="mailto:miccjh@nus.edu.sg">miccjh@nus.edu.sg</a></td>
</tr>
</tbody>
</table>
**Course content and syllabus**

Both the lectures and practical classes provide an overview of microbial diversity, the biological properties of microbes, methods and approaches in the study of microbiology with the emphasis on the fundamental techniques in microbiology. The concept of biosafety in microbiology research is also introduced in this module.

Lectures:
(1) Introduction to the diversity of microbial world and phylogeny
(2) Biosafety
(3) Isolation and identification of microbes
(4) Microbes in the environment: Where are microbes found and why are they there
(5) Microbes and immunity

Practical Classes (Wet Lab):
(1) Soil microbiology: Isolation, identification and characterization (antibiotic producers, polysaccharide producers)
(2) Water-borne pathogens: Isolation, enumeration, physiology and behaviour outside the host
(3) Food microbiology: Isolation, enumeration and characterization (yeast, lactic acid bacteria, enteric bacteria)
(4) Human skin microbiology: Isolation, are they pathogens?

**Learning activities**

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Expedition/Field Trip/Site Visit
2) Laboratory Activities (Wet/Dry)
3) Report/Essay Writing

This module provides an overview and introduction to the fundamentals of microbiology with the heavy emphasis on the development of technical skills to basic microbiology. The content of lectures is kept to minimal (no more than 13 hours) and a series of interesting practical sessions (32 hours) are lined up for the students. There is a lecture that introduce to the concept of biosafety in microbiology research and a field trip is organized for students to visit a microbiology-related industries such as Yakult Singapore and Asia Pacific Breweries Singapore. Together, these learning activities will ensure that the students will achieve the learning outcomes of knowledge, cognitive, generic skills and/or attributes development as stated above.
Intended Learning Outcomes

Knowledge development

At the end of the module, students should have fundamental knowledge of microbiology, including tools in the study of cells and microbes and the awareness of biosafety, and students should be excited by the microbial world and wishing to know more.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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Required and/or recommended readings

(1) Foundations in Microbiology, Talaro
Module Information

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<tr>
<td>LSM2301</td>
<td>Life Sciences Industry Seminar</td>
<td>2</td>
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</table>

Module Description

An important component of the education at NUS is to demonstrate the translation from theory to practice. In this module, there is a series of topical seminars will introduce students to the latest innovations and developments in a range of industries. Leading technical experts will be brought in to share their insights and advise students on the knowledge, skills and abilities that are needed to enter and succeed in each field. Complementary field trips will allow students to see how theory is applied in the industrial context.

Workshops will provide the opportunity to develop and apply industry-valued transferrable skills, such as the ability to prioritize urgent and important work, and practise stakeholder management. This will culminate in an actionable career development plan.

Eligibility and requirements

Prerequisites (prior knowledge required): NIL
Corequisites: NIL
Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Seminar
3) Workshops

Assessment modes

The following assessments will be employed:
1) Bi-Weekly Reflection Journals or Case Studies = 40%
2) Workshop Assignment = 30%
3) Concluding Report = 30%

There is no Final

Contact information for Module Coordinator and other instructors

Dr. Ng Ngan Kee (Module Coordinator)
Office: S2, Level 4, Science Drive 4, Singapore 117543
Phone number: 66011091
Email: ngankee@nus.edu.sg
Course content and syllabus

Eight seminars from the following industries:
- Healthcare and Science Consulting
- Pharmaceuticals and Biotechnology
- Retail & Hospitality
- Clinical Research and Contract Research Organisations
- Financial Services
- Animals and Plants, Environment and Sustainability
- Chemicals, Energy and Resources
- Fast-Moving Consumer Goods
- Pharmaceutical Research
- Agri-Tech & Alternative Food Sources
- Medical Technology & Biotech Start-Ups
- Biopharmaceutical Industries

Three company Visits for example:
- International SOS, GSK, Uniqlo, Covance, JP Morgan, NParks, Singapore Food Agency, BASF, P&G, Fragrance & Flavours, Transformation in Healthcare, Food Science & Sustainability etc.

Four Workshops on:
- From School to Workplace Productivity
- Communications, Building Workplace, Relationships & Navigating Workplace Politics
- Developing Collaboration and Interpersonal Skills
- Interview Skills
- Coming up with your own Career Development Plan
- Career Planning

Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Case Studies  4) Group/Individual Project
2) Expedition/Field Trip/Site Visit  5) Interactive Lecture
3) Group Discussion or Discussion Forum

Lectures and interactive lectures to provide basic knowledge and allow various forms of interactions with all the guest lecturers.

Seminars are delivered by selective representatives from the industries.

Site/company visits allow the students to visit the various companies, allowing the students to find out more about the companies.

The module ensures that there are as many opportunities/meetings/interactions between the students and industries.
Workshops are provided by colleagues from Centre for Future-ready Graduates will equip the students with the necessary skill to enter the workforce upon graduation.

Group Discussions will allow the students to discuss and share their thought about the various industries.

Individual reports are submitted by the students after each lecture or seminar, site visit and workshop. The final report for this module is the development of the student's CV and Concluding Report. CFG colleagues will personally go through the student’s CV to pinpoint the flaws and inadequacies, so that the students can improve and refine their CVs.

### Intended Learning Outcomes

**Knowledge development**

After taking this module, students will:

1) be updated on the latest industry technologies, practices, challenges and solutions.

2) be able to apply their course theories and materials to the industrial context.

3) learn and apply critical transferrable skills for the modern workplace.

4) draft and implement an action plan for their career development.

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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**Required and/or recommended readings**

There is no specific list for reading. The reading list will be provided based on the topics/fields/disciplines covered in the semester.
Computational thinking is becoming increasingly important across the life sciences, from molecular and cell biology to evolution and ecology. This module will introduce students to computational thinking and will focus on how to solve biological problems using computational approaches. How can you become a computational thinker? How do computers represent and solve problems? How can computers and computational thinking be used to solve problems of relevance to biology? The applied component of the module will teach the basics of programming in R and will focus on biological problems including population growth modelling, epidemic modelling, and analysis of biological data.

Eligibility and requirements

Prerequisites (prior knowledge required): GCE 'A' Level or H2 Biology or equivalent, or LSM1301 or LSM1301X
Corequisites: NIL
Precluded modules (if any): NIL

Instructional methods

The following instructional methods will be employed:
1) Lecture
2) Blended Learning

Assessment modes

The following assessments will be employed:
1) Quizzes (one for each lecture): 10%
2) Four assignments: 20%
3) Mid-term test: 30%
4) Final exam: 40%

Contact information for Module Coordinator and other instructors

Assoc. Prof. Ryan Chisholm (Module Coordinator)
Office: S3-01-11
Email: chisholm@nus.edu.sg

Dr. Duane Loh (Lecturer)
Office: S1A-02-07
Email: duaneloh@nus.edu.sg
## Course content and syllabus

Specific computational skills:
- Algorithmic thinking
- Simple variables, data types
- Basic arithmetic and computation
- Logic: if, then, else; Boolean logic
- Loops: for, while
- Functions
- Specific algorithms: sorting, searching
- Algorithms: abstraction, recursion, modularisation
- Representation: binary and hexadecimal number systems
- Strings, arrays, matrices, multidimensional data types
- Matrix operations
- Pseudorandom number generation and Monte Carlo simulation

Examples of biologically relevant problems to be used as applications:
- Simple discrete-time population growth models: exponential, logistic
- Age-structured population model
- Individual-based model, e.g., of an epidemic
- Data processing: computing simple properties of a data set such as means, standard deviations, and quantiles, and breaking these down by groups, application of linear regression, correlation
- Randomisation tests to assess statistical significance in data analyses
- Analysis of protein sequences as text strings using searching and sorting algorithms

## Learning activities

The following learning activities will be employed to achieve the learning outcomes of knowledge, cognitive skills, generic skills and/or attributes development stated in the ‘Intended Learning Outcomes’ below:

1) Group/Individual Project  
2) Interactive Lecture  
3) Problem-based Learning

The three learning activities (individual project, interactive lecture, problem-based learning) will help achieve all learning outcomes listed under items 4 and 5.

## Intended Learning Outcomes

### Knowledge development

1. Understand what it means to think computationally.  
2. Write computer programs (in R) to solve simple problems, with a focus on problems relevant to the biological sciences.  
3. Read computer programs (in R) and understand them.
4. Know and explain how standard algorithms work (search, sort, etc.).
5. Perform basic data management and analysis (in R).

This module will provide the opportunities to develop the following cognitive skills, generic skills and attributes:

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Required and/or recommended readings

Supplementary reading: “The Power of Computational Thinking” by Paul Curzon and Peter McOwan
DBS Life Sciences Module Handbook Volume 1 -
Levels 1000 to 2000

Designed, edited, and compiled by Xu Weiting,
Cai Hongxia & A/P Lam Siew Hong

A/P Lam Siew Hong is the co-chair of DBS Department
Teaching Committee. Xu Weiting and Cai Hongxia are
the full-time teaching assistants of DBS.

The module descriptions are contributed by the
respective module coordinators and are accurate at
the point of publication.

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This handbook is the first edition (2021) and it is an e-
publication of the Department of Biological Sciences,
National University of Singapore.