Your first year in biomedical sciences: a guide to university

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Looking at my time as an undergraduate student, and my time as a lecturer at a number of different institutes, it’s quite clear to me that a great many incoming students struggle to adapt from the environment of a school or college to life as a university undergraduate. Although even the best universities run orientation days, give out handbooks and institute mentoring programs, huge numbers of students still have difficulties and so can underperform.

Naturally there is an awful lot to take in, and the prime part of any life science based undergraduate degree is going to require the acquisition of many skills and much knowledge in a short space of time, and in a new teaching environment. This means that the adjustment period can be short or non-existent and things tend to be done in a different way with different expectations to what you are used to. A lack of preparation or ability to adapt means you will struggle as a student and your grades are likely to suffer as a result. You have probably never had a formal lecture in a room with a hundred (or two hundred) other people, or had near 1:1 instruction from a supervisor, and may never have encountered a university professor or read a scientific paper. I have seen countless intelligent and diligent students fall foul of basic errors that perhaps they simply have not had to deal with before, or just didn’t see coming. It’s easy for lecturers and professors that have been immersed in this culture for years (or decades) to overlook this transition and to forget how hard it can be, and that combination is therefore difficult for all concerned.

This guide is here to help bridge that gap. It is intended to provide a primer for starting at university – something you can read before you start or in the opening weeks of your course, and is there to get you familiar with how things run at a university and the kinds of problems and issues you can expect to encounter and how to deal with them. It is not about rules and regulations but how to adapt and learn at university compared to a non-university setting. Reading through this should leave you well prepared for many of the trials and tribulations of being an undergraduate student in biomedical science, and will provide a source of information and advice when things go wrong or new issues arise.

Perhaps all of this can be condensed into this: go to your lectures (and practicals), listen, work hard, follow instructions, hand things in on time, and good luck.
However, you might expect a bit more from this guide so I'll keep going. To make this as easy as possible to read and navigate, the guide is broken up into sections with unifying themes. These naturally crossover and overlap in various places and so there are as many references put in as possible so that it is easy to trace problem areas across the guide and find all the relevant information as easily as possible, but without duplication. Each section has a title and then appropriate sub-headings to help you through. It should be fairly easy to access and find relevant sections later on when you need them as issues arise so do refer back to this guide when a problem as come up. Don't try to read it all in one go, but look at what sections are here and the topics covered and dip back into it as a given issue crops up.

I hope this proves useful and interesting. Now, go to your lectures (and practicals), listen, work hard, follow instructions, hand things in on time, and good luck.
A quick note on terminology:

Note that various institutes around the world use different names and titles for various academic and learning institutes and people. For example, the academic progression among researchers in the U.K. is typically that of ‘lecturer’, ‘senior lecturer’, ‘reader’ and finally ‘professor’. In North America almost all ranks carry the title of ‘professor’ be it assistant, associate, or senior so the title of ‘professor’ carries a lot more weight in the U.K. that it may do abroad. Here I use ‘professor’ to talk about senior people, and ‘lecturer’ may cover anyone employed at the university to teach students and / or do research. Plenty of lab technicians, PhD students, postdoctoral researchers, teaching fellows and other people may be involved in teaching you, but I’m bundling them all up under the general heading of ‘lecturer’ or ‘instructor’.

Similarly, universities in the U.K. may be divided into schools or colleges, but are still part of a university, and these are not synonymous with a U.K. school or college which are for children and /or young adults (i.e. levels below university). I’ll refer to anywhere conferring degrees as a university, and a section within that (e.g. those dealing with biology or dentistry) as a ‘department’. I will use ‘term’ as a period of teaching separated by breaks and this is more or less synonymous with ‘semester’.
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1. Preparation – before you go

You can begin to prepare yourself for university before your course even begins. Much of the basic information about your first year will up on the departmental or university website, so take a look at what is coming up. Use this to get ahead – you will be able to buy at least some course textbooks in advance (or find them online, and local libraries will carry at least some common textbooks and the university library will have multipole copies of everything you really need) and start reading and try and identify areas in advance in which you are likely to be weak. Little tricks like this can give you a small edge going into your first few weeks and take a bit of the pressure off your arrival – if you know what you are going to be doing and when and with whom, and have all the material to hand in advance, that first settling in period is likely to be rather less stressful and you'll make fewer mistakes.

1.1 Rules and regulations

The university will provide a student handbook about the rules and regulations, penalties for late work, disciplinary issues etc. etc. Do read this thoroughly and use it as your first point of reference whenever you have problems – it is there specifically to help you so use it. If this doesn’t answer your questions or you need clarification, then speak to the appropriate member of staff.

1.2 Finding your way around

While you should have some time to orient yourself before your lectures begin, it’s a good idea to learn your way around the university a bit (and indeed the city if you have not lived in the East End) before you start. Getting lost when going to lectures or tutorials can be embarrassing and obviously is frustrating. So try to hunt down the major lecture theaters and laboratories in advance and learn where the administration office is, the office of your tutor, and any other major locations you are likely to need. If possible, a trip to the university before the start of term will allow you to orient yourself, find major buildings and landmarks, and check out facilities as well as looking in advance for things you might need on arrival like the campus bookshop.

1.3 What to expect from a scientific degree

A typical bachelors degree will give you the grounding in the basis of scientific research and the knowledge base to pursue this. You can expect to learn a great many skills (many or even nearly all of which are transferable to many professions) and of course a great deal about the subject. You will hopefully develop as a person too, and for those who are school-leavers and leaving home for the first time, the opportunity to mature and grow, meet people from very different backgrounds and gain a new sense of independence and freedom. It can be hard work and difficult at times, but it should also be fascinating and enjoyable. Be prepared for problems to come up, but also relish the challenge to deal with them and succeed.
Links:

Starting at university:
http://www.youthcentral.vic.gov.au/studying-training/tertiary-study/9-tips-for-starting-1st-year (an Australian site, but pragmatic and applicable to just about anywhere)
2. University is not a school or college

Many students struggle on reaching university as they have never experienced learning outside of a classroom at school or college. The fundamental way in which things are taught and how you are expected to learn are rather different at university and it can take time to adapt to this.

2.1 Lectures, labs, tutorials

At school or college you will likely have simply had lessons assigned to a timetable and some of these would involve you being taught directly about a subject by a teacher, and others more practical based work and experiments. There would likely be a text-book that followed the taught material rather closely, as well as a syllabus set at the regional or national level. Regular homework would be set that you would be expected to return for marking. In short, this is driven by the teacher delivering material for you to learn and understand and with constant feedback on this process to steer it. However, at university the lecturer is there only to provide the framework of material and context and it is for you to fill in the gaps and build on this and make sure you understand it (see 2.2). You can expect to have three main kinds of teaching sessions to help you with this.

2.1.1 Lectures.

Here you will be in a lecture theatre or large classroom, and the lecturer will present material to the class from their notes and probably using slides or writing on black (or white) boards. The class may be big (over 100 students in the first year is common, some may be with several hundred students) and interaction between students and instructor will likely be low. Classes may include questions or problems to work through and other interactive activities but are still somewhat based around the traditions of ‘chalk and talk’. You will likely not be set any direct assignments for lectures.

2.1.2 Laboratory work.

These will be set in a lab (either a standard lab with Bunsen burners and the rest, or a computer lab with multiple machines) and will require developing practical skills for experiments etc. Work may be completed in the session and turned, or it may be finished later and then submitted.

2.1.3 Tutorials.

These involve small groups of students (typically 8-10, but may include 1-to-1 sessions) sitting down with a specific lecturer to discuss various aspects of research and skills or your work. This is an opportunity to ask questions and discuss ideas and develop your abilities and get some detailed interactions with an experienced researcher.

2.2 Self-directed learning

The key at university is learning how to learn. You will not be guided through your work as you were at school (it’s impossible for a lecturer to deal effectively with several classes of over 100 that he sees once a week for one term in the way a teacher might for a class of 20 they see three or four times a week over two years for A-level) and you will not likely be given regular sets of homework or tests for all of your modules. Any course textbooks will be
general and unlikely to be tied directly to the course you are taking because there is no fixed country-wide syllabus, but is instead based around the expertise of the instructors. While you will have lectures, labs and tutorials, these will be surprisingly sparse leaving you with apparently a lot of free time.

This means you will have to do things for yourself: you will have to work out what you need to learn, and take the time to find the right resources and learn from them. The taught classes and labs are there to provide a framework for you to build on. Do not expect to be able to go to all the classes and check your notes and be ready for an exam or assignment – you are expected to, and indeed need to, read far around the subject and spend many more hours outside the class learning the subject than you do inside a classroom or in a tutorial session. (Typically this is about 1:4 so for 2 hours in the lecture theater, you should be doing about 8 hours of reading, note taking etc.). Certainly you can and should ask lecturers and teaching assistants for help and guidance, but they are there perhaps more to help you learn that to actually teach you directly. Lecturers will not be leaning over your shoulder and taking notes of your scores or performance regularly in the way a school teacher might and not everything you might need to learn will even be covered in the classroom.

Don’t wait to be informed of issues, but identify them yourself and seek to correct them. This will help you do well and is naturally a key skill for the future in any career.

2.2.1 Attendance.

Attendance is rarely taken at any of these classes however, it is simply impossible to catch up from lecture notes or recordings if you miss much material. You are investing a lot of time and effort (and probably money) to attend a university degree program so you have an obligation to attend everything, not only to yourself, but also those who are trying to instruct you or support your being there. Don’t assume you can rely on lecture handouts or recordings - they are not the same thing and perhaps unsurprisingly research has shown that students do perform better from being present in lectures.

2.3 Learning from lectures and taking notes

Students will be coming to the university from a huge range of countries, and with a wide variety of backgrounds and experiences (as well as differing abilities in English and the sciences) and will have potentially done very different things in the field to you. The end result of this is that first year classes need to be taught such that by the end everyone has the same basic information to the same standard.

This means that any given session or module can be very difficult for some and very easy for others. Some students might find themselves repeating things they did at school, while others are totally new to everything, and for the instructor there will a certain amount of work and information to get through in a set amount of time. It is pretty much impossible for a lecturer to go through material at a rate and in a style that will suit everyone of 30+ students, let alone a class of 150. Bear this in mind, and even if it is easy or you have done it before, keep showing up – the course may get progressively harder and in any case it’s always good to update and refresh your knowledge.
The key to lectures is to take good notes. While many lecturers will provide the slides they have used, and there may be recordings of the lecture online that you can revisit, it is still critical to take notes. You will need to distill what is being said into choice words and sentences that you can easily learn from later and use to build upon with your reading and research. Don’t try and copy down everything that is on the screen or every word that is said, but enough for you to reconstruct the material later on. (Note, studies have shown that it is far better to take notes by hand than on computers and it also means that come exam time you have done some writing recently).

As soon as possible after your lectures, sit down and write up your notes. Write them more neatly or type them up so they are legible. Fill in any gaps. Then start reading up on other interlinked areas and add extra detail and information to your notes from textbooks or scientific papers. Link across in your notes to other lectures or sources that relate to what you have covered in the class and build up the information. Don’t leave it for days or weeks (or until the week before the exam), you will forget key issues and it will make things much harder.

This will really help you learn the material and enable you to apply things learned in one course to another and build you knowledge breadth and depth. This is a real key to success in coursework and exams, as well as laying the foundation for the coming years.

Pay attention to the stated aims and objectives of a given course or session. Be aware of what it is you are trying, or expected, to learn and bear this in mind when writing up notes or researching around the subject. These core points and issues will help keep you focused. That said, you will benefit (in general and in your marks) from reading around and outside the subject. Don’t stick narrowly to only these points and expect to be able to get top marks.

See also section 5 for much more on learning.

2.4 Keeping track

Things are not as strictly timetabled as at school and changes will likely occur as situations arise and circumstances can force changes at short notice (academics have a lot of commitments – see section 3). If a biology teacher at school is ill, a replacement can probably be found fairly easily who can teach the same material. But if you are being taught by a world expert on their specialist area and they are away or ill, there might not be another person in Europe who could cover their material as well, let alone being able to get them to teach you at short notice. Different students doing the exact same courses and with the same requirements may be given different deadlines or attend tutorials or labs in different rooms at different times if labs are split into multiple groups.

In short, make sure therefore you know what is expected of you and when. Keep careful track of which days you have which labs and lectures. Note down things that have changed or altered as soon as you find out so you do not forget (keeping track with a personal calendar, digital or paper, is obviously very useful). Ensure work is handed in on time in the right way to the right place. Check your university e-mail regularly (and the e-learning resources like QM+) and reply to those that need it as soon as you can.
Be aware of the structure of your course and key points in it. There may be requirements for each year to progress to the next one or to do certain courses etc. Obviously you should be aiming to do as well as possible, but it is easy to fall behind. Something failed or missed in your first year might put you on the wrong track, so don’t get stuck early on.

2.5 How to fix problems / who to speak to

Problems will inevitably arise at some point, and you are likely to have a conflict of some description or require help. Who you need to speak to for assistance will likely be linked to the problem you are having and your student handbook (1.3) will have some guidelines or the answers you need. Your personal tutor (aka academic advisor) is likely to be a useful first port of call for most general problems, and if you are struggling with a particular course or task, the person who set this work or the module organizer is probably the best person to speak to. There are lots of people in the university who can help you such as the Student Support for many personal problems, Careers Office if you are looking for a job etc.) and be able to offer advice or put you back on track or assist with problems. They are there to help, so don’t be afraid to approach them or anyone for assistance. The academics and the admin staff want our students to enjoy themselves and succeed.

Do not wait for people to work out you are in trouble and help you - it may have gone unnoticed that you are having problems. And don’t wait until after the event (if you know an issue is looming) to do something about it, but try to be proactive. It will for example be much harder for us to help the day before (or even after) an exam if there’s a problem. Let someone know as soon as possible that you are unavoidably ill, away or have issues. Similarly, if you notice friends struggling, encourage them to speak up, or perhaps have a discreet word with their tutor to let them know there may be a problem.

Systems and procedures are in place to help you. Allowances are always made for students with disabilities, and can be made for those suffering with illness, as well as unexpected problems like bereavements, issues with a visa, and the like. Major conflicts with staff or disciplinary problems will have formal procedures to go through and can be arbitrated. It’s not like school where you may be hauled in front of the headmaster, so don’t be afraid to raise concerns or make complaints if you are sure there is a serious issue at hand. Don’t be afraid to escalate things if a reply is unsatisfactory, but pressing the nuclear button first can be damaging to everyone so try to work through any issues you may have with staff.

Links:

Studying tips especially on self-directed learning (huge with numerous useful sections):
http://www.studygs.net/index.htm
3. What do academics do?

As discussed in section 2, a university is not a school and those instructing you are not teachers. While obviously a key part of their position, lecturers are typically both scientists and instructors. In short, although teaching is a massive part of the life of an academic, it is not the only one.

So, what do academics do apart from teach? This is something rarely passed on to undergraduates and even those continuing to study for a Masters or Doctorate may not at first grasp what else goes on or how the university or department functions.

3.1 Teaching

Academics do of course teach and will take practicals, labs and tutorials. They may also teach or work at other institutes if they hold a joint position, and may teach advanced courses for Masters students, or adult learning classes etc. They will also supervise research projects and dissertations for undergraduate students, and will also supervise the research of PhD students or postdoctoral researchers. This of course also involves planning these things, and since courses have no set syllabus or course work, that means designing and creating all of the course materials and lectures, and keeping them up to date with current science. The core of a class may be the same year to year but it is likely that every year some aspects of any given lecture will be changed and updated to reflect new ideas and new discoveries so lecturers are constantly updating and changing courses. Academics will also need to create the various assessments and exams that you sit and to mark them, and deal with any issues arising.

3.2 Administration

Academics also help with the administration of the department or university. They will need to organize what teaching is done and assess teaching standards, sort out budgets, new appointments, timetables, development of the department or research groups and the like. They may be managing other staff and will sit on various committees appointing new staff, assessing equipment purchases, looking at how modules are taught and how the syllabus can be improved and more.

3.3 Apply for grants

Science costs money and, despite huge work by various botany departments, money still does not grow on trees. Researchers need to apply to funding bodies (the university itself, the government, international funds, philanthropic organisations, industrial partners and so on) to cover the costs of their research. This essentially means making a pitch for the money and writing up reports on how the work went.

3.4 Odd jobs

There are all manner of odd-jobs and pieces of work that can take up the time of academics. They may sit on grant committees to assess grant applications of other academics, they may be editors of scientific journals handling scientific papers, they will review papers, they will attend scientific conferences to discuss their research and exchange ideas, may consult for
governments or companies over their field of expertise, act as an examiner for PhD students or assess the teaching quality and exams of other universities.

3.5 Actually carry out and publish research

This is of course the core of any academic’s work outside of teaching. Ideas are investigated and research carried out. Once the core science is done, this must be written up and published in a scientific journal (see also section 10) or may be presented at a research conference. They will also be engaging with other researchers and reading research papers and the like to keep up with the field (which should also feed back into teaching).

Links:

What do academics do:
4. Etiquette and how to communicate with academics

While university is not school (section 2) it is a learning environment. There are those who are there to instruct you (lecturers, postdocs), and peers (other students) there to learn alongside you. You are entering a more adult-orientated environment and this can be considered closer to a normal job or business than a school. Science is generally very egalitarian – what triumphs is not the person behind the idea, but the evidence, but this does not mean everything is totally informal and free and easy.

4.1 Basics

Treat both staff and your fellow students with respect. As described elsewhere if there is a problem, make sure people are aware of it (2.5) as soon as possible.

4.2 Timekeeping

Do not just arrive for lecturers and tutorials or meetings on time, but be early. This of course may not be possible if you are stuck in traffic or trekking across campus from another lecture that finished late, but really you should aim to be in place *before* any activity starts. Coming in late will disturb your fellow students who are trying to learn, as well as the person try to teach. If you are late, come in as quietly as possible and avoid disturbing others. Personally, I’d prefer someone was late but made an effort to come to the lecture than didn’t turn up at all, but the university rules do allow staff to exclude late arriving students.

4.3 Addressing academics

Academia can be very informal, and people do not tend to make a big fuss about their qualifications or titles. That said, especially as a starting undergraduate, you are best advised to address academics by their formal title (e.g. Dr Smith or Professor Jones) unless invited to use their first names. If in doubt, be formal – no one will ever be offended by you being too polite.

When sending an e-mail, it’s best to write it as a formal letter (Dear Professor…) with a clear title, and do say what it is about and send this from your university e-mail account. Include what course it is about and which lecture / practical etc. you have an issue with. You will find people are generally friendly and open about things but it helps us to help you if we know exactly what the problem is and not have to mail back to find out more details.

4.4 Behaviour in class

Turn your phone off in class. If it rings, turn it off as soon as you can: don’t answer it. If you’re expecting a critical call, keep it on silent, sit where you can get out quickly and quietly, leave the room and then answer it. Obviously if you have to leave for the bathroom or a medical appointment or similar, then do so, but be as quick and quiet as possible. If you know you’ll have to leave early, make sure you are sitting close to a door and can leave without disturbing others.

Avoid talking as far as possible. It is generally OK to whisper quietly on occasion. If you have missed a critical point or slide you may feel it better to get an answer from your neighbour than interrupt the lecture to ask, or risk misunderstanding the next part of the class. However, this should be done
quickly, quietly, and kept to the bare minimum. Even if the lecturer cannot hear you, you will likely be disturbing others. Do also encourage others to behave. Someone talking at the back of a large room may not be heard by the lecturer so they won’t know it’s an issue and be able to help, so be proactive and ask them to be quiet or give a ‘shhh’. Do back up other students who are trying to do the same.

4.4.1 Asking questions
It is generally considered rude to interrupt lectures with questions, even if that is just raising your hand and waiting to be called upon. If you are utterly lost, or really struggling then it might be advisable to make a point of it (and if so, pick your moment, don’t cut the instructor off mid-sentence, but wait till there’s an obvious break between slides or something similar), but generally you should avoid this. Good lecturers will often pause at various points and ask if things are clear, giving you your chance. In general though, it’s considered normal to wait until the end of the class for questions. This is obviously a good time to see people about the content of their course and any problems you have as well as asking general questions about the lecture or for advice or clarification on the content.

4.5 What you can and can’t ask
Naturally you are welcome to ask academics about the course or assignment, for further details or explanations of things from the class or any outside reading, etc. It is easy to mishear, misunderstand or lose track of things in a class and that should be corrected so do make sure you get the help you need. However, do try and help yourself first if you can. If an idea isn’t clear, do check the lectures notes and take a look at a text book. Try to work it out for yourself if you can (an important step in self-directed learning) and then seek help if you are still stuck.

On the other hand, don’t ask what will be in the exam. Don’t ask what is the most important part of the course. Don’t ask for things that are already in the class notes, or in the course handbook, or have been made available on the website etc. Students do really ask which bits of the course they can miss or whether or not they need to go to all the lecturers and oddly enough this doesn’t tend to go down well.

4.6 Remember that academics are human
It’s worth mentioning that academics are every bit as human as other people. The Professor Frink stereotype of the nerd in thick glasses permanently in a lab-coat is about as far from the truth as it can be. More importantly, there will be people who you don’t get on with, or who have a fearsome reputation, as well as those who you love to be taught by and get on with wonderfully.

Critically, while academics often work well beyond ‘typical’ working hours, don’t treat them as being on 24-hour call. E-mailing at 10 pm to ask about tomorrow’s 9 am lecture, or on a Sunday afternoon about something from Friday’s practical is unlikely to get a timely response. Similarly, don’t expect an instant response even during working hours – they might not be
teaching you but that doesn’t mean they are sitting in an office at the computer and ready to reply, so give people time to respond.

4.8 Your feedback

At various points you will to be given the option to give feedback on the course or sessions you have had. Do be honest about it: this is your chance to help improve things for yourselves and your fellows. However, do also be fair: you should give an appropriate appraisal and be objective about it – you might have hated the style of the lectures, but if the content was good and well laid out and you learned a lot you should say so. Don’t let single issues (good or bad) or how well you like the lecturer cloud your responses and evaluations. This is of course something you should do regardless, but it will not be taken seriously if your comments are clearly exaggerated or based on personal comments rather than a fair appraisal of their effort and abilities.

Getting feedback from 90% of the students on a course when attendance levels rarely rose above 60% clearly means that many students are commenting on lectures they did not attend. This is obviously neither fair nor honest comment from some and makes the whole process irrelevant, since it’s impossible to judge the accuracy of the comments coming in. In short, be honest, and as far as possible be impartial.

If you are having issues with the module, do seek help from the lecturer or your tutor. If there are conflicts and serious problems with the lecturer and their work then you should speak to the lecturer, a tutor or your student representatives. For example, if a lecturer runs repeatedly over and makes you late for another class, you should raise it with them, or if there are insufficient books in the library for everyone let them know. Do this as the problem occurs, waiting till the feedback session after the module to complain that you needed more help is too late for anyone to correct the problem.

Links:
Advice on learning from feedback (link downloads PDF):
https://www.heacademy.ac.uk/sites/default/files/tfa_student_guide.pdf

True tales of terrible e-mails from students:
https://www.theguardian.com/higher-education-network/2016/feb/05/im-not-lmao-at-ridiculous-emails-from-my-students
5. What you need to learn (key skills)

There is a wide-range of key skills you can expect to be introduced to and develop as part of a biomedical science degree (2.3). These skills are taught because in addition to the actual scientific information you need in terms of knowledge, you also need to be able to apply that knowledge, use it to solve problems or gain new information, and communicate this to others. These skills will not only stand you in good stead to successfully pursue an academic career in the sciences but many other fields as well. Many employers love science graduates because they come with training in these areas when graduates of other fields may not.

5.1 Critical analysis

Science teaches us to critically evaluate data and ideas. This in part comes from using statistics to provide empirical tests of dataset, but it also come with assessment of the quality of the source. Is there likely to be a bias there, is there any kind of hidden agenda or vested interest here, is the person qualified to make this judgment? Is the argument logical, are they any gaps or does each step follow on from the previous one? Most importantly, different datasets or ideas often conflict so being able to evaluate both and see which is more viable or better supported, or where the conflicts lie and how they may be resolved, are key skills with extremely broad applications.

5.2 Clear communication

Communicating your ideas accurately, clearly and succinctly is a critical part of science. Ultimately you need to get ideas out of our head and into that of another person, and that’s not half as easy as it sounds with complex concepts and technical details. Good scientific writing (or speaking) is often very dry and lacks emotion precisely because it needs to be clearly understood and specific. Nuances in language, phraseology and tone are all important as well, and these need to be considered. Things must be presented in a logical sequence of increasing complexity or an appropriate sequence to make sure they can be followed. This also applies to presentation skills like making diagrams or laying out sets of data (tables and graphs) and spoken presentations and oral discussions of issues. You also need to be able to write for different audiences – communicating to another expert on the subject is a very different skill to being able to ‘dial down’ and explain the same issue to a member of the public who lacks specific and detailed knowledge. This obviously has implications for almost any aspect of communication to an audience in any role, inside or outside of academia.

5.3 Researching on, and summarising, material

You will need to be able to find appropriate materials for your own studies, and be able to read, absorb and digest these. This includes evaluating the sources themselves, but also selecting the best and most reliable documents and being able to derive the key points and what they mean. You will also be required to demonstrate and understanding of the material, and to synthesise this and produce a précis of the appropriate length and pitched correctly for the target audience.
5.4 Computer literacy

While the world is becoming ever more computer-reliant, actual competence with software beyond surfing the net is still not that common. Being able to use word processing and publishing software, statistics and image manipulation packages remains rare. Being able to produce high-quality documents with appropriate figures, and to manage and manipulate data correctly is an important part of scientific research and communication.

5.5 Numeracy and statistical analyses

Basic numeracy is a major issue for students coming into university and many still struggle. It is not impossible to get a good degree and even progress in academia without it, but as with all other areas outlined here, it will make it harder to do so if you cannot master this and again it will also be an advantage in any other career. Understanding statistical tests (what they mean, what to use and what to avoid under which circumstances) and their application will be a major advantage in assaying materials and reading scientific papers. Actually being able to carry out a number of tests will be a further advantage.

5.6 Independence and goals

You will need to learn to work both independently, and as part of a team. This means being able to be self-reliant on projects, but also interact and integrate with others and perform as required. You must be capable of planning to ensure that work is done correctly and to complete tasks on time (both the final result, and to feed into work being done as part of a group) and to the required level of quality. On a related note, you will need to be able to achieve stated goals or to set yourself appropriate targets and achieve them.

Links:

Skills you will acquire at university:
https://www.enterprisealive.co.uk/connect-with-us/5-soft-skills-you-will-learn-during-university/
6. Learning

University is an environment set up to both carry out research and to help people learn. This is as true of senior professors as well as first–year students: new papers are constantly being produced, new methods are available, and skills need to be acquired, improved, or relearned. Everyone is learning all of the time. However, what is often not taught is how best to learn.

6.1 Try to learn from everything

Naturally you will be instructed on a great many things and pick up much from both classes and reading. However, there are far greater opportunities to learn that from the actual content of the material at hand. Try to analyse the material you have available – don’t just read the text and look at the illustrations for pure information, but look at how it is constructed. Is the writing always clear, are things in a good, logical order, are there useful turns or phrase or references to other materials, which parts get extra information or explanations and which do not, are the figures clear and have the right level of detail? Try and work out what is good about these and copy these aspects. Bad material is often easier to learn from than the good (mistakes are generally easier to identify than to spot why things are good). Analyse lectures in the same way – which lecturers do you enjoy to listen to and which do you struggle with? How much of this is down to the subject at hand and what is down to the instructor? Do they engage the audience well, are their points clear and well made? Is the material appropriate to the level?

6.1.1. Use your peers and friends

Discuss things with your peers and compare your essays and notes – it is much easier to judge another’s work than your own, so each of you can help the others spot errors and improve. That also means getting work done early enough for you to have time to check over it and edit as necessary (7.5.2).

6.2 Do experiment

It’s likely you have a set routine for working when taking notes, revising for exams and so on when you arrive. However, although you may be used to this and like it, this may not be the best for you and it is worth experimenting and trying out alternatives. Again, speak to your friends about different methods and try them out, and seek advice from students in the years above you and from your tutor. You may well be able to improve your ability to gain and retain information and get a better understanding of how other people work or tackle problems.

6.3 Cross-referencing

Ultimately all parts of science are interlinked, though of course these tend to be broken down into teachable chunks are relatively separate subjects with a unifying theme. Working to see how these things relate to each other is often left to the student and can be easily overlooked. Try to put these things together – for example an understanding of the anatomy of the heart allows you to appreciate how well adapted it is for the function it performs once you get on to considering cardiovascular physiology, and this understanding of physiology allows you to appreciate how drugs used to treat heart conditions
act to improve cardiovascular function. See how these things interact and use them to inform your other studies and courses. Outside reading (like keeping up with major journals, or sources like New Scientist) can also be interlinked to those areas directly under study and give you a new level of understanding and extra information and context to draw on for assignments and exams.

6.4 Extra reading

As part of your studies you will be expected to read around the subject in some depth. Attending lectures and practicals and re-reading their content is not enough. While you will often be given advice on what to seek out (or even provided with some papers or links to good sources) you need to go beyond even this.

You can get a solid base for starting to get to grips with a new subject though a variety of sources. Generalised textbooks of biology, physiology, genetics etc. are a perfect place to start (and many will be available in the library and, increasingly, online), but not the only one. Many academics write primers for specific topics online and will be on their blog or homepage and can be searched for easily enough. Popular science books aimed at the general public can also be a good introduction to a new or unfamiliar topic since these are aimed at getting people familiar with advanced topics that they know little about. Online lectures may be available from your course or others (many US universities now have entire lecture series online) and build on this with chapters from more specialised books and review papers. Then you can move into peer-reviewed papers (10.4.9).
7. Essays and exams

A natural part of your time at university will involve you taking essays, exams and various tests. Obviously these need to be completed on time and to the best of your ability but don’t forget the basics like good grammar and correct spelling (even easier these days with word processing software).

7.1 Practicalities

Document every piece of work you hand in. Make sure your name (and use the name the university has you registered under – you may go by your middle name normally, but use the one we have written down) and student number and date is on the top, and in the file name of any electronic file. There are only so many ‘Essay 1’ files you can download to discover they don’t have a name in them before things get hopeless for a marker. Back up electronic files regularly and keep copies in separate locations (it’s no use having the backup on a hard-drive and kept with your laptop if your bag is lost or stolen). If it’s handwritten then take a photocopy or even a photograph so if it goes missing you can prove that you have done the work and that it was submitted on time. Ensure the work is submitted on time, to the correct person or location and in the right format.

7.2 Basics

No one is bothered by the odd typo or spelling error – everyone makes mistakes, but numerous or repeated errors are obviously a problem. The basic errors are the ones that are the most easy to avoid with a second’s thought, and of course therefore also appear the most careless when you fail to heed them. Having a friend check over your work will help eliminate a great many of these.

7.2.1 Handwriting.

Good handwriting goes a long way. Obviously this can be tricky in exams or under time constraints but this is worth working at. Neatness counts, but legibility in particular is a big issue. If an assessor simply cannot read your handwriting, then you cannot be given marks for what you have done.

7.2.2 Basic errors to avoid

Write in black or blue pen. Don’t write in pencil, red or green ink (or any other colour for that matter, it’s amazing that some people do think that pink sparkly pen is acceptable at university). If you make a mistake, cross it out with one single stroke. When typing, ensure everything is in the same font and has consistent spacing and formatting.

7.2.3 Some basics on scientific writing.

Indent paragraphs properly. Avoid paragraphs of just one sentence or just one line, and keep each paragraph to a separate subject. Judicious use of sub-headings can help link together subjects (or keep them apart). Don’t write very short or very long sentences, or very long or very short paragraphs. Use good grammar and correct spelling and punctuation. Write out the numbers one to ten, any number higher should be written as 103 or whatever. Don’t start sentences with a number (e.g. 43 samples were taken…). Don’t
use contractions in formal writing (this is an informal document, so this is fine, but do not do this for essays and the like).

Avoid needless repetition and redundancy. Students often add unnecessary sentences to essays which only pad things out and take time. Don’t explain what you are doing “I will now describe the four features of the heart valves”, just do it. This is then exacerbated by concluding the paragraph with “and these are the four features of heart valves”. Most egregious of all is for each point in between starting the sentence with “the next feature of heart valves is”. Use some different turns of phrase (the next one is, in addition, furthermore, thirdly, to be considered next is, also present is…).

7.3 Figures, diagrams and tables
Making figures and the like is a common feature of scientific reports. We do not expect you to be brilliant artists, but you will need to present something identifiable so do make an effort.

Draw all figures in pencil. Use a ruler to produce straight label lines and don’t use stationery for things that are not geometric - I have seen a cell drawn using a compass before making it unnaturally circular. Make sure there is a proper scale bar included (with a sensible value – don’t use mm for a whale, or m for a nucleus) and use SI units for this (see 12.4). A scale bar is a simple short line of a basic length (e.g. 1, 2, 5, 10 or multiples thereof) so that it is easy for someone to use this to take other measurements from your figure. Don’t therefore draw a line the length of the whole object with ‘27 mm’ next to it, this is not a scale.

Tables get their caption above the grid and figures get a caption underneath. Give each a number (e.g. Table 1, Figure 1) and make sure it is referred to in the text (i.e. somewhere it says ‘See Figure 1’). Captions should work even if the text is not there, so do not write ‘Figure 1, graph of results’ but something like ‘Figure 1, graph showing relationship between body mass and area covered for feeding cows’.

Electronically created figures and graphs should be simple and neat. There’s nothing wrong with a little bit of a flourish to make them stand out, but don’t use 23 different colours, or lay green text on pink etc.

7.4 Read the @*^%ing question!
This will have inevitably come up numerous times when you were preparing for exams, but the reason it is constantly brought up by teachers of all kinds is that without fail one student (at least) in each exam will answer what they think the question asks for (or they hoped it would ask for) but does not. Read the question carefully: you will get few if any marks for answering about DNA when you should be writing about RNA. More than this though, analyse the question – what does it want, what does it not want? With essay questions in exams, or essays in general, this is obviously something more critical and more time should be devoted to this.

7.5 Plan and think
Do take time to plan an essay answer before you start writing. Even in an exam, it’s well worth taking a few minutes to work out what you want to say, when and how. Just a few bullets of key points and examples can be laid out, then put them in order, and use this as a framework.
Assuming you have time, think through each sentence and paragraph before writing. Make sure it says what you want it to, and that it communicates the information accurately and succinctly, and makes sense.

You should be planning and taking notes as you do your research. Well-structured notes will let you know how much material you have and how thorough it is. It will be easy early on to do more research than is required for the task in hand but any knowledge gained can be considered a good thing, and you should learn to balance this against the set work. Keeping track of how long things are taking and how much work you have done should give you an idea and help with time management (7.5.2).

7.5.1 Drafts

For piece of work where you have time (i.e. generally outside of the exam room), it pays to write a draft. Treat this as seriously as your final effort – make notes from your research, write out a plan, think about the structure and the individual sentences and write it out. Then read it through and see how it goes. Does it all make sense? Do the ideas follow on logically? Are any areas unclear? Reading things out loud can make a big difference, or get a friend to help: someone who is studying an unrelated field is ideal, if they can more or less follow it, then it’s probably well written.

7.5.2 Time management

In addition to keeping track of what deadlines you have for what work (2.4), you will need to allow sufficient time to complete projects. It’s not a good idea to try and do the research, planning and writing of an essay in a day or so. Naturally some planning is required when multiple deadlines are likely to be due or overlapping, so again, keeping track of these and being aware of what is required when is important. Almost all work benefits from being left for a few days and returned to with a fresh and clear mind – mistakes and omissions are much easier to spot – so try to finish things well ahead of the deadline. This also gives you some leeway with any unexpected problems.

Plan well in advance, life can easily get in the way and you want the flexibility of time because of an unexpected problem holding you up or an opportunity you want to take advantage of. Assuming you can do all the work you need to in a day and waiting till the last day to make a start is destined to go wrong sooner or later. With multiple modules and work due at various times it’s also easy to miss something so keep a record and plan thoroughly.

7.6 Use examples

Do include examples to support your arguments. These should be both relevant and correct, and supported by appropriate sources or citations (see 7.7.6 on inappropriate sources). Do also use counter-examples to illustrate where there may be flaws or gaps in your case, so that you are able to show that you understand the intricacies of the problem and recognise the limits of the data.

Do also provide examples whenever you have made a general point. Don’t say “there are many conditions which can affect memory” and leave it at that, it looks like you only know this much and have not read around the subject, or have lifted the quote. Write “there are many conditions which can
affect memory, including Alzheimer’s Disease, Parkinson’s Disease and stroke”.

7.6.1 Defining terms

Science is founded on rigorous and applied definitions. Multiple definitions of single ideas often abound in the scientific literature because different researchers want to emphasise or remove certain areas from consideration, or because the evidence for, or our understanding of, a given idea has been changed. This does not generally mean any given definition is wrong, but we must be specific about the terms being used.

7.7 Traps to avoid

There are endless small writing traps and scientific conventions that students endlessly fall foul of. None of them will kill an essay, but can appear clunky or problematic. This is the kind of thing you will develop with experience of writing, but also of reading the scientific literature, but below are some to avoid.

7.7.1 ‘I believe’

Colloquially, we often use the word ‘believe’ as a synonym for ‘think’ (“I believe I will have another donut”, “I believe we will win the match this weekend”). However, literally it can mean to take something without evidence or support. As such, using the word in a scientific context rather implies you are rejecting evidence for another hypothesis, or favouring a hypothesis without evidence - the very antithesis of scientific reasoning. You will see other dictionary definitions of this word which include things like ‘is wholly accepted’ implying that this is a safe use of the word, but the problem is that it is ambiguous – it could easily be taken to mean that something is extremely well known OR that it is unknown but accepted without evidence.

7.7.2 ‘I think’

We know you think this, you wrote it. There’s no need to state that there are your thoughts or opinions, and in any case it should be about the assessment of the data.

7.7.3 ‘Significant’ and a few others

Be careful with words like ‘significant’. Again, colloquially this is fine for ‘interesting’ or ‘important’, but in a scientific context it implies that a statistical test has been passed and deemed ‘significant’. Similarly ‘while’ and ‘since’ can give the impression of a temporal sequence so try to use ‘although’ or ‘because’. ‘Proof’ should be saved for mathematics, you are testing hypotheses and theories, and finding evidence or support for them.

7.7.4. Logic traps

There are a few basic logic traps that are easy to fall into. Don’t think that evidence against idea A is necessarily evidence for idea B. Don’t confuse correlation with causation - the sun comes up in the morning at the same time that it gets light, but the sun doesn’t rise because of the daylight.
7.7.5 Accuracy and exaggeration

Be accurate and specific as far as possible (within reason). There’s no need to say 1001.56473 in an essay, simply write “just over one thousand”. But equally, don’t say “quite a few” or “lots” or “more than”, give a value of some kind. Avoid absolute statements (“X always leads to Y”, “all members of the group do Z”) unless you are very sure. There are so many exceptions to even apparently very hard rules in the life sciences that you are always likely to have missed something.

A related but different issue, don’t overuse punctuation. One exclamation mark is probably enough for any essay and never use more than one at the end of a sentence. It looks overly dramatic if the essay is scattered with emphasising marks, italics or rhetorical questions.

Don’t exaggerate ideas or points. There’s no need to say that a development is ‘amazing’ or ‘revolutionary’, not least when you don’t know, just say it is ‘important’, or ‘has great potential’.

7.7.6 Inappropriate sources

We will later cover finding appropriate materials to read (section 10 and 10.2) but in the meantime, it is worth highlighting the issue of poor sources. You are expected to read and absorb the scientific literature and use this to build an argument. Don’t cite TV programs, things from the news, or, in one case I saw, the Sunday Times Style Magazine. Yes, really. A colleague recently topped even this with a reference that turned out to be from a computer game online discussion forum.

7.8 Feedback and improvement

How much feedback you get from your lecturers and tutors for different pieces of work will vary, it may be very little and non-specific or very (possibly depressingly) detailed. In the case of the latter, don’t be put off: see what you have done wrong and try to learn from it. Note down major problems and compare them between your assignments – are you making the same mistakes repeatedly? If so, this will help you identify them so that they can be worked on more effectively. Try to be ruthless with your self-criticism and identify weakness, but don’t take it all to heart – your work is being corrected so that you can improve.

Look at the mark schemes and grading guidelines and study them: compare your grades to those and the feedback you have had to identify weaknesses and areas you are falling behind. You are at university to develop as a student, but there are certain mechanical hurdles to overcome, so applying yourself to these to get good scores will help in addition to learning and understanding the material.

Links:

Logical fallacies:
https://yourlogicalfallacyis.com/

Essay writing tips:
http://www.internationalstudent.com/essay_writing/essay_tips/
8. Oral presentations and posters

Giving talks to an audience are typically feared by students, and their importance is much underappreciated. No matter what job you go into or career you pursue, sooner or later you will have to stand up in front of a group of people and speak about a subject, so practice is important. Posters are often a novelty too and for both it can be difficult to strike the balance between brevity and content.

8.1 Content and design

Treat a talk like a miniature essay – it needs some kind of introduction, discussion and conclusions. You have only a very limited amount of time to cover it all however, so things need to be concise. You may only be able to have a line or two to cover a wealth of material so prepare carefully.

It is best to plan what you are going to say alongside any slides or visual material you need to present. Naturally the two are intertwined, but are not replicates – your slides should help illustrate points or add new information. Keep these brief and to the point with a limited number of words on screen. Stick to bullet-points, not full (or at least, long) sentences.

Make slides stark and clear. Make the text large and easy to read for the audience. Make images large and simple and keep contrast high.

8.2 Timing

Make sure you know how long the piece is supposed to be and work to this. There’s nothing wrong with being a little short, but don’t go over. The only way you can get this right is to practice and practice. Repeat your talk over and over again to get the phases right and make sure it is the right length. Don’t rely on speaking fast to get it all in, cut the unnecessary material, and don’t rip through slides or points too fast for people to follow. Make sure you speak out loud when you practice (running though it in your head is not the same thing). All of the practice will also help your delivery and mean you won’t have to rely on notes and deliver correctly. Keep track of key points (hit slide six by minute five, for example) so when it comes to the real thing you will quickly see if you are behind or ahead and can adjust accordingly.

8.3 Delivery

Face your audience. If possible, position any computer or aids to face you, so you can have your back to the screen when you speak. If you need to refer to this (say with a pointer) try to keep facing and talking to the audience as much as possible. If you have notes in hand, don’t just read them or what is on the screen, but speak to people. Speak in a loud, clear and steady voice. Keep your head up (not looking at your feet or notes) and look around the room (don’t stare into the middle distance or direct everything at one person). Try to stand relatively still and not shuffle your feet or hunch up. Don’t keep your hands tucked into your pockets but instead use your arms to be expressive (though don’t windmill them around). Practice can really help, especially in front of an audience of a few friends. Best of all, video yourself. It’s horrifying to watch, but you will quickly eliminate errors.
8.4 *Poster layout*

Lots of options are available here in terms of style. You can base things around a central image, or intersperse text and figures in multiple ways. However, it must be brief. The point of a poster is to communicate the maximum amount of information as briefly as possible – more than a few hundred words is far too much (and means the text will be small and hard to read). Work to be as economic as possible in words and images but to include some form of background / introduction and discussion.

Make sure you know the size of a poster you are making and the orientation (landscape or portrait). You will need to include the names of everyone involved, give it a simple but comprehensive title and might also need some references and acknowledgements. This might already eat into your space so you need to plan what information (text and figures) you can include.
9. Basics of good research

Getting into the habit of good research practice will come in handy in your later studies and give you a head start in labs in your first year. Here this means documenting your work and ensuring that data is collected properly and archived correctly to avoid future errors and problems.

9.1 Documentation and accuracy

Get into the habit as soon as possible of thoroughly and accurately documenting your work. A notebook or similar will obviously help here. Keep separate notebooks or electronic files for each major project, so that work is not all in one place if lost, and you won’t mix up different issues because your notes are unclear.

Ultimately the documentation of what you do is there to provide two key points: 1) accurate recording of data, and 2) repeatability of experiments. In theory, any other scientist should be able to take your notes and reproduce your experiments and methods exactly to derive the same results. There is a reason that methods sections in papers can be long and tedious (10.4.4).

Take down more information that you think you need - it’s always easy to cut back on things later, but impossible to add in extra information you have forgotten. This is also true of data, write down data to more decimal places than you think you need, or record any extra tiny details (“this point may be in error as the scale slipped”), again you can always ignore them or cut them down later (see also 10.5).

9.2 Ongoing checks and updates to look for errors

Do check on your work and data as it comes in. Don’t do all of the experiments and collect all the data and then check up on it: if there’s a fundamental error or things are going wrong, you won’t know until it’s too late and the whole thing has to be restarted or canned.

9.3 Backup

Do also back up files with electronic copies or photocopies of your notes or datasheets (7.1). It’s horrific to lose weeks or months of work though five seconds of carelessness.

Make sure all electronic files are titled properly. Give them dates in the file name and keep them together in one place. Keep updating things regularly and keep these (and any papers) well organized. It is much more efficient to spend a few seconds or minutes sorting things at the time they are created or updated than it is to try and reorganize huge rafts of material every few months.

9.4 Statistical analyses

Statistics are there to analyse collected data and provide an objective conclusion about their meaning. Two things might appear to have a relationship, but do they really, or is this just an artefact of how we are looking at the data or our own biases making out more than is really there? Again, by removing subjectivity and letting the maths take over, we can test our hypotheses more rigorously and determine if it has merit or does not. Statistics is the branch of mathematics that will allow us to do this.
Many students are terrified of statistics, but the basics are easy enough to grasp and the concepts of which to use and when are not too difficult. You will probably not be expected to perform complex stats (not without electronic help anyway), and will be trained to use those which are most appropriate, the key issue being which should be used to answer which sort of question. This is important when it comes to experimental design, there is little use carrying out experiments which produce data that can't be analysed with the correct analysis to test the hypothesis. All these need to be linked together (hypothesis, data, stats) during design.

*Links:*

A guide for good research:  
http://www.lifehack.org/articles/communication/advice-for-students-10-steps-toward-better-research.html

On experimental design:  
http://www.stat.yale.edu/Courses/1997-98/101/expdes.htm
10. Papers

Bizarrely and unhelpfully, students are often not introduced to the mechanics and importance of scientific papers until they are quite some time into their studies (if at all). This is a major mistake, and I hope this will help introduce you to reading the scientific literature. The publication (and to a degree, more critically, the review) of papers is a fundamental part of research and learning. Learn to deal with papers and how to extract information from them and you will take a major step forwards in the early part of your degree.

10.1 What are papers and how are they published?

Publications by scientists come in a number of forms. They may write an entire book (which is typically not reviewed, though it may have been looked over by experts). They may contribute a chapter to an academic book or volume of papers (which are generally reviewed), or an abstract to a conference talk or poster (generally not reviewed). Mostly however, they tend to write scientific papers. These are typically short publications (anything from a single page to around a hundred in length) that appear in scientific journals (those dedicated to research and generally only available to, and certainly written for, researchers) and describe an area of research or study that the scientist and their colleagues have completed. They are effectively therefore, reports of research carried out, or summaries of sets of research (reviews). Critically, these are generally peer-reviewed.

10.1.1 Peer-review

This is the process by which papers are assessed by other scientists before they are published. A paper will be submitted to a journal and the editor will check that it is suitable for the theme of the journal, and will send it for review. Other researchers (generally two or three) with expertise in the area of the paper will then read and assess the paper as referees and report to the editor. If the paper passes muster (and it is worth noting that few do on the first attempt) it will be published. Otherwise it will be returned to the authors to rewrite and improve the paper based on the comments of the referees, or rejected from further consideration when it can then either be started again completely, or submitted to another journal.

The referees are there to spot any errors in the paper. It is clearly written and does it make sense? Have the authors used the right methods and stats to analyse the problem? Have they collected the right data and enough of it? Is it put in the correct context of existing research and theories? Are the conclusions correct based on the available evidence? Is the literature cited correctly and accurately? All this is taken into account and errors or problems are highlighted for the authors to correct (and the cycle may well begin again with new reviews).

Naturally there are problems with this, and bad papers get published and good ones rejected. However, on average, it is a good system. A paper in a peer-reviewed journal therefore represents not just what an author or team of researchers says and thinks about a subject, but that other scientists agree this is a generally reasonable and accurate representation of the data and analyses. That makes it by definition a robust and important document and very different from anything that has not been reviewed and can be
considered more trustworthy and accurate (but do not take them as the truth or incontrovertible - people make mistakes!).

10.2 Other sources

As noted above, some books may consist of reviewed chapters, each of which is written by a different set of authors and which are analogous to reviewed papers. Textbooks as a whole however are just written by one or a few people, and are not reviewed formally, though other researchers may well comment and add suggestions and corrections to them during their production. Naturally although unreviewed, textbooks are typically produced by experts in the field and thus are unlikely to contain many errors (though may go out of date since they cover so much material).

There is now of course a huge wealth of information on the internet as well as more 'popular' science material in magazines and books. Treat these with caution (though some are naturally better than others – the research webpage of a world expert on a subject = probably good, the blog of a teenager on his pet subject = probably bad). As far as possible stick to formal sources that provide detailed citations of other papers and works they have cited. It is not that all blogs and webpages and Wikipedia are bad, but there is, on average, more bad than good and telling the two apart is difficult without great experience. So to begin with, stick to obviously more trustworthy and formal sources – text books in the library and peer-reviewed papers in creditable journals. Note that some sites are deliberately designed to look trustworthy and accurate and dupe you into thinking they are correct summaries and details of subjects (e.g. creationist websites) so be careful in what you select.

10.3 How to find and get hold of papers

Wikipedia is, on balance, a reasonable source of information but it is still not a great place to get hold of 'first hand' information about a subject. What it is good for is identifying better sources to check out. Most articles on scientific subjects will have a list of sources at the bottom and these will often include major works in the field and peer-reviewed papers by scientists (and even links to the papers themselves). This is a great place to start for a subject you know little or nothing of.

In terms of hunting down papers, Google Scholar is useful in providing indices of papers on subjects (though it will also turn up blogs, unreviewed works, and pseudo-science on some subjects). PubMed, Web of Science and others can all be used to search for specific papers or general areas or even researchers. Review papers are especially good for students as they will cover all the basics and cite all the key papers you might also want to look out for.

If the university has a subscription to a journal, you should be able to download a given paper from the internet with a university password. Other journals (or papers within some journals) are 'Open Access' and available to anyone. If you do not have access to the paper you want, try a more general search – many researchers archive collections of their papers online, and many books and chapters are available on sites like Googlebooks. Various interest groups may also have archives online or mailing lists where you can ask if people have a copy of a paper. Finally, you can always e-mail an author
and ask for a copy of their work – people are generally delighted that people want to read about their research, so just ask.

The international language of science is English, and as a result, even journals based in non-English speaking countries may produce journals that consist mostly, or entirely, papers in English. So do not be put off look for or reading papers in journals from Japan, Poland, or Brazil etc., as the paper may well still be in English.

Don’t forget your library! There will be hard copies of huge numbers of papers (especially pre 2010) as well as important single papers as well as text books and other volumes. Not everything is available digitally and it’s generally much easier to browse and check physically too.

10.4 How to read papers

This may sound like an obvious or even trite section, but academic papers are not like normal essays or things you may have read before and have a style and set patterns that can be confusing to the inexperienced. Some of this you really should try to replicate in your own writing and will see in profusion here but the contents and getting information out of them may prove tricky. It is also useful to look at this structure since you may well be asked to write pieces of work in the style of a paper or be able to summarise them and pick out key bits of information quickly.

10.4.1 Layout

Most papers have a simple pattern that you will come to be very familiar with: abstract, introduction, material and methods, results, discussion, acknowledgements, and literature cited / references. This is not too dissimilar to existing lab or project reports you may have written before, but the actual content and even context is likely novel.

10.4.2 Abstract

This will be a very short summary of the paper. A good abstract will cover the whole paper in a few lines including the scientific context, methods and results, and the wider implications. This will highlight key findings, but will naturally not cover a great deal of information or nuances about the results.

10.4.3 Introduction

This provides the context for the work. What is the current state of knowledge of the theory and evidence about the subject at hand? Why is this interesting and important? This may be rather technical and hard to follow without a decent knowledge-base on the subject. This will typically end with a paragraph about what the point of the experiment or analysis was, and generally also what researchers expected to find out.

10.4.4 Materials and methods

This will describe the methods used. This may be done in excruciating detail (see 9.1 on repeatability) and could involve very complex methods and almost impenetrable jargon or technical terms if you are not well familiar with the subject and even history of research.
10.4.5 Results
The results of the methods, and only the results. There should be no interpretation of data in here. These may be very brief (just a few words and graphs or tables), with the actual data points held in a supplementary data file online (increasingly common when some analyses can have hundreds of pages of data).

10.4.6 Discussion
This naturally discusses the results. The aim here is to put them in context of existing knowledge, note the strengths and weaknesses of the methods and results, what they probably mean, and speculate a little on where future research may lead or what may follow from this. Note that there is not normally a specific ‘conclusions’ section, though the discussion is likely to finish with a paragraph that summarises the paper and acts as a conclusion.

10.4.7 Acknowledgements
This is a space for the researchers to recognise any help and assistance they had in producing the paper. It’s important to credit where ideas may have come from and financial support.

10.4.8 Literature / references
Here all of the other papers, books, reference materials and sources of data should be supplied in full so that these can be tracked down and verified as necessary (and so again, to allow for repeatability – 9.1).

10.4.9 Reading papers
This will sound like odd advice, but it’s probably not a great idea to read most papers straight through. For the early part of your time at university, you really will just want to use these as a source of some information to inform essays or lab reports. As such the methods and results are likely to be of little interest. Don’t ignore them – you want the context of what was done and why - but don’t get bogged down trying to follow the details and work out exactly what happened either. Read the abstract and introduction first and then try going onto the discussion before moving back to the methods and results. The discussion might well be complex and long too, and the middle part may deviate off into other areas, so the start and end of this section may be the most fruitful for the information you are after.

Reading papers should rapidly become your main source of information outside of the classroom, so work hard to develop your ability to quickly identify suitable papers, access them, read them, and take notes you can refer back to later.

10.5 How to cite papers or sources
It is critical to cite the work you have used or referred to in your work correctly, and to do so accurately. Points you have raised or ideas you have taken from the literature should be properly credited. As you will see in academic papers, this is done by citing the names of the authors, and the year of publication in the text to accompany points and then providing a full reference at the end.
Similarly, you should also credit other sources such as the origins of images. Do include important details (like the edition number of a book – the 6\textsuperscript{th} edition is likely different in places to the 2\textsuperscript{nd}) and for things taken online like a blog, given the full URL and also the date the material was accessed (it may have changed or moved since).

\textit{Links:}

How to read academic papers:  
http://www.sciencemag.org/careers/2016/01/how-read-scientific-paper

and:  
http://www.sciencebuddies.org/science-fair-projects/top_science-fair_how_to_read_a_scientific_paper.shtml
11. Science ethics

Ethics are core to scientific research. There are strict rules and guidelines about the conduct of researchers with regards to scientific best practice, as well as experimentation with animals or humans and the rest. As with life outside academia, any kind of fraud or manipulation of things will be considered serious misconduct. It can, and has, ended the careers of both students and researchers.

As a student, the university will take a less harsh tack on this than would be the case for qualified researchers, you are students and are still learning after all. But it is often unappreciated just how seriously this is taken. I am sure most students, however good and diligent, at some point at school ’borrowed’ a friend’s homework and made good use of it when completing their own, or something similar. Not that it was OK then, but if caught it would likely have led to not much more than a detention from a teacher, at this level expect some pretty severe sanctions for anything like this.

Obviously there is a basic morality to this – you didn’t do the work properly and shouldn’t benefit unfairly from someone else’s efforts. It’s not fair on them, or others who did do the work responsibly. But more than this, it cuts to the heart of scientific publication: as a researcher it is critical you get the credit you deserve for the ideas you have had, and the work you have done. Pretending otherwise (though manipulating data, claiming incorrect results, stealing ideas, or not giving credit) is extremely bad.

11.1 Plagiarism

This essentially amounts to reproducing someone else’s work and claiming it as your own. This is therefore tantamount to theft of ideas or effort. This may take the form of copying someone else’s work (that of a student, or taking text from online or a paper or textbook, or getting someone else to write your work for you). This may be direct (i.e. word for word) plagiarism, but also simply paraphrasing material, or using ideas without correct attribution and credit (10.5). In short, presenting something as your work which was not your work, in the words on the page or the ideas they represent, is considered plagiarism. Demonstrating that you have not plagiarised someone else’s work is often a lot easier if you have dated drafts of your notes and early attempts, so this is another reason to backup work and not just of the ’final’ submitted work.

11.2 Data falsification

This is the other big issue to avoid. Data must be collected honestly and represented accurately and your recording of it must be honest and accurate. Don’t fudge data. Yes errors can be recognised (you missed the key moment, or dropped the pipette, or only wrote down two decimal places not three for some of the data points), but these are errors and can be handled in the analysis or discussion.

11.3 Ramifications

You can punitive effects against you (or anyone who may have assisted you) such as failing a piece of coursework, an entire module, year, or even being asked to leave the university. This will also likely appear on your
transcript – any time any future employer looks at your degree and qualification they will see a record of this on it. That is obviously not good.

In addition, don’t forget what this means in the wider context. Scientific analyses affect medical advances, government policy and social issues. Falsification or manipulation of data can have huge consequences, even life-ending ones when it comes to medical studies, which is why they are taken so seriously. Do not even consider such actions and do not be fooled into thinking that it’s OK because it’s only an undergraduate lab exercise or project. That is the worst mindset to get into; it clouds judgment about what is and is not acceptable practice.

*Links:*

On plagiarism:
http://tlt.psu.edu/plagiarism/student-tutorial/defining-plagiarism-and-academic-integrity/

Ethics in science:
http://www.niehs.nih.gov/research/resources/bioethics/whatis/
12. In the lab

You will undoubtedly be spending time in the lab over the course of your study, and should be aware of the following.

12.1 Health and safety

You may be handling chemicals that can be dangerous, or be in a (potentially) generally dangerous environment. Be careful at all times: you may not be handling anything dangerous, but the people on the next bench, or working nearby, may be.

Read all notes for the given lab exercise and pay attention to all health and safety advice. Take basic precautions: wear the correct safety equipment (pay attention to footwear, make sure you won't trip or slip), keep your workspace clear and tidy, make yourself safe (tie up long hair, take off dangling jewelry or anything that may snag), know the steps to take in an emergency, know who is the nearest first-aider and where the first aid kit is, what is the local or in house emergency number to call etc.

The vast majority of accidents come about though a lack of attention or ignoring guidelines. Treat them all seriously – small accidents can lead to profound injuries or even death. You don’t want to be at risk, or responsible for injuring others – either can end a promising career.

12.2 Basic tools

Make sure you have all basic tools you are likely to need for a practical session (ruler, pens and pencils, eraser, calculator, lab coat etc.) and of course any required or suggested safety gear.

Know how to operate basic equipment. If you have not handled a microscope or Bunsen burner before, take time to practice, or find an online guide. More complex tools will be explained to you, but pay attention and make notes so you do not forget how to carry out the tasks assigned. You may not need to use them again for months or years but will be expected to know so write it down.

12.3 Descriptions and diagrams

A good diagram goes a long way, but accurate description is also a skill. Keep things short and to the point but be as accurate as possible with precise language (say “rectangular” or “sub-rectangular” not “sort-of square”).

12.4 Symbols and abbreviations

Effective science communication relies on accuracy and detail, and there are also various conventions for symbols and abbreviations that you should become familiar with. SI units (derived from the French “Le Système international d'unités”) are the standardized metric units used through the sciences worldwide. Do not use inches, miles, foot-pounds or any other imperial unit unless quoting a source that used them, but even then provide an SI value alongside it. Even many common metric units are not part of the SI system though are at least metric and thus tolerated, centimeters being a measure very commonly used, but not actually an SI unit (e.g. cm is not actually SI, but everyone uses it).

Various divisions of measures have common denominations (‘milli’ is $10^{-3}$, ‘kilo’ is $10^3$ hence kilometer and kilogram are both 1000 units of the...
base) and many of these have commonly used symbols (e.g. µ for ‘micro’ at \(10^{-6}\)). These should be learned – you will not always have the opportunity to look them up or have a conversion to hand in an exam. Note also that you should leave a space between the value and the unit so it should be 53 mm, and not 53mm.

The great thing about SI units is that in addition to all being in base 10, they all interlink with one another. So water boils at 100 °C and freezes at 0 °C, and 1 cm\(^3\) of water weighs one gram (and 1 L of water is 1 kg, and a cube on water 1 m on each side would be a ton), and it takes one calorie to increase the temperature of 1 cm\(^3\) of water by 1 °C and so on.

Links:

Safety in the lab:
http://nobel.scas.bcit.ca/debeck_pt/science/safety.htm
13. Basic facts and ideas of science

A great many undergraduate science courses (and even school qualifications) do not include the basics of the philosophy of science as part of the program. Often these are covered, but without making things explicit. You may well have been introduced to the ideas of creating hypotheses and null hypotheses and testing them, but probably not why we do this and how they are formally done during scientific analyses, or how hypotheses are different from theories.

13.1 The scientific method

The essential point of the scientific method is to make things as rigorous and objective as possible — in short we want to make sure that something is true because we have tested it and not just because we think it is, or it looks like it should be true. It is very easy for the mind to make mistakes, and much work has shown just how fallible the mind can be. We have biases and preconceptions and misunderstandings that can easily affect our judgement or position on a problem.

The scientific method therefore tries to take us as observers and our biases out of the equation. We don’t have to estimate or judge which of two things is bigger, or has more units, or is more important: we measure, we count, we statistically test.

Those things that pass our tests may be accepted as tentatively valid, those that fail, provisionally rejected. Repeated success leads to confirmation and acceptance and integration into theory, repeated rejection leads to abandonment. Thus, we slowly but progressively test our way through the world and partition knowledge into things that are known, things that are untested, and those that are false.

13.2 Hypotheses

Hypotheses might be likened to the base unit of science. They represent a single idea or concept that may be subjected to testing to evaluate its correctness. This might be something like ‘X correlates with Y’, ‘A is bigger than B’ and so on. These are typically framed as statements, but can also be considered questions (does X correlate with Y?). Hypotheses may be shown to be correct, incorrect or we may not be certain. Repeated tests should be done to ensure that mistakes were not made or we didn’t get ‘lucky’ (13.6) with the collected data.

13.2.1 Generating hypotheses

Hypotheses could conceivably be dreamed up to be absolutely anything. However, this is impractical and likely to lead to the testing of hypotheses that prima facie cannot be correct. Hypotheses should normally fit within the bounds of accepted theory.

Hypotheses should also be created with an observation in mind, that is, there should be a plausible reason to think that it might be true. Noticing that a certain stain always appears after a reaction could lead to the hypothesis that a second reaction is taking place or unrecognized reagents are involved. In short, you should be able to justify a new hypothesis as worthy of investigation rather than just dreaming things up.
13.2.2 The null hypothesis

This is effectively the inverse of the hypothesis. This is there to provide an alternative to the hypothesis for statistical testing (9.5) and allow a hypothesis to be accepted or rejected. The null hypothesis is effectively the opposite to a hypothesis, or encompasses the alternatives. Thus a hypothesis may be “X is positively correlated with Y” and the null hypothesis would then be “X is negatively correlated with Y, or there is no relationship between X and Y”. The null hypothesis is conventionally given the abbreviation of H0 [note, this is a zero, not the letter ‘O’].

It is common for students to be expected to make a null hypothesis explicit in writing lab reports etc., but in scientific papers this is very rarely stated. Given that the format of the null hypothesis is pretty standard, it is not required since all readers should recognise it from the context. Thus a statement such as “the null hypothesis is accepted and the hypothesis that A is larger than B can be rejected”, it is not required to state that the null hypothesis is that B is equal to or larger than A.

13.2.3 Testing hypotheses and falsifiability

Hypotheses must be testable in some way. It is not required that the hypothesis must be testable now (we might have to wait for the right conditions, or need to develop a new machine to measure the key character) but they must have the potential to be tested, and thus the chance to pass or fail that test. Thus, a hypothesis must be falsifiable and we must be able to determine if it is true or false.

13.3 Theories

Theories are the big brothers of hypotheses. Whole clusters of hypotheses are unified into the theory as they are mutually supporting, or all point to the same conclusion. Theories have both explanatory and predictive power that go well beyond the simple hypothesis. A theory provides a fundamental explanation of some major aspect of the world (that gravity is a universal force of attraction linked to mass, that natural selection causes organisms to change over time as a response to selective pressures) but also provides predictive power that allows us to work out how certain things are likely to happen in the future (this satellite will hold orbit at this mass and distance, this animal will get bigger to escape predation). These predictions may themselves be used as hypotheses for future testing and be integrated into theories.

13.3.1 Theories as facts and the ‘just a theory’ falsehood

The term ‘theory’ has a specific meaning in science that is much more solid and is in a sense ‘proven’. Note that this is rather different to the often colloquially used term which is more or less synonymous with ‘think’ or even ‘guess’ and the two should not be confused. But gravity is ‘only’ a theory, so are the existence of ‘cells’, and ‘atoms’ and many other fundamentals of science. As wryly noted, if scientific theories are not important or well supported, try theory to see you through the fall (or indeed the stop at the end).

Theories may also be considered facts. Gravity certainly does exist, and evolution does occur, and atoms and cells are quite real. There is a
subtle difference here though: that a single cell can be identified certainly is a fact and makes cells real, verifiable, even ‘true’ objects, but that alone has little explanatory or predictive power; cell theory however, does.

13.4 Occam’s razor and parsimony

The principle of parsimony is an important one in the sciences. It is commonly attributed to William of Occam (or Ockham) and effectively means that one should make the least number of assumptions possible, or to accept the simplest explanation to be true. Do not therefore attribute a more complex explanation than is necessary to explain the current data (e.g. invoking another unknown variable or untested hypothesis).

This does not of course mean that the simplest explanation is true. The razor of parsimony is there as a tool to avoid overcomplicating analyses and understanding, and of course to prevent rampant hypothesising or over explanation. More complex ideas may be investigated and supported by analysis, but leaping straight for them is a mistake.

13.5 Controversies and consensus

Science to a certain degree relies on consensus. This may sound bizarre – if the point of all these analyses and statistics is to remove subjectivity, why would there need to be consensus on some factor or other? The problem lies in that rarely will any complex problem (or even many simple ones) be solved by ‘the’ experiment or analysis. Instead, dozens of papers pushing different hypotheses or explanations, different tests on different datasets with different stats, and there will be some odd answers that appear contradictory, or one key experiment will have a flaw, or not been repeated and so on ad infinitum. In short, there will be data and analyses supporting alternative hypotheses or ideas, and no easy way of comparing those results of differing analyses.

What will tend to form is a consensus among experts. The data and analyses may be imperfectly aligned, but there is enough weight of evidence to support one case over the other (Occam’s razor again, if in a different manner). Eventually, the work will build up to a point that the evidence is overwhelmingly in favour of one hypothesis over another and at this point it is likely to become incorporated into, or described as, a theory.

Consensus may take time to form however. The data and results may be more delicately poised and it may not be clear which hypothesis is likely to come out on top. Recognising the limitations of analyses and evidence is of course excellent scientific practice, though the disagreement typically manifests itself as vehement disagreement between opposing scientists (human nature again) and hypotheses may well be controversial.

13.6 Significance and 95%

Stats results are typically presented as some kind of numerical value that represents a probability of something being correct, rather than a simple positive / negative, or yes / no result. The convention in science is that a value of 95% or greater (or alternatively, 0.05 or lower) indicates that the results can be considered suitably probable (or significant) to be provisionally regarded as correct. This is termed the p value. Any p value that is above 0.05 (e.g. 0.050001) is deemed not significant and the hypothesis should be rejected
(do NOT call this ‘almost significant’ or ‘nearly significant’ or ‘trending to significant’), though of course with a value this close to significant, it is worth adding more data or carrying out the experiment again to try and get a clearer result either way.

Note that these values only provide an indication of whether or not the hypothesis is correct, not the magnitude of it. One could get an extreme p value of 0.000001 which would indicate it extremely probably that the result is correct.

Links:

On the scientific method:
http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml#keyinfo

Hypotheses and theories:
http://undsci.berkeley.edu/article/howscienceworks_19

Occam’s Razor:
http://math.ucr.edu/home/baez/physics/General/occam.html

On repeatability:
http://bioscience.oxfordjournals.org/content/56/12/958.full
Conclusions

Your first year at university as a biomedical science student will likely be one of major culture shocks. Independence from home, living in a new city or even continent, meeting a very wide variety of people from backgrounds well beyond what you will have seen to date and in an environment that prizes (or should) thought, reason and learning. There are huge amounts of skills and knowledge to acquire and perfect, and this can be difficult given the novelty of the environment and the breadth and depth of material flung at you.

Hopefully this guide will have primed you to many of those problems, highlighting traps to avoid, giving you tips and tricks to improve on your writing and research, and preparing you for what to expect and how to tackle new problems. This should help you prepare and work to succeed in this new environment and to be productive and still find some time to enjoy life at university.

Now, work hard, and best of luck.
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