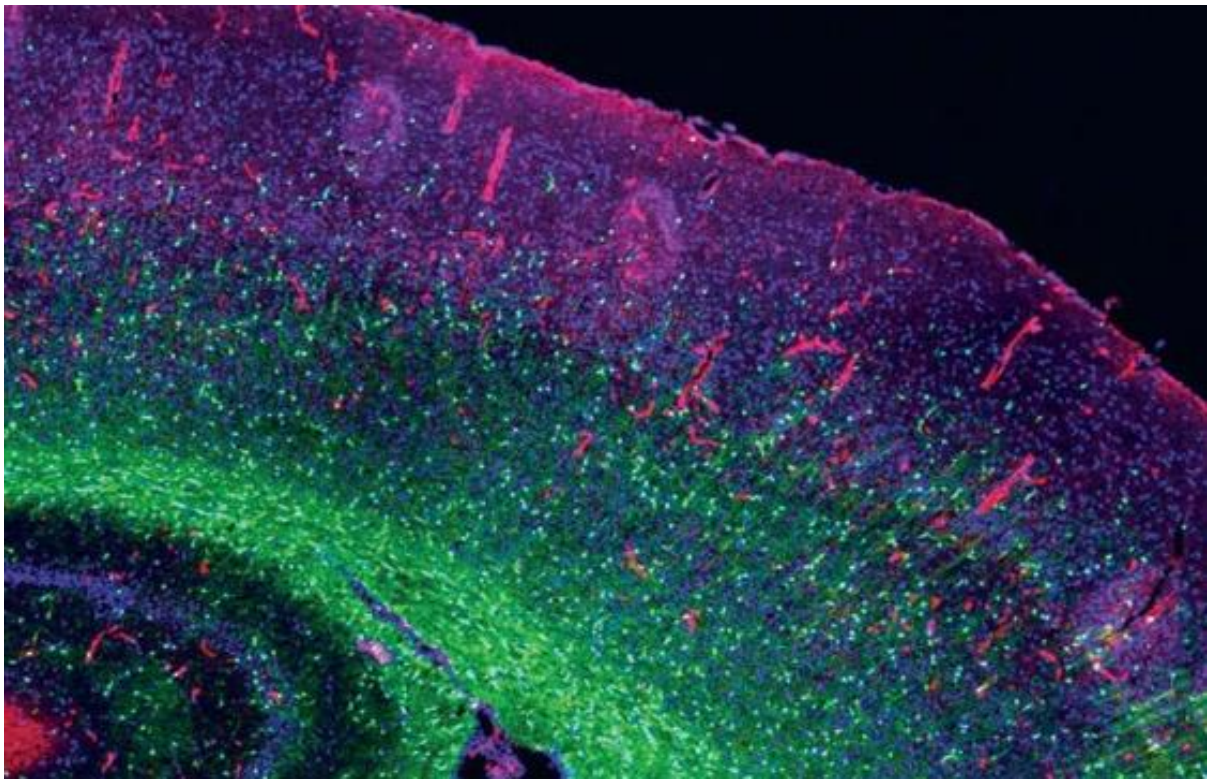
Stem Cells Australia

Life as a Researcher

Module 2



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Professor Megan Munsie is the Convenor of Stem Cells Australia at the University of Melbourne where she heads a research program in the ethical, legal and social implications of stem cell research. As a trained developmental biologist, Megan combines her scientific expertise with a deep understanding of the ethical and regulatory considerations required to facilitate responsible research in stem cell science and its clinical translation.

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Introduction to Module

Have you ever wondered what it's like to work as a researcher? Or what is involved to start and maintain a career in science? Have you ever heard the phrase 'Lets act like a scientist' but have not really known what that would entail?

It's a hard thing to do if you have never actually met a researcher or scientist and had a chance to speak to one and have them detail to you what it is that they do. It is also hard to imagine a career as a researcher when thinking about life outside school, without necessarily understanding what the work of a researcher entails.

This module is designed to help you answer these questions by describing the nature of the professional lives and workplace realities of researchers or scientists. In this module we address the lack of clarity and awareness around what it means to prepare and work as a scientist, particularly when focused on research within a research focused institution.

It is important to note that terms such as 'scientist' and 'researcher' are often used interchangeably. A scientist can be defined as a person who is studying or has expert knowledge in one or more scientific areas or concepts, while a researcher is someone who specifically investigates scientific concepts. There is often overlap between the two roles, however as both professions are focused on developing a greater understanding of the world around us.

This module specifically explores the following aspects of becoming, and working as, a researcher:

- The nature of preparation and transition into the profession
- Career progression and prospects once working in the profession
- Research group structure and hierarchy
- Daily work responsibilities and workspaces of lab-based researchers
- Different types of research and data collected through research projects

This module is also valuable for highlighting the nature of science, that is, better understanding science as just one way of generating new knowledge and that working as a scientist requires certain dispositions, such as a love of problem solving, curiosity, resilience, and perseverance.

Links to the current curriculum:
Australian Curriculum: Science as a Human Endeavour (SHE)

Curriculum Descriptors:

- Structure of scientific laboratories and staff (i.e., structure and hierarchy of science research groups and specific roles within groups)
- Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures ACSHE226

Key to module:

Teacher's Notes	Figures and Tables	Student activities.	Links to further reading.

Table of Contents

1. Career as a Researcher

Teacher's Note:
This section provides a brief description of pathways to becoming a researcher, highlighting modes of education from undergraduate to post graduate preparation degrees. The module also explores employment options, from casual research assistant work to mapping the progression of an entire career to senior leadership roles within the profession.

1.1 Introduction:

A career as a researcher can be exciting, challenging and constantly evolving. Positive aspects of a career in research include: the opportunity to have an impact on creating new knowledge; addressing issues facing society; to have a degree of freedom to research an area of personal interest and passion; and to have the opportunity to work in diverse and collaborative teams in a varied workplaces around the world.

A recent survey of Australian researchers asked them to identify the 'best aspects' of their research. Responses indicated that the capacity to find solutions to important problems, helping people, making a difference, and stimulating working environments were positive aspects of being a researcher (1). The study also found that many researchers expressed concerns over workplace conditions and workload. A not uncommon characteristic of many professions in the 21st century.

These findings highlight the beneficial nature of working in research, but also show the challenges of the profession more generally. Being able to offer multiple perspectives about the working life of a researcher can support students to make informed decisions about their future career pathways.

1.2 Career pathways and stages

There are many pathways which prepare students for a career research and, once entering the workforce, there are also multiple professional pathways. For example, an individual might complete an undergraduate degree before moving into a master's degree, whereas another might do an Honours degree and then continue onto a PhD (also called a doctorate). From there, some individuals may choose to engage with temporary or casual work as a part time or full-time research assistant, while some (specifically PhD students) may apply for ongoing positions in an academic position or apply to a post doctorate position, and so on.

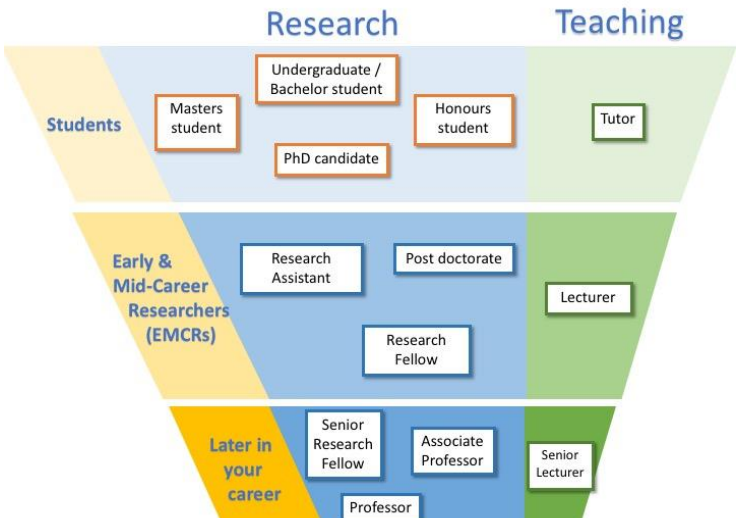

Figure 1 Stages in your research career

The following section highlights the different stages of preparation and career pathways for researchers. Many researchers may combine teaching and research. Research career stages are outlined in **Error! Reference source not found.** and the different research positions, roles and responsibilities are outlined in the following pathway glossary.

1.3 Pathway through research – a glossary of research positions, roles, and titles

Role	Description	Role Responsibilities	Student	Employee
Undergraduate student:	An undergraduate degree, usually a bachelor's degree, is awarded by a higher education institution, such as a university. Undergraduate degrees vary in length, depending on the specific degree. Bachelors usually completed over 3 years but can be longer if you do a combined degree or study part-time. Some undergraduate degrees are specialised, and profession focused (e.g., Bachelor of Accounting) and some degrees are broad (e.g. Bachelor of Science, Bachelor of Arts).	• Complete coursework units over the life of the degree • Become educated in terms of developing key attributes and skills, such as critical and creative thinking and being responsible and active global citizens	✓	
Honours Student:	An Honours degree is a university course; usually a one-year research project completed at the end of an undergraduate degree. To complete the Honours year, the student might engage with some course work, but the predominant form of assessment is a 10,000-15,000-word thesis on a specific research project.	• Conducting a year-long research project under supervision by one or more senior researchers • Writing a 10,000 approx. word thesis • May have some coursework component • Presenting research to faculty and at conferences	✓	
Master's Student:	A Master's degree is a post-graduate usually a 1-2 year course if completed full time. Some master's degrees involve coursework, coursework and research or purely research. Students completing a Masters in research will need to describe their research in a thesis.	• Conducting a research project for 2 years under supervision of a more senior researcher. • Writing a final 40,000-50,000-word thesis • Presenting research to faculty and at conferences	✓	
PhD student/ candidate:	A PhD or Doctor of Philosophy is a postgraduate degree, also referred to as a doctorate. A PhD takes 3-4 years to complete. Like Honours and Master's by Research, this degree involves a long research project, where students must develop independent research skills. The PhD research should make a substantive and new contrition to knowledge. A PhD student must write a substantial thesis (about 80,000 words). A PhD is the highest postgraduate achievement.	• Conducting a 3–4-year research project • Working with one or more supervisors, but required to conduct more independent research • Designing and planning their own research methods • Writing a final 80-000 – 100,000-word thesis • May work as a sessional tutor (teaching/ marking) • Presenting research to faculty and at conferences	✓	

Research Assistant:	A research assistant (RA) is employed to assist with research. RAs can be people who want to work part time or full-time doing research but not necessarily leading the research and can include recently completed graduate students at the beginning of their research careers. A research assistant is usually supervised by a more senior researcher or mentor within a larger group, to gain valuable skills and experience.	• Assists with research projects, under supervision • May contribute to research projects • May work as a tutor (teaching/ marking)		✓
Post doctorate:	A post doctorate (Post doc) is the most common next step from a PhD. The Post doctorate allows PhD students to continue their training and gain skills and experience. Post docs are no longer students, and are typically employed by a university, organisation, or industry. Often, there is no set length of time for a post doctorate and can depend on a range of factors.	• Designs, plans, and conducts their own research projects • Publishing and presenting their research • May work as a tutor		✓
Research Fellow:	A research fellow is the next step that a researcher may take after completing one or more post doctoral appointments. A fellow is often an academic research position at a university. Research fellows must have a PhD as well as some experience in research. They may also have teaching roles in the university alongside their research positions e.g., working as a tutor or lecturer in undergraduate or postgraduate unit. They may hold the title of Lecturer.	• Creates vision for research project • Designs, plans, and conducts research • Creates teams for research projects • Responsible for budgeting research projects • Publishing and presenting their research • Tutoring or lecturing		✓
Early & Mid-Career Researchers:	Early & Mid-Career Researchers (ECR and MCRs). ECRs are within 5 years of having completed a PhD or within 5 years of stating their tenured/employed position. MCR's are beyond 5 years from commencing. This can include post-doctorates and research fellows.	• Creates vision for research project • Designs, plans, and conducts research • Publishing and presenting their research • Supervises students • Tutoring or lecturing		✓
Senior Research Fellow:	A senior research fellow has a more leadership role compared to that of a research fellow. For example, they might lead a research group or supervise a project. They may also have more senior teaching roles and may hold the title of Senior Lecturer, which is a promotion from the position of Lecturer.	• Creates vision for research project • Designs, plans, and conducts research • Publishing their research • Supervises students • Tutoring or lecturing		✓

Associate Professor:	Associate Professor is a more senior research position. Associate Professors usually have many leadership positions, such as the head of a research lab. They are usually considered experts in their field of interest and have published many papers in research journals.	• Representing their university at conferences • Teaching and mentoring students • Publishing their research • Serving on faculty committees • Lecturing and leading teaching course development		✓
Professor:	Professor is the highest ranked research and teaching position. Similar to Associate Professors, they have research (and possibly teaching) leadership responsibilities and are experienced and expert researchers. Professors are often leaders in their field on an international scale, having published and presented extensively. Professors are often in charge of many people within a research group.	• Giving presentations at national and international conferences • Giving class lectures and evaluating student performance • Publishing research articles or books • Participating in faculty meetings and departmental planning • Lecturing		✓
Emeritus Professor	Emeritus Professor is a distinguished title offered to retired academics who are still connected to the profession to offer valuable wisdom, support, and mentoring, but who are not actively working full time.	• Mentoring and support for researchers and students within the profession • Act as a valuable source of wisdom		

Further Resources:

- What is a PhD? https://www.findaphd.com/advice/finding/what-is-a-phd.aspx
- What does a research Assistant do? https://www.gradschoolhub.com/faqs/what-does-a-research-assistant-do/
- What is a Postdoc? https://academicpositions.com/career-advice/what-is-a-postdoc
- Difference between Professor & Associate Professor: https://study.com/articles/difference_between_professor_associate_professor.html

2. Where do researchers work?

There are many opportunities to work as a researcher within Australia and internationally. Researchers have the capacity to choose what they want to research, and where, by approaching research groups which are related to their areas of expertise and interest. Researchers are usually a specialist in a particular discipline but may work with others and develop skills and interests in multi-disciplinary research projects.

Researchers have the freedom to move from one organisation to another during their career, by applying for jobs which cater to their skill set and expertise. For example, a researcher who has experience with tissue culture (growing cells) of one cell type, could apply that skill set in a lab which is focused on growing cells of another type. Over the course of their career, researchers may move between universities and medical research institutes across Australia and/or in different countries.

Medical Research Institutes are a specific category of research organisation which focus on medical or biomedical research, often within a specific area of interest.

Researchers may also be employed by government or private industry companies for a short period of time, or permanently. Working in a government organisation can include conducting research within a specific agency, such as the Department of Health, or can involve writing policy, consulting and working with policy makers to use research to inform legislation. Researchers may also work for private and industrial research companies, which may be concerned with developing new drugs, treatments, and medical devices.

Researchers who choose to work in a university have the opportunity to conduct their own research while also developing their expertise in education. This can involve working as a tutor or lecturer in undergraduate or post graduate units. As an academic in a university, a researcher's time may be split between research (40%), teaching (40%) and leadership or service (20%). Leadership in this sense refers to 'giving back' to society through acting as a peer reviewer for journals or being associate editor or editor of a journal, being on boards and committees within and outside the university, assessing grant applications, and so on. Being able to give back to the profession by using their expertise in this way, is a form of professional leadership.

Figure 2 Places where you can work as a researcher offers examples of different organisations which employ researchers, such as: universities; medical research institutes; Government agencies; private research institutes and pharmaceutical companies.

Figure 2 Places where you can work as a researcher

Activities for students

Activity 1.
a) Click on this link to view a list of research organisations in Australia. Choose one that looks interesting to you and report to a partner what the organisation is, what they do and where they are located.

b) Click on the following link to view a list of international research organisations. Choose one that looks interesting to you and explain to a partner: what the organisation does; what their mission is; and which country they are located in. Do some countries have more research organisations than others? Why do you think this might be the case?

3. A Day in the Life of a Researcher

Teacher's Note:

In this module we focus on laboratory based scientific inquiry, but it is valuable to help students recognise that this is just one way of generating knowledge. There are many other culturally based ways of knowing and developing knowledge such as Indigenous, Eastern and Middle Eastern scientific inquiry, which have long and productive histories. Teachers can refer to the Science as a Human Endeavour strand of the national curriculum for more information and guidance about different ways of knowing in science.

Researchers have many responsibilities and roles within their workplaces. These include expectations about the way they conduct their research and how they behave in the workplace. Not only are the researchers themselves diverse, but the workplaces in which they work are also diverse.

Experimentation or investigation in a laboratory is only part of the role of a researcher and is just one way of generating new, science-based knowledge. There are other forms of knowledge development which contribute to our understanding of the world around us, such as palaeontology or astronomy, both of which cannot rely on purely experimental data generated in a laboratory.

Laboratory-based researchers can be found doing a number of different tasks involved in conducting research, such as planning and designing experiments, which includes considering ethical guidelines for research, applying for funds, conducting investigations, writing up results, and communicating their research to others.

In the following section, the responsibilities and tasks associated with various stages of laboratory-based research are discussed, to give insight into the life of a laboratory-based researcher.

It is important that studemts understand the processes involved when conducting research, as it can often be a long, meticulous, and challenging journey. Much of the time, the research which scientists conduct may generate more questions and will likely be characterised by trial and error, where scientist learn from mistakes and develop new questions for inquiry.

If scientists are at the forefront of knowledge creation, mistakes, failures, and challenge would be commonplace, as they don't have any pre-made recipes to follow. It is valuable for students to have opportunities where they can observe scientific endeavour as being problematic, where scientists are problem solvers who need to be comfortable with uncertainty and failure. Scientists must develop dispositions such as resilience, patience, curiosity, and perseverance.

Laboratory based research can be explain broadly through 4 key processes, which are outlined below. Each of the stages will be discussed briefly to give a sense of how they might typically be conducted.

Researchers are often involved in multiple research projects or investigations. On any given day, a researcher may be conducting any stage of research, on more than one research project.

Activities for students

Close your eyes and **picture a researcher**. What is the image that you created? Describe the image that came to you to a person beside you or briefly write down or draw your image. What did you draw/describe?

This question has been posed to students through research projects for many years. The results of the research have been similar across the years. Primary and secondary age students typically picture a man, with glasses, wearing a white lab coat and working with test tubes or looking down a microscope. In reality, scientists and researchers are a diverse group of people, who usually work in teams, often will colleagues from around the world. They work together to gather data and develop new theories about how things work and share their research with those in the scientific community and beyond.

Planning and designing research

Before conducting a research project, which includes investigations or experimentation, researchers need to know about the knowledge and 'scientific conversations' that already exist and how their research will be adding new insights to the ongoing conversations. To do this, they need to read widely, from a variety of sources. A key source is academic literature, such as scientific journal articles, book chapters and books related to the field of research they are interested in. They also read from other sources, such as government white papers, publications from industry, news and other media outlets which help scientists to situate and cater their research to the everyday needs of society.

The planning and designing stages of research take time and requires scientists to be meticulous. Planning and designing a laboratory-based experiment includes defining a research question, which guides and justifies the research trajectory. Planning also involves meeting with other researchers to create and discuss plans, reading previous studies (see the 'reading about the current field in research' above), designing the methods that will be used, considering any risks and other safety issues, and applying for ethical approval to conduct the research (see the Ethics Module on the Stem Cells Australia website for more information). Planning also involves creating timelines, delegating tasks to different people within the lab, and managing a budget. Careful planning is crucial to ensure the research project is effective, safe, necessary, and efficient.

Experimental and investigative methods

Once the experiment has been planned, including obtaining all necessary approvals and managing any safety risks, the experimentation phase can begin. Experimentation and investigation involve gathering data, either firsthand (i.e., primary data) or from other sources (i.e., second-hand data) to answer the research question/s.

Investigation methods may not be limited to a single laboratory, as some research groups collaborate and complete various stages of an investigation at different locations, due to specialised equipment and/or staffing. Some data gathering methods may also take place in the field, such as qualitative data collection from groups of people (e.g., surveys, interviews) or sourcing second hand data from other institutions (e.g. medical data sets from hospitals).

It is worth noting that the phases outlined here do not always proceed in a linear fashion for all scientific endeavours. There are some common characteristics for lab-based research, but it is not always a linear process. It is common for people to think that science occurs in a similar fashion to school-based experiences and that a 'lab report' is the way science is done. Having conversations about the characteristics of lab-based research can help individuals to develop a more realistic understanding of scientific research.

Documenting and interpreting research

When data is gathered, scientists use the information gathered to develop theories and explanations about what they are noticing and how this might relate back to their research question. They look for patterns, or the absence of patterns. For example, if a research team wanted to test if a certain drug reduces patients' blood pressure, after recording the measurements they must determine if the results show an increase, decrease, are the same or perhaps are inconclusive.

As mentioned before, sometimes data can generate more questions than it can help to answer, so the process can be iterative. That is, scientists move in and out of research phases as they gather data, define new questions, develop new approaches, read new research and so the process also requires critical and creative thinking. Scientists are analysing the results and trying to make sense of them, based on existing knowledge but at the same time, developing new knowledge and insights.

To maintain the integrity of their research, scientists keep extensive records about their progress. They may even seek to publish elements of their research progress as they are going, as it may be of use to other scientists.

Communicating research

A vital skill that researchers must develop is the ability to communicate their research to others. Communicating occurs throughout a research project and requires scientists to communicate to a range of audiences. Examples include:

- Collaborating with other scientists to develop a possible research project
- Describing the project aims and purpose to various audiences (i.e., academic, and general audiences)
- Developing grant (i.e., funding) applications and communicating value to funding bodies (which may or may not have scientific backgrounds)
- Describing the project value to science and non-science audiences, (i.e., to justify funding, time, resources, etc)
- Describing the project risks and benefits to potential participants
- Applying for research approvals, like ethics boards
- Communicating scientific thinking and analysis to other scientists to advance scientific endeavour and knowledge through journals articles, book chapters, books and conference presentations and posters
- Communicating overall project findings to funding bodies, participants, and other interested stakeholders

4. Structure of a Research Laboratory

A research laboratory, or lab, is a room or building dedicated to research. It is a place where scientists can conduct scientific experiments, engage with teaching or manufacturing materials, such as drugs and pharmaceuticals. A research 'lab' is sometimes used as a collective term for a group of researchers who may be working on the same research project.

When speaking about a laboratory as a physical space, labs can be organised into 3 main areas or types: wet labs; dry labs; and areas for administration, teaching, meetings and non-lab-based research activities (see Figure 4 Types of research labs). Each of these spaces will be discussed in turn.

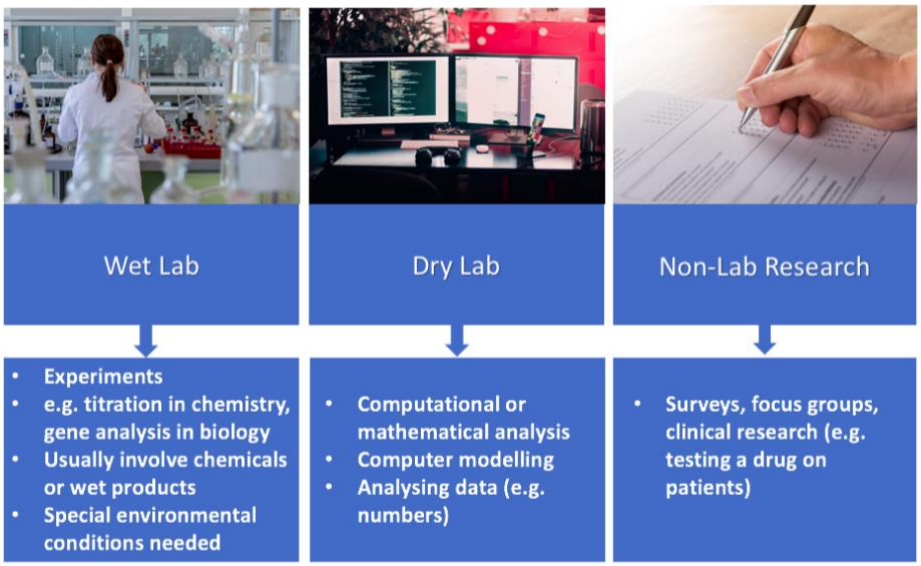

Figure 3 Types of research labs

A wet lab is a type of laboratory which is designed to accommodate work which requires the use of hazardous or dangerous chemicals and other substances and/or specialist equipment. These kinds of labs are carefully designed to minimise risk, even though hazardous or dangerous equipment and chemicals may be in use. Safety is of paramount concern, so wet labs have strict safety measures, such as the wearing of lab coats, enclosed shoes, safety glasses, gloves and careful procedures for handling equipment and safe disposal of chemicals. Laboratories also have specialised safety equipment, which must meet specific safety standards, such as separate ventilation, fume cabinets, safety showers and spill kits, to name a few. Wet labs include special areas for using and disposing of dangerous chemicals, washing up, storing, and preparing equipment. A large financial investment is needed to set up, stock and maintain wet laboratories.

A dry lab was a term which was once used to indicate a space used to store dry substances for experiments. However, more recently, dry labs are spaces which may contain equipment for analysis, such as computers for mathematical analyses, modelling or simulations. Dry labs provide a specialised space for equipment which assists with data collection and analysis. The safety requirements for dry labs may be less strict than wet labs, due to the lack of hazardous equipment and chemicals. However, as spaces within a workplace, they would still need to be maintained and monitored for hazards. Dry labs are an important space for scientific research. Other areas available to scientists include workspaces for planning experiments, writing results, meeting and teaching spaces and administration.

Activities for students

Activity 2. Match the following tasks a researcher may complete to a wet lab, dry lab or neither. You can write 'W' for Wet-lab, 'D' for Dry-lab or 'N' for Neither.

a. Looking at cells under the microscope
b. Titrating two chemicals
c. Graphing a set of data points taken from a national survey
d. Writing up notes in an experiment
e. Planning a new experiment with other researchers

5. Types of Data and Research

While we may initially think of research as experiments conducted in the lab, there are in fact many kinds of research. Figure 4 Types of Data and Research offers an overview of various forms of research and different types of data which can be collected during research projects.

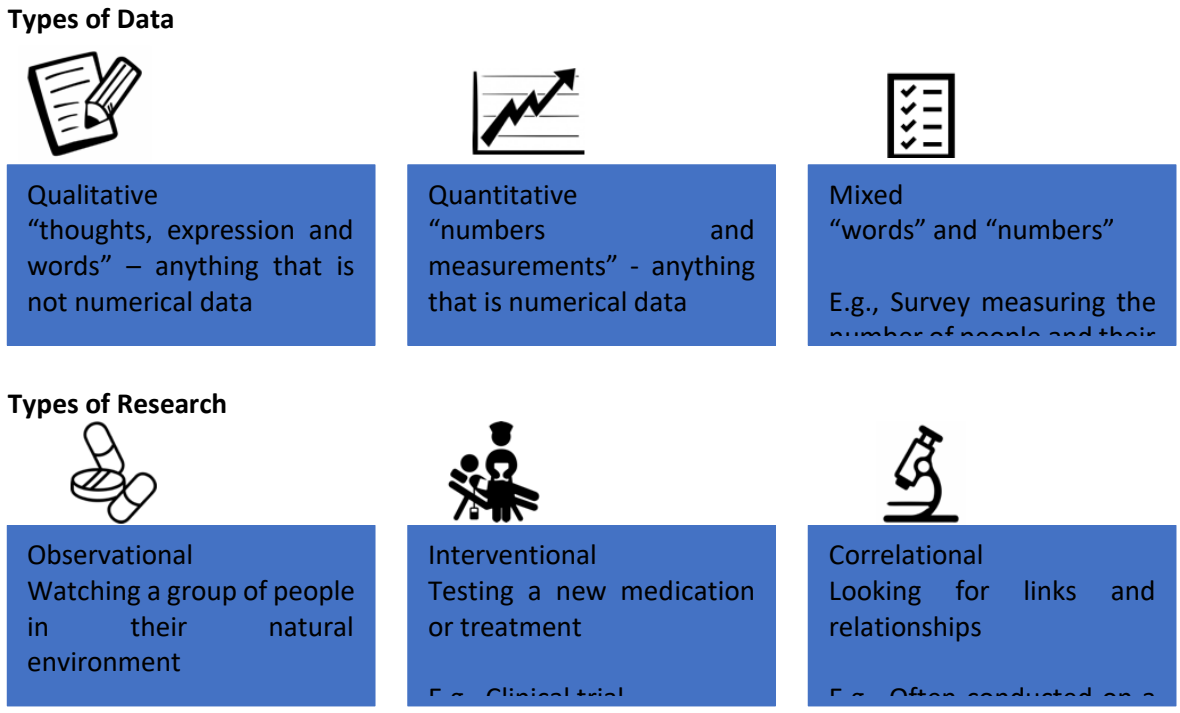

Figure 4 Types of Data and Research

Some investigations can involve multiple types of research methods. For example, lets imagine a research study that seeks to investigate the effect of drinking coffee before bed and examining the effect on sleeping habits. This could be framed as an observational study, where the researchers 'observe' participant behaviour. However, if the researchers decided to split the participants into two groups and give one group caffeinated coffee and the other group decaffeinated coffee (but not identify which group was drinking which coffee), this would be considered an interventional design.

The data that could be collected in the hypothetical coffee drinking experience could also differ. If we asked our group of coffee drinkers to describe their sleep after drinking coffee, we would be collecting qualitative data, as the data is descriptive and non-numerical. On the other hand, if we measured how many hours each person slept after drinking coffee compared to not drinking coffee, we would be collecting numerical or quantitative data.

Researchers also need to make sure that their experimental designs are ethical and conducted ethically. For example, it would be unethical to test the efficacy of a possible COVID-19 vaccine by giving one group of participants a new vaccine and another group a placebo (i.e. a substance which has no effect, but makes the patient think they have been given a treatment) and then have them come into close contact with a person who has COVID-19. Although this might help us to know how well the possible COVID-19 vaccine works, it puts a group of people at risk. Therefore, research designs are developed based on a number of decisions, with consideration for moral and ethical implications. For more information about ethical aspects of research, please visit the Ethics Module on the Stem Cells Australia website.

Activities for students

Activity 3. For the following research projects, state what type of research it is and the possible types of data which may be collected. Some projects may be applicable to more than one research type.

a) Testing a new medication on patients and asking patients to answer a multiple-choice questionnaire about how they felt before and after.
b) Sending out a survey to adults in Australia, asking their opinions about climate change. The survey encourages people to write open-ended answers.

Further Resources:

- Research: Department of Health https://www.health.gov.au/about-us/what-we-do/research
- Research Organisations: BioMelbourne: https://biomelbourne.org/industry-insights/resources/research-organisations/
- What is health and medical research: Research Australia: https://issuu.com/researchaustralia/docs/what_is_health___medical_research
- There's work (and life) outside of universities for PhD students: https://theconversation.com/theres-work-and-life-outside-of-universities-for-phd-graduates-63401
- Career support for researchers: understanding needs and developing a best practice approach: https://acola.org/wp-content/uploads/2019/01/2012Nov-CSR-Career-Support-For-Researchers.pdf

References:

1. Australian Council of Learned Academies. Career Support for Researchers: Understanding Needs and Developing a Best Practice Approach [Internet]. Department of Industry, Innovation, Science, Technology and Tertiary Education. Available at: https://acola.org/wp-content/uploads/2019/01/2012Nov-CSR-Career-Support-For-Researchers.pdf [updated November 2012, cited June-2021].

Notes for teachers and answers

Activity 1

Purpose of the question:

These questions are designed to support students as they learn more about the different research organisations within and outside Australia. Letting them choose an area of personal interest engages students and supports them as they develop and appreciation for the variety of workplaces available for researchers.

Example answer:

1.a. Choice 1: The University of Melbourne: This organisation is a university in Parkville, Victoria which conducts scientific research in many different areas including Ageing, Computational Biology as well as non-science areas such as research about the history of Indigenous Australians.

Choice 2: The Florey Institute of Neuroscience and Mental Health: This organisation is found in Parkville, Victoria and is considered one of the largest brain research centres in the world. Researchers at the Florey do a lot of different research into prevalent diseases such as Alzheimer's disease, stroke, epilepsy etc.

Choice 3: Diabetes Australia: This is a national organisation, and primarily funds other research institutes around the country that are researching diabetes. They don't have their own research building, but they give money to other organisations to support diabetes research.

Activity 2

Purpose of the question:

This question is designed to consolidate students' understanding of the different types of scientific labs that exist and the work which may take place within these specialist spaces. The differences between the spaces reinforces the dynamic variety of research environments.

Example Answer:

a. W
b. W
c. D
d. N
e. W, D and almost anywhere! Tea rooms can be a perfect place to discuss research ideas.

Activity 3

Purpose of question:

This question asks students to apply their new understanding about research types and the kinds of data that can be obtained from research.

Example response:

Interventional experimental design with quantitative (numeric) data
Observational experimental design with qualitative (non-numeric) data