PHYS242

Big Ideas in Science

S2 Day 2014

Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
Unit Convenor
David Coutts
david.coutts@mq.edu.au
Contact via david.coutts@mq.edu.au
E6B 2.714
By appointment

Lecturer
Alex Fuerbach
alex.fuerbach@mq.edu.au
Contact via alex.fuerbach@mq.edu.au
E6B 2.608
By appointment

Lecturer
Michael Steel
michael.steel@mq.edu.au
Contact via michael.steel@mq.edu.au
E6B 2.708
By appointment

Lecturer
Luke Helt
luke.helt@mq.edu.au
Contact via luke.helt@mq.edu.au
E6B 2.405
By appointment

Credit points
3

Prerequisites
12cp

Corequisites

Co-badged status

Unit description
What is science? How have influential thinkers such as Einstein and Darwin shaped our view of the world? This unit presents a big picture of science as a great triumph of the human mind and imagination. Scientists have given us a powerful framework for understanding our world from the microscopic scale to the scale of the whole universe. This unit gives students insight into some of the big ideas in science; from cosmology, and the universe through the mysteries of quantum phenomena; from atoms to the evolution of life itself. By exploring the big ideas in science, students gain an understanding of the power and dynamism of scientific knowledge. This unit provides intellectual enrichment for both science and non-science students.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Students should gain a broad perspective of some of the big ideas in science.
Understand and comment on the historical development of scientific ideas and the idea of science itself.
Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
Students should gain a greater understanding of the science behind topical issues such as climate change.
Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment Tasks

Name	Weighting	Due
Quizzes	20%	Weeks 2-10, Week 13
Source Evaluation Assignment	15%	Friday 22 August
Essays	50%	19 Sept and 14 Nov at 9 am
Talk	15%	Weeks 11/12

Quizzes

Due: **Weeks 2-10, Week 13**

Weighting: **20%**

Each week (from weeks 2 to 10 and week 13) there will be an on-line multiple-choice quiz based on the set readings and the lecture for that week. This is to encourage you to read the assigned material (usually one or two chapters from the textbook, or material which can be downloaded from ilearn) prior to attending each lecture and to encourage you to attend every lecture or at least to listen to them carefully on Echo360. The quiz marks will make up 20% of the final grade.

On successful completion you will be able to:

- Students should gain a broad perspective of some of the big ideas in science.
- Understand and comment on the historical development of scientific ideas and the idea of science itself.

Source Evaluation Assignment

Due: **Friday 22 August**
Weighting: **15%**

In this assignment, you will be asked to evaluate some web sites as to their accuracy, motive, usefulness etc. When so much information is freely available on the web, it is important to critically assess its accuracy/value, particularly because anyone can publish anything on the web, yet what is published often has hidden biases or agendas, or may contain misconceptions, errors of fact both intentional and unintentional. This assignment will get you to explicitly evaluate web sites, though you should always evaluate a web site before considering it to be a useful resource for information.

On successful completion you will be able to:

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.

Essays

Due: **19 Sept and 14 Nov at 9 am**
Weighting: **50%**

Two essays will be set during session 2, worth 25% each. There will be a choice of essay questions for each of the two major essays. Please include a bibliography (not included in any word- or page-limit), listing any relevant print- or Web-based resources from which you gathered your information. We are flexible with regard to format, as long as your citation references are clear and accurate. In order to satisfy the Policy on Plagiarism, it is important for you to use quotation marks ("...") to designate text that you have directly extracted and clearly acknowledge its bibliographic source. Plagiarism attracts severe penalties.

Essays will be submitted in hard copy with coversheet to The Student Centre, Faculty of Science

E7A Level 1; AND electronically via ilearn (to allow plagiarism checking through Turnitin).

For guidance on writing essays including details on how to reference sources (and avoid plagiarism) please see this web site:

http://www.students.mq.edu.au/support/learning_skills/undergraduate/academic_skills_quickguides/

If you feel you need extra help with writing, see the Undergraduate Learning Skills Program:

http://www.students.mq.edu.au/support/learning_skills/undergraduate/

On successful completion you will be able to:

- Students should gain a broad perspective of some of the big ideas in science.
- Understand and comment on the historical development of scientific ideas and the idea of science itself.
- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.
- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Talk

Due: **Weeks 11/12**
Weighting: **15%**

Each student will give a short presentation to the class on a topic selected from a list (to be provided). This will help develop an important generic skill as well as give each student an opportunity to talk about a topic in science that they have researched. Students should use visual aids such as a PowerPoint type presentation to help communicate their topic.

On successful completion you will be able to:

- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Delivery and Resources

Classes

Lectures on Wednesday mornings from 10 am to noon, E6A Theatre 102.

Tutorials are on Wednesdays at 2 pm and Thursdays at 11 am and noon. There will **not** be a tutorial each week - see unit schedule for tutorial weeks.

Prizes

The Arthur Pryor Prize is awarded for excellence in this unit - worth extra effort!

Arthur Pryor was a brilliant student of Physics and Electrical Engineering. His career took him to the UK, New Zealand and back to Australia. He made major research contributions in under-water acoustics, neutron and thermal physics. He co-authored “Thermal Vibrations in Crystallography” and shared the 1964 Syme Prize, with AINSE co-workers, awarded for the best science contribution in any discipline in Australia. He taught PHYS242 in its beginnings in 1985 through to 1995.

Required and Recommended Texts and/or Materials

Required Text

Bill Bryson, A Short History of Nearly Everything, Black Swan (Random House).

Note a list of known errata for the text can be found on the unit iLearn page.

Further required reading for specific lecture topics will be available for download from ilearn.

Recommended Readings

Physics for Future Presidents, or Physics and Technology for Future Presidents, both books by R A Muller, Norton.

Galileo's Finger: The Ten Great Ideas of Science, Peter Atkins, Oxford University Press, 2004.

Technology Used and Required

This unit has an iLearn page at: https://ilearn.mq.edu.au/

Teaching and Learning Strategy

This unit is taught through a weekly 2 hour lecture plus one hour tutorials (these do not run each week, see schedule).

The textbook provides an interesting narrative account of science with emphasis on the people involved in scientific discovery as well as the evolution of the ideas themselves. The lectures will build on this background reading with an emphasis on gaining an understanding of important scientific concepts. In-class discussions will explore the foundations of our scientific understanding including confronting challenges to accepted scientific wisdom. Students will have assigned readings (mostly from the Bryson textbook) which should be completed prior to each class.

Discussion tutorials will be provided for selected topics covered in the lectures as well as tutorials to aid in preparation for assessment as required.

Students will be able to explore selected topics in greater depth through their essays and source evaluation comprising the major part of the assessment for this unit, as well as through presenting a short talk on one of the Big Ideas topics to their peers. Unlike most other units with

a PHYS prefix, this unit does not require a mathematical background, and is more conceptual than mathematical in nature.

Unit Schedule

Week	Topic	Lecturer	Bryson	Tutes
1	Planet Earth and Deep Time: This lecture will explore the first two Big Ideas: That the Earth is billions of years old, not thousands, and that our planet has largely been shaped by gradual rather than catastrophic processes. We will make our first steps away from the time and length scales our every day experience, a process that will be a subtext throughout this unit.	David Coutts	Chapters 5, 12	No tute.
2 Quiz 1	Climate Change: We live on a finite planet: As a species, through our actions we can have an impact on the planet as a whole. This is most evident in Anthropogenic Climate Change, which has been described as one of the hottest issues of our time. We may all have to modify our lifestyles both to reduce climate change and because of the consequences of climate change. Climate change has emerged as a major political issue, yet do you really understand climate science sufficiently well to be making informed electoral choices? We will explore the basic science which results in the mean global temperatures we see today, and why these temperatures are rising, and what the effects of the temperature rise may be.	David Coutts	17, 27	Sources & Essays
3 Quiz 2	Cosmology: Although we may believe we are masters over our domain, Planet Earth, and that we are the Centre of the Universe, actually, we live on a small pale blue dot orbiting an nondescript star that is just one of billions in an unremarkable galaxy in an incomprehensibly vast Universe. This lecture will cover the story of our universe from the Big Bang to the formation of the solar system and the ultimate fate of the universe.	David Coutts	1,2,3	Tute on Climate Change
4 Quiz 3	Particles: From the vast scale of the Universe, we now turn inwards to the microscopic realm: One of the most important and oldest ideas in Science is that the physical world is composed of particles (atoms and sub-atomic particles). While atoms are almost self-evident nowadays, the development of atomic theory is a fascinating journey through the history of ideas. We will look at some of the important milestones on this journey, taking us up to the present day where scientists can control and study single atoms or groups of a few atoms.	Alex Fuerbach	7,9	No tute
5 Quiz 4	Energy and Entropy: Energy is neither created nor destroyed, it is just transformed from one form to another as a fundamental primary quantity that drives all physical processes. But energy is also something that we pay for at the petrol pump and we receive regular electricity bills. So what is Energy, and what is Entropy, and how are these fundamental concepts related? What is their connection to the arrow of time? Do you know how much energy is contained in a cupful of petrol, an AA battery or a meteor impact? We will explore energy in all its forms including energy generation through renewable and other technologies.	Alex Fuerbach	13	The Energy Crisis

6 Quiz 5	Relativity: Einstein showed us that no one is a privileged observer of the world, and that the laws of physics should be the same for all regardless of their relative motion. This simple idea led Einstein to some startling mind (and space) bending conclusions where our everyday common sense is completely wrong. We will explore Einstein's theories of Special Relativity and General Relativity at a conceptual level including curved space time and the mysteries of black holes.	David Coutts	8	No tutorial
7 Quiz 6	Evolution: Historically, one of the most shocking Big Ideas in Science was Darwin's publication of On the Origin of Species in 1859 where he argued convincingly for the first time that all life on Earth has descended from a common ancestor. The objective of this topic is to explore the question "Where did living things (including ourselves) come from?" We will trace the history of our attempts to answer this question beginning with ideas of the spontaneous generation of life and culminating in Darwin's theory of Evolution, Mendelian inheritance and DNA. We will also explore some of the issues for society including GM foods, eugenics, cloning, pharmacogenetics and the human genome.	Michael Steel	19, 25, Optional: 21, 22, 2	Evolution: Can you answer the critics?
	Break.			
8 Quiz 7	The Quantum World: As Einstein was overturning our understanding of space and time, the founders of Quantum Mechanics upended the concepts of determinism and the clockwork universe in the effort to describe nature at the very small scale. Quantum mechanics today is by far our most accurate and successful physical theory, and yet its core tenets seem to conflict with our common sense and experience even more profoundly than relativity. Why must we accept that particles can exist in multiple locations at once, why can familiar quantities like position and momentum not coexist, what is really the role of an observer in an experiment, and how does our macroscopic classical world emerge from such an exotic microscopic foundation?	Michael Steel	9, 11	tbd
9 Quiz 8	Symmetry: Symmetry pervades art, architecture and nature through to the deepest laws of physics. Indeed, many of the fundamental laws of nature arise from arguments based on symmetry. Are symmetry ideas then the basis for all our physical laws? We will explore the importance of symmetry as a powerful concept in science and the world.	Luke Helt	Readings will be provided	No tute
10 Quiz 9	Limits of Reason: Is reality real or are we all living in a matrix? Does an objective reality exist independent of any observer? "If a tree falls in a forest and no one is there to hear it, does it make a noise?" is a philosophical thought experiment that raises questions regarding observation and knowledge of reality. With our brains, we simulate the external world as an internal model, based on sensory inputs that we receive. This means that there is no direct access to reality and our brain and the mind it creates is constrained to interpret the world in certain ways. In this lecture we will examine the neuroscience of thought processes and the way that the brain handles information. We will also look into the science of consciousness and explore the differences (or similarities?) between human and artificial intelligence.	Alex Fuerbach	Readings will be provided	No tute

11	Class Talks	David Coutts, Alex Fuerbach, Michael Steel		Class Talks
12	Class Talks	David Coutts, Alex Fuerbach, Michael Steel		Class Talks
13 Quiz 10	Lecture from the Future: In the final lecture, we will travel through time with Michael Steel for a talk from the future! He may also look back on the 2014 Nobel Prizes.	Michael Steel	Readings will be provided	No tute.

Learning and Teaching Activities

Lectures

Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.

Tutorials

Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Disruption to Studies Policy http://www.mq.edu.au/policy/docs/disruption_studies/policy.html *The Disruption to Studies Policy is effective from March 3 2014 and*

replaces the Special Consideration Policy.

In addition, a number of other policies can be found in the Learning and Teaching Category of Policy Central.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/support/student_conduct/

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://informatics.mq.edu.au/help/.

When using the University's IT, you must adhere to the Acceptable Use Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.

Assessment task

- Source Evaluation Assignment

Learning and teaching activity

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcomes

- Students should gain a broad perspective of some of the big ideas in science.
- Understand and comment on the historical development of scientific ideas and the idea of science itself.
- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.

Assessment task

- Source Evaluation Assignment

Learning and teaching activity

- Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.
- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment tasks

- Quizzes
- Essays
- Talk

Learning and teaching activities

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.
- Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- Students should gain a broad perspective of some of the big ideas in science.
- Understand and comment on the historical development of scientific ideas and the idea of science itself.
- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.
- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment tasks

- Source Evaluation Assignment
- Essays

Learning and teaching activities

- Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Assessment tasks

- Source Evaluation Assignment
- Essays
- Talk

Learning and teaching activities

- Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have

tutorials.

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcome

- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment task

- Talk

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome

- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment tasks

- Source Evaluation Assignment
- Essays
- Talk

Learning and teaching activities

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should

have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcomes

- Students should gain a broad perspective of some of the big ideas in science.
- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.
- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Assessment task

- Talk

Learning and teaching activity

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.
- Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcomes

- Students should demonstrate a capacity to distinguish between what are still open scientific questions and what are settled.
- Students should gain a greater understanding of the science behind topical issues such as climate change.
- Students will develop skills in critically analysing issues in science and will be able to communicate these to a general audience.

Learning and teaching activities

- Each week there will be one 2 hour lecture slot, each week devoted to one of the Big Ideas in Science.
- Some lecture topics cover material that is very well suited to further discussion and debate, and for those topics there will be specific discussion tutorials. Other tutorials related to the assessment will also be provided. See schedule for which weeks will have tutorials.

Changes from Previous Offering

For 2014 we have broadened the quizzes to cover the lecture material and increased their total value to 20%. Correspondingly we have reduced the number of essays required from three to two (now 25% each). We have reordered (and extensively revised) some of the material for 2014 which will provide a better narrative of the Big Ideas.

General Reminders

Student Liaison Committee

The Department of Physics and Astronomy values quality teaching and engages in periodic student evaluations of its units, external reviews of its programs and course units, and seeks feedback from students via focus groups and the Student Liaison Committee (SLC). Please consider being a member of the SLC, which meets once during the semester with the purpose of improving teaching via student feedback. Meetings are open and friendly, and invite honest feedback. Student representatives receive a list of outcomes from the preceding meeting. At the beginning of each meeting, an update on responses to feedback is provided by the Head of Department. Feedback is acted upon in a number of ways, mostly initiated via department meetings where decisions on actions are taken.

Standards Expectation

Grades

For a grade of pass or higher, satisfactory performance in each aspect of the unit is required

The broad standards as defined by the academic senate can be found at http://www.mq.edu.au/policy/docs/grading/policy.html.

A marking rubric for the essays will be posted on iLearn to aid you in understanding the key assessment criteria for the essays.