Earth & Ocean Sciences
School of Natural Sciences

NUI Galway
OÉ Gaillimh

Undergraduate Handbook

2016 - 2017

Welcome to Earth and Ocean Sciences (EOS)

Earthquakes, tsunami, nuclear accidents, volcanic ash, flooding, landslides, fracking, oil spills, climate change and geo-engineering: these issues seem to be constantly in the news, and their effects can range from small scale local events to wider regional events and in some cases even to long term global significance. How do we begin to understand these phenomena and their impacts? EOS is perfectly placed to train you as an earth and ocean scientist equipped with the academic, technical and field skills required to better understand the complex processes of planet Earth and our interactions with them.

At NUI Galway we offer an approach to Earth and Ocean Sciences that is unique in Ireland. Our staff's expertise covers a wide range of disciplines such as mineralogy, petrology, geochemistry, geophysics, hydrogeology, physical and chemical oceanography, marine biogeochemistry, palaeobiology, sedimentology and plate tectonics. Whether we are studying earthquakes, plate tectonics, volcanoes, ocean productivity, ocean currents, mass extinctions, climate change, energy or environmental pollution, the most productive insights into these phenomena often arise from interactions amongst the different disciplines.

Whether you are coming from Ireland, UK, continental Europe or beyond, whether you have just left school or are returning to education after years outside of formal education, we hope you will find the Earth and Ocean Sciences programme at Galway a lively, interesting, challenging, engaging and friendly environment.

If you have any difficulties, if you have any questions, if you're not sure how to find someone or where to find an office, please remember that there are plenty of people – in EOS, Student Services and the College of Science - who are here to help you. Don't hesitate to ask.

Prof. Peter Croot

Head of Discipline

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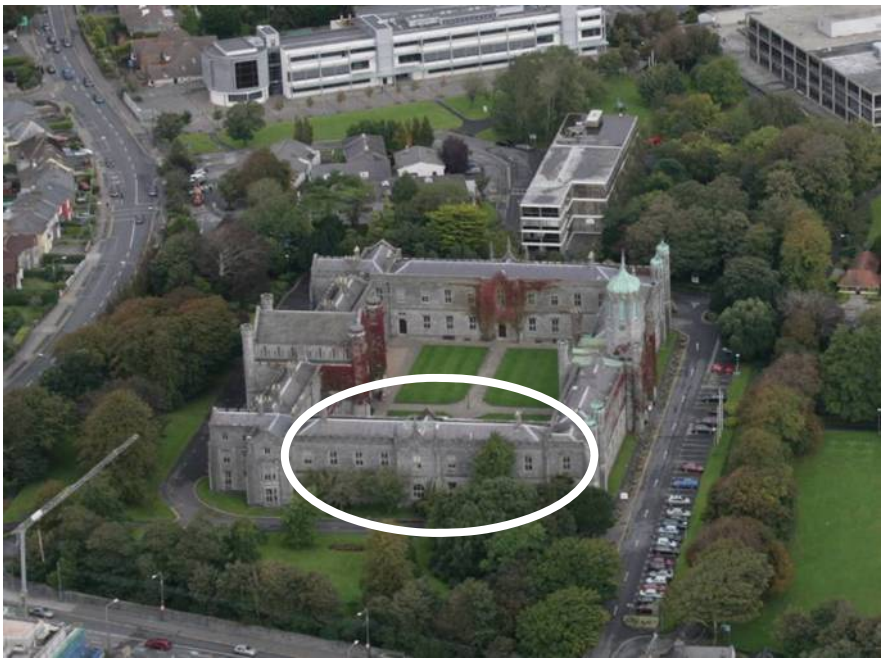
Section 1: Contacts and Communications

Where to find EOS

The main EOS offices and classrooms are housed in the south wing of the Quad (*see picture below*). There are a number of other EOS office, lab and storage spaces at other locations around the campus.



(Photo courtesy of NUIG)

All of the academic staff is housed in the Quad, along with the EOS administrator and Chief Technician and some research staff. Other technical and research staff are housed in the Ryan Institute on campus. The two teaching rooms in the Quad (A206 and A202) are used mainly for Third and Fourth Year classes and labs/practicals. Larger First and Second year classes use a range of venues across the campus.

EOS general contact details:

Earth & Ocean Sciences
School of Natural Sciences
NUI Galway
Galway H91 TK33
IRELAND

Phone: +353 (0)91 492126
FAX : +353 (0)91 494533
EMAIL: lorna.larkin@nuigalway.ie
WEB: http://www.nuigalway.ie/eos/

Academic Staff	***Office***	***Phone***	***Email***
Prof. Peter Croot (Head of EOS)	A207b Quad	2194	peter.croot@nuigalway.ie
Dr. Sadhbh Baxter	A105Quad	5962	sadhbh.baxter@nuigalway.ie
Dr. Rachel Cave	A210a Quad	2351	rachel.cave@nuigalway.ie
Dr. Eve Daly	A105 Quad	2310	eve.daly@nuigalway.ie
Dr. Anthony Grehan	A107 Quad	3235	anthony.grehan@nuigalway.ie
Dr. Tiernan Henry	A207c Quad	5096	tiernan.henry@nuigalway.ie
Dr. John Murray	A209 Quad	5095	john.murray@nuigalway.ie
Dr. Shane Tyrrell	A204 Quad	4387	shane.tyrrell@nuigalway.ie
Dr. Martin White (Deputy Head)	A204a Quad	3214	martin.white@nuigalway.ie

Research Staff	***Location***	***Phone***	***Email***
Dr. Liam Morrison	Ryan Institute	3200	liam.morrison@nuigalway.ie
Dr Triona McGrath	Marine Institute	091 387200	triona.mcgrath@marine.ie
Dr Sarah Nicholas	A210 Quad	2773	sarah.nicolas@nuigalway.ie

Administrative & Technical Staff	***Office***	***Phone***	***Email***
Ms.Lorna Larkin (Administrator)	A105 Quad	2126	lorna.larkin@nuigalway.ie
Mr. Shane Rooney (Chief Technician)	200a Quad	2310	shane.rooney@nuigalway.ie
Dr.Alessandra Costanzo	A215 Quad	2129	alessandra.costanzo@nuigalway.ie
Ms.Sheena Fennell	Ryan Institute	2269	sheena.fennell@nuigalway.ie
Ms. Bernadette O'Neill	Ryan Institute	2269	bernadette.oneill@nuigalway.ie

Guest Lecturers	**Location**	**Phone**	**Email**
Dr. Robin Raine	Ryan Institute	3200	robin.raine@nuigalway.ie
Dr. Evin McGovern	Marine Institute	091 387200	evin.mcgovern@marine.ie

Office Hours & Appointments

If you wish to talk to staff members please feel free to do so before or after classes or during practicals and labs. As much as possible all EOS staff operate an open door policy so please feel free to drop by offices as needed; however, it is advisable to arrange a meeting time and date with staff ahead of time. Please email or phone to make an appointment.

Contacts for Enquiries

If you have any enquiries relating to a particular module, you should contact in the first instance the relevant lecturer. If you have any concerns about a module or your degree or life at NUI Galway you should contact the Head of EOS (*Professor Peter Croot*) or Lorna Larkin (*EOS Administrator*). If they cannot help you directly they will refer you to someone who can.

EOS and Student Representatives

The formal running of EOS is conducted at Staff Meetings that normally take place on a monthly basis during term time. They are attended, as appropriate, by the teaching staff, technical staff representative, undergraduate students' representatives and research students' representative

Student representatives serve as a vital connection and communication between staff members and students. Anyone can stand for the position so it may be something you would want to consider. Even if you don't put yourself forward, it is important to know who your representatives are in case you have any difficulties or suggestions that need to be passed on to staff members. Undergraduate representatives are elected to serve for one year. There are representatives for each year of the EOS degree. Student Representatives also attend a Staff-Student Liaison Committee, normally held at the beginning of each semester. Being a student representative can enhance your CV.

E-mail/ Blackboard/Notice Boards

You should check your e-mail regularly. Information Solutions & Services (ISS) will already have allocated an NUIG e-mail address to you. The University requires all students to use their registered NUIG email for communications relating to your studies. *All EOS modules are on Blackboard and all registered student email addresses are assigned to the relevant modules*. Specific information (lecture slides, handouts, papers, assignments, notices, etc.) on each module is posted on the relevant Blackboard page so check these regularly. General notices are posted on EOS notice boards in the Quad.

Check the EOS website (www.nuigalway.ie/eos) for updates and for more details on staff, ongoing research etc. Log on to Blackboard regularly for information, updates and notices regarding specific modules (https://nuigalway.blackboard.com).

Check your NUI Galway email account regularly for announcements and notices and delete old emails regularly so your quota is not exceeded. If you miss an important announcement because your inbox was too full, or you failed to check it, the responsibility is yours.

Section 2: The Earth & Ocean Sciences Degree

Aims and objectives

Higher education is about teaching *and* learning: this is much more a collaborative process than secondary education. You will be taught in many different ways – in large and small classes, in groups, individually, in laboratories and practicals, and, in our case, in the field. One key element for your success is the level of *your* engagement in the process. Each year more and more responsibility for your learning will be given to you.

We aim to provide you with a supportive environment in which you can successfully pursue your degree and develop your academic, vocational, personal and interpersonal skills. By the time you graduate you will have been exposed to the major contemporary academic, practical and societal questions within EOS.

Your objective should be to achieve a basic but rigorous grounding in EOS by: (1) acquiring knowledge of the core concepts and questions which define EOS; (2) becoming familiar with the key disciplines within EOS; (3) achieving flexibility in the use of a variety of intellectual approaches required by the inter-disciplinary character of EOS; (4) developing a range of practical skills in EOS; (5) the in-depth study of at least two specialist areas within EOS; and, (6) applying your understanding of EOS to addressing major practical social and economic issues.

In addition to these intellectual objectives, you should also be developing your academic, personal and interpersonal skills throughout your undergraduate career. These will help you to succeed in achieving the intellectual objectives to the best of your abilities and prepare you for your career after graduation. Specifically, we expect you to (1) develop your reading and critical analysis skills, (2) acquire a range of information technology skills in the retrieval and use of source materials, (3) enhance your ability to take meaningful notes and produce reports; (4) improve your capacity for presenting concise and cogently structured arguments, (5) learn how to work independently and take responsibility for your own learning, (6) develop your abilities to co-operate and communicate with others and (7) learn to meet deadlines effectively.

EOS Degree Structure

EOS is a field of study as distinctive as any in the sciences. However, we believe that the richest engagement with this subject is gained by an approach that combines a variety of different disciplines. We have therefore made this into the organising principle of our teaching by building interrelations and integration into the heart of the curriculum. You are required to take 60 ECTS[1] credits in each year of your undergraduate programme. The first two years are focused on ensuring that everyone in the class is fully grounded and that all options remain open.

Residential Field Trips in EOS

There will be one residential field trip in second year (only open to denominated EOS students), one residential field trip in third year (open to denominated EOS students and any undenominated students intending to complete fourth year in EOS), and a choice of two residential field courses in fourth year (open only to fourth year EOS students): one for students specialising in oceanography and one for students specialising in geology (students complete one of the two). The charges for each trip vary, depending on time, number of students and accommodation availability. EOS arranges all transport and accommodation on each trip, and each trip is typically self-catering. ***Please note that the costs to students of each trip are typically around €200-300 per student, payable in advance.***

[1] ECTS: *European Credit Transfer and Accumulation System*

Degree Structure

Fourth Year: Students take a minimum of 50 ECTS from EOS

Core modules (30 ECTS)	**OR Core modules (20 ECTS)**
EOS403 Final Year Project (20)	EOS4102 Minor Project (10)
EOS4103 Advanced Fieldskills (5)	EOS4103 Advanced Fieldskills (5)
EOS402 Global Change (5)	EOS402 Global Change (5)

+ selection of 5 ECTS modules to make up ***minimum*** of 50 ECTS* from EOS
(* except where pre-requisites for some EOS modules are missing)
NOTE: Students choose one of the two Advanced Fieldskills options
The SMART Ocean option runs in Sem 1, the Geological option runs in Sem 2.

5 ECTS Modules - EOS			
EOS418	Applied Field Hydrogeology	S1	Wk 7-12
EOS422	Sedimentary Basins	S1	Wk 7-12
EOS407	History of Life	S2	Wk 1-6
EOS4101	Earth Observation & Remote Sensing	S2	Wk 1-6
EOS409	Biophysical Interactions in the Oceans	S2	Wk 7-12
EOS402	Petrotectonics	S2	Wk 7-12

5 ECTS Modules – Outside EOS, no pre-requisites
TI303 Coastal Dynamics, S1 wk 1-12
PAB4103 Climate Change, Plants and Agriculture
ZO415 Biometry, S1 wk 5-12

Other modules available but requiring pre-requisites in the relevant subject area
ST311 Applied Statistics 1, S1 wk 1-12
BPS4103 The Plant Cell, S1, wk 1-6
BPS402 Current Topics in Algal Research, S1, wk 7-12
ZO418 Phylogenetics & Conservation, S1 wk 9-12 AND &2 wk 1-4 (bridges both sem.)
ST312 Applied Statistics 2, S2
BPS4104 Primary Productivity & Global Change, S2
BPS405 Ecology & Conservation Issues, S2
Students who have taken physics/chemistry options in 3rd year may have additional options available – NOTE check timetabling to avoid clashes with EOS modules

Third Year: All modules listed below are core for EOS students (45 ECTS) and for other students planning to take 4th year EOS

For students intending to take 4th year EOS only

EOS3101 Geological Structures & Maps (5)
EOS3104 Fieldskills Training (5)

For EOS & non-EOS students

EOS303 Ocean Dynamics (5)
EOS304 Aquatic Geochemistry (5)
EOS305 Applied Field Hydrology (5)
EOS323 Sediments and the Sedimentary Record (5)
EOS3102 Environmental & Marine Geophysical Remote Sensing (5)
EOS3103 Palaeontology & Evolution (5)
EOS3105 The Crystalline Crust (5)

Second Year: EOS students take all 25 ECTS
Other students take 20 ECTS

For EOS students only

EOS2101 Introduction to Fieldskills (5)

For EOS & non-EOS students

EOS213 Introduction to Oceanography (10)
EOS222 Ancient Earth Environments (5)
EOS225 Optical Microscopy of Minerals and Rocks (5)

First Year: EOS students take Module EOS104 (15 ECTS) plus 3 modules from Biology, Chemistry, Maths, Physics

Teaching and Learning

The most critical concept for students to grasp is that you are here to learn. The teaching we deliver is only one part of that process – the rest of the work you must do yourself. You are expected to read widely around the subject matter you are given in lectures and practicals, and to apply what you learn in the field. **Turning up for lectures and practicals is less than half of the work you need to put in each week.**

The EOS degree is arranged in modules. Each year you take 60 credits made up of 5, 10 or 15 credit modules and you are examined on each module at the end of the semester it falls in. Despite this element of self-containment, the EOS degree should be seen as a whole and the parts follow on from one another in a coherent pattern. Year 3 and 4 are similar to years 1 and 2, however *at the end of your undergraduate course you will be awarded a degree that depends upon marks that you accumulate in both your third and fourth years.* ***Your third year marks will count towards 30 percent and the remaining 70 percent will depend upon your marks in fourth year****. It is critical therefore that you improve your marks year on year.*

The method of teaching is by lectures, practical classes, field work and seminars. The lectures are typically 50 minutes long. Each module will usually have some practical or example classes. This is the principal mode of teaching in first year. In the second year, in addition to lectures, individual modules will begin to introduce project-based teaching in which students will be expected to submit written essays or scientific reports. We value good writing and it is a significant part of the learning process in the EOS degree. Writing essays or reports is perhaps the most powerful of all methods for coming to grips with a subject and you should take them very seriously. They are the most rigorous test for finding out whether you really understand something, and report writing is a fundamental skill requirement in the jobs market.

In the third and fourth years, students will begin to do both group and individual presentations in modules. These presentational skills are useful at university and in the workplace. Some of these modules are examined in whole or in part by essays or project reports, formally submitted after the end of the module.

Teaching and learning are of course closely interconnected. The way our modules are structured and the way we teach are designed to encourage you to become a self-directed, independent learner. That means we expect you to organise much of your

own learning time, in terms of attending lectures and practicals, taking the appropriate notes, reading background material, and, in later years, preparing for seminars, producing presentations, writing essays and so on. Feedback from students is critical in continually improving the modules. A *Student Evaluation Questionnaire* is given out towards the end of each module and filled in by you anonymously. Members of staff look at their own forms to see where improvements can be made. This does not preclude you from talking to staff members about the nature of the modules, where you think there could be improvements or even, if you feel like it, mentioning the good points about modules. You can also feedback comment through your student representative.

The dates for the start and end of semesters, study weeks, examinations etc. are available in the academic calendar for 2016:

http://www.nuigalway.ie/academic_dates/academic_term_dates.html

Semester One

First Year Orientation	Tuesday 30 Aug – Friday 2 Sept, 2016
Lectures/Practicals Start	Monday 5 September 2016
Lectures/Practicals End	Friday 25 November 2016
Semester One Exams	Monday 5 – Friday 16 December 2016

Semester Two

Lectures/Practicals Start	Monday 9 January 2017
Lectures/Practicals End	Friday 31 March 2017
Easter Break & some fieldtrips	Sat. 19 March - Fri. 21 April 2017
Semester Two Exams	Monday 24 April – Wednesday 10 May

You are studying to gain a professional qualification. Attendance at lectures, practicals, field work and seminars is therefore mandatory. You will be penalised for missing any of these unless you have a valid reason, and may not be allowed to sit for examinations if you have not completed the required coursework.

EOS Modules

Year	Code	ECTS	Module Title	Convenor	Semes-ter
1	EOS104	15	Introduction to EOS	Eve Daly	1 & 2
2	EOS2101	5	Introduction to Field Skills	Shane Tyrrell	2
	EOS222	5	Ancient Earth Environments	Shane Tyrrell	2
	EOS225	5	Optical Microscopy of Minerals and Rocks	Sadhbh Baxter	2
	EOS213	10	Introduction to Oceanography	Martin White	1
3	EOS303	5	Ocean Dynamics	Martin White	2
	EOS304	5	Aquatic Geochemistry	Peter Croot	2
	EOS305	5	Applied Field Hydrology	Tiernan Henry	1
	EOS323	5	Sediments & the Sedimentary Record	Shane Tyrrell	1
	EOS3101	5	Geological Structures & Maps	TBA	2
	EOS3102	5	Environmental & Remote Sensing	Eve Daly	2
	EOS3103	5	Palaeontology and Evolution	John Murray	1
	EOS3104	5	Fieldskills Training	John Murray	2
	EOS3105	5	The Crystalline Crust	Sadhbh Baxter	1
4	EOS403	20	Final Year Project	Rachel Cave	1
	EOS4102	10	Minor Project	Rachel Cave	1
	EOS4103	10	Advanced Fieldskills	Anthony Grehan	1/2
	EOS4101	5	Earth Observation and Remote Sensing	Eve Daly	2
	EOS402	5	Global Change	Peter Croot	1
	EOS407	5	History of Life	John Murray	2
	EOS409	5	Biophysical Interactions in the Ocean	Martin White	2
	EOS417	5	Petrotectonics	Sadhbh Baxter	2
	EOS418	5	Applied Field Hydrogeology	Tiernan Henry	1
	EOS422	5	Sedimentary Basins	Shane Tyrrell	1

First Year	**EOS104 *Introduction to Earth & Ocean Sciences***	Semester 1 & 2 15 ECTS

Aims:

- To introduce students to the history and evolution of the Earth from the big bang to the present day.
- To introduce students to earth processes such as plate tectonics, volcanic activity, earthquakes, resources (*mineral, rock, water, oceans*).
- To introduce students to oceanographic concepts and earth's climate
- To introduce students to map and chart reading and map production
- To introduce the scientific method and basic mathematics to problems in earth and ocean science.
- To provide a set of transferable skills to other science modules.

Module Convenor: Eve Daly **Lecturers:** EOS staff
Practicals Convenor: Anika Rumstich

Format & Duration: 72 lectures (three lectures per week); one two-hour practical per week. 24 weeks (Semester 1 & 2).

Assessment: Theory paper 1 (30 %) examined end of Semester 1, Theory paper 2 (30%) examined end of Semester 2; Continuous assessment (40 %) includes a practical exam at the end of each semester, quizzes and academic writing. NOTE a student who fails the continuous assessment component will be deemed **incomplete** and cannot progress to second year until they repeat the module.

Structure: Semester 1 - Evolution of the Earth, geological processes
Semester 2 - The Oceans and hydrosphere

On successful completion of the module, students will:

- Understand the evolution of the Earth from the Big Bang to the present day.
- Be able to recognise and describe with illustrations various Earth processes.
- Be able to describe identify various earth materials (rocks and minerals).
- Be able to describe the basic properties of seawater
- Be able to read and make maps (contouring, profiling, map scales, geographic coordinates).
- Be able to apply standard scientific maths to problems in Earth and Ocean Science (e.g., dimensional analysis, SI units, conversion between units, scientific notations, basic calculations, graphing, etc.).
- Be able prepare scientific data for presentation in Microsoft Word, Excel and PowerPoint formats

Recommended Reading:

Marshak, S. (2010) *Earth: Portrait of a Planet 4th Ed*. W.W. Norton, New York.
Pinet, Paul R. *Invitation to Oceanography 6th Ed.* Jones & Bartlett.

Target Groups: Compulsory for EOS, Marine Science and Environmental Science students. Recommended to Physics, Chemistry and Biology students.

Second Year	**EOS2101 *Introduction to Field Skills***	Semester 2 5 ECTS

Aims: This is a field-based course, and will dominantly be taught during a five day residential field trip to Northern Ireland. Its aim is to introduce students to basic concepts in the earth sciences, e.g. field relationships, stratigraphy, records of environmental change and volcanic activity. It also aims to teach the basics skills required to collect and interpret data in the field, e.g. navigation and geological mapping. It is available to denominated Earth and Ocean Sciences students only.

Module Convenor: Shane Tyrrell **Lecturer:** Shane Tyrrell

Format & Duration: 6 hours of lectures during Semester 2 (weeks 7-12) and a 5 day field trip at the end of semester 2

Assessment:

Continuous assessment (100%)

Structure:

The course will cover: basic field skills; map navigation; the use of the compass clinometer; the principles of stratigraphy; interpretation of sedimentary depositional environments; Irish geological history; volcanic rocks; field relationships; geological map production.

On successful completion of the module, students will be able to:

- Recognise and interpret different field relationships and contacts
- Record the spatial distribution of rocks and produce a geological map
- Identify and explain the origin of sedimentary structures
- Measure the orientation of dipping layers
- Navigate ordinance survey maps
- Interpret ancient depositional environments from the sedimentary record
- Relate observations made in the field to Irish geological history
- Recognise a range of volcanic rocks in the field

Recommended Reading:

Stow, D.A.V. (2011). Sedimentary rocks in the field: A colour guide 6th Impression. Manson Publishing

Holland, C.H. & Sanders, I. (Eds.) (2009). *The Geology of Ireland 2nd Ed*. Dunedin Press.

Mitchell, W.I. (Ed.) (2004). *The Geology of Northern Ireland, 2nd Ed*.. Geological Survey of Northern Ireland

Prerequisite Module: EOS104

Target Groups: Compulsory for all EOS students

Second Year	**EOS213 *Introduction to Oceanography***	Semester 1 10 ECTS

Aims:

This module will cover the fundamental interactions between the oceans, the atmosphere, and the seafloor. Students will study how physical, chemical, biological and geological properties and processes shape the ocean we have today, and the key role of the oceans in Earth's climate.

Module Convenor: Martin White **Lecturers:** Martin White, Rachel Cave

Format & Duration:

36 lectures, 36 hours coursework; 12 weeks duration, Semester 1 weeks 1-12

Assessment:

Two-hour theory examination (50%) and continuous assessment including practical exam (50%)

On successful completion of the module, students will be able to:

- Explain the processes that exchange energy and water within the Earth system
- Describe the main sources, sinks and pathways of material in the oceans
- Explain how the temperature, salinity and density structure in the ocean arises and be able to distinguish different water masses on a T-S diagram
- Explain how waves and tides are generated in the oceans and how these in turn generate currents
- Recognise the difference between Eulerian and Lagrangian co-ordinate systems and measurement techniques and be able to represent them graphically
- Describe the process of hydrothermal circulation of seawater through the seabed and resulting transformations in the chemistry of seawater
- Describe the biogeochemical cycling of O_2, CO_2 and nutrients in the oceans
- Discuss the formation and global distribution of biogenic marine sediments
- Carry out simple calculations of volume transport and fluxes of material to and within the oceans
- Grasp the breadth of instrumentation used in oceanography and understand how a subset of these work and how they are used in oceanographic research

Recommended Reading:

Pinet, Paul R. *Invitation to Oceanography 6th Ed.* Jones & Bartlett.
Libes, Susan R. *Introduction to Marine Biogeochemistry 2nd Ed.* Elsevier.

Prerequisite Module: EOS104

Target Groups:

- Compulsory for EOS and denominated Marine Science students
- Strongly recommended to Environmental Science, Physics, Chemistry, Zoology and Botany students

Second Year	**EOS222 *Ancient Earth Environments***	Semester 2 5 ECTS

Aims: This module will investigate the generation and behaviour of sediment on the earth's surface and how sedimentary rocks record information about changing environment over geological timescales. Students will learn about processes such as weathering, erosion and sediment transport and how to differentiate and classify sedimentary rocks. Different sedimentary environments, and associated sedimentary structures, will be investigated with reference to the geological history of Ireland.

Module Convenor: Shane Tyrrell **Lecturer: Shane Tyrrell**

Format and Duration: 24 lectures which will include continuous assessment elements. 12 weeks duration (Semester 2)

Assessment: One two-hour theory examination (70%), continuous assessment (30%)

Structure:

- The principles of stratigraphy
- Origin of sediment
- Classification of sedimentary rocks
- Texture and composition of sandstones
- Transport of sediment
- Interpretation of depositional environments
- Irish geological history
- Biochemical sediments
- Modern and ancient glaciations
- Fluvial, shallow and deep marine environments
- Extraplanetary sedimentology

On successful completion of the module, students will be able to:

- Describe the principles of stratigraphy
- Discriminate and classify sedimentary rock types on the basis of grain size, texture and composition
- Compare the transport of sand grains by wind and water
- Distinguish the key framework components in clastic sedimentary rocks
- Describe how simple sedimentary structures form
- Contrast shallow and deep marine sedimentation
- Discuss Irish geological history in terms of environmental change
- Describe terrestrial depositional environments

Recommended Reading:

Stow, D.A.V. (2011). *Sedimentary rocks in the field: A colour guide' 6th Impression*. Manson Publishing

Tucker, M.E. (2001). *Sedimentary Petrology, 3rd Ed.* , Blackwell Science

Prerequisite Module: EOS104 **Co-requisite:** EOS225

Target Groups:

• Compulsory for EOS students. Optional for undenominated, Environmental Science and Marine Science students

Second Year	**EOS225 *Optical microscopy of Minerals and Rocks***	Semester 2 5 ECTS

Aims:
This module demonstrates how the petrographic microscope is used to identify minerals and study the textures of igneous, metamorphic and sedimentary rocks in thin section. It uses the wave theory of light to explain how polarised light interacts with the crystal structure of rock forming minerals. Optical properties of minerals and rock textures are studied and recorded, from both 'real' examples and the Open University's Virtual Microscope.

Module Convenor: Sadhbh Baxter **Lecturer:** Sadhbh Baxter

Format & Duration: 12 hours of lectures, 12 two hour practicals, 12 weeks duration, Semester 2

Assessment:
Two-hour theory exam (70%); practical exam (20%); continuous assessment (10%)

Structure:

- Explains how minerals and rocks can be identified using the transmitted polarising light microscope.
- Uses the optical classification of crystals to explore the optical properties that aid in the identification of the rock forming minerals in thin section e.g. refractive index, relief, pleochroism, interference colours and extinction.
- Introduces microscopic studies of typical mineral assemblages and textures in igneous, metamorphic and sedimentary rocks.

On successful completion of the module, students will be able to:

- Describe how polarised light interacts with the crystal structure of rock forming minerals; identify and record the optical properties: relief, pleochroism, interference colours and extinction
- Demonstrate competency with the petrologic microscope
- Distinguish between isotropism and anisotropism in minerals
- Describe the optical classification of crystals.
- Tabulate the optical properties of the main rock forming minerals
- Recognise record and illustrate typical textures in thin sections of igneous, metamorphic and sedimentary rocks; deliver a cogent thin section description of common igneous, metamorphic and sedimentary rocks.

Recommended Reading:
Perkins, D. & Henke, K.R. *Minerals in Thin Section* Prentice Hall
MacKenzie, W.S. & Adams, A.E. *Rocks & Minerals in Thin Section*. . Manson Publishing.
Klein, C. & Philpotts, A. *Earth Materials*.Cambridge University Press.

Prerequisite Module: EOS104 **Co-requisite:** EOS222

Target Groups: Compulsory for EOS students. Optional for other students

Third Year	**EOS303 *Ocean Dynamics***	Semester 2 5 ECTS

Aims:

This module will introduce students to the forces that control ocean and shelf dynamics. The module will introduce the different types of ocean currents and features such as wind driven flow, turbulence and mixing/diffusion. The fundamental links between these dynamics and basic biogeochemical cycling (nutrient and phytoplankton dynamics) will be explored.

Module convenor:

Martin White

Lecturers:

Martin White

Format & Duration:

18 lectures, six 3-hour practicals; Semester 2 weeks 1 to 6

Assessment:

Two-hour theory examination (70%) and continuous assessment (30%).

Structure:

- Basic forces that drive ocean circulation
- Large scale geostrophic, wind driven circulation, shelf sea dynamics
- Turbulence, mixing and vorticity
- Large scale nutrient and phytoplankton dynamics
- Benthic currents and sediment dynamics

On successful completion of the module, students will have:

- An appreciation of scales, dimensional analysis and problem solving
- Completed a case study through measurement and analysis of collected data
- Developed skills appropriate for a career in marine geoscience

Recommended Reading:

Stewart. R. *Introduction to Physical Oceanography* This is an online book that will be provided on Blackboard in pdf format

Pre-requisite Modules: EOS213 OR both EOS229 and EOS230

Target Groups:

- All EOS and non-denominated students
- Compulsory for denominated Marine Science students
- Recommended for Physics, Chemistry, Zoology, Botany and Microbiology students.

Third Year	**EOS304 *Aquatic Geochemistry***	Semester 2 5 ECTS

Aims: This module introduces students to the quantitative treatment of chemical processes in aquatic systems. It includes a brief review of chemical thermodynamics and photochemistry as it applies to natural waters. Specific topics covered include acid-base chemistry, precipitation-dissolution, coordination, and redox reactions. Emphasis is on equilibrium calculations as a tool for understanding the variables that govern the chemical composition of aquatic systems and the fate of pollutants.

Module Convenor: Peter Croot **Lecturers**: Peter Croot

Format and Duration: 24 lectures (4 hours per week for 6 weeks) The continuous assessment portion of this module will involve students making a short report and two short presentations (15 mins. each), one intended for scientists, the other to policymakers, on a topic covered in the module syllabus. The students will work in small groups to achieve this and the projected workload is c. 24 hours

Assessment:

Two hour theory examination (70%) and continuous assessment (30%)

Structure:

- Introduction to the key geochemical and biogeochemical processes in natural waters
- Acid/Base chemistry; Precipitation of solids from solution
- Redox reactions (Pourbaix diagrams); Complexation kinetics
- Photochemistry in Aquatic Systems

On successful completion of the module, students will be able to:

Construct and balance chemical equations for reactions in aquatic systems

Use thermodynamic data to calculate the solubility of minerals and construct stability diagrams

Use geochemical analyses of rocks and waters to determine and quantify weathering reactions, describe the main factors that control weathering rates

Know the main chemical elements and compounds of river water and sea water and explain why they are present and what sets their concentration

Explain important principles for oceanic element budgets and mass balances

Describe the behaviour of light in aquatic systems

Recommended Reading:

Essential: Chester & Jickells (2012). *Marine Geochemistry*. John Wiley & Sons.
Howard (1998). *Aquatic Environmental Chemistry*. Oxford Chemistry Primers. OUP.
Advanced: Morel & Hering (1993). *Principles and Applications of Aquatic Chemistry*. Wiley-Blackwell
Schwarzenbach, Gschwend & Imboden (1995) *Environmental Organic Chemistry*. Wiley-Interscience.

Prerequisite Modules: EOS213 OR both EOS229 and EOS230

Target Groups: All EOS students and students from other disciplines interested in the fundamental of (bio)geochemistry in natural waters.

Third Year	EOS305 Introduction to Applied Field Hydrology	Semester 11 5 ECTS

Aims:

Hydrology is the term that broadly describes the study of water on, in and above the Earth's surface. This introductory module is designed to introduce the students to the theories and concepts underpinning the discipline and to allow them to learn how to measure, estimate and calculate river and groundwater flows in the field and in the lab.

Module Convenor: Tiernan Henry **Lecturers**: Tiernan Henry

Format and Duration:
24 lectures and six practicals. Semester 1, weeks 1 to 6.

Assessment:
Two hour theory examination (70%) and continuous assessment (30%)**On successful completion of the module, students will:**

- Have an appreciation of the nature of the relationships that exist between water and the land;
- Be able to complete water balances at local and regional scales;
- know where and how to source data and information to prepare and produce water balances and water audits at various scales;
- Be able to compare and differentiate between methods for *measuring*, *estimating* and *calculating* hydrological data sets;
- Be able to assess past hydrological events and future (predicted) events and contextualise these into return intervals; and,
- Be able to incorporate field data, published data and interpreted data to make reasonable inferences about water and the land.

Recommended Reading:

Brassington, R. (2007). *Field Hydrogeology 3rd Ed*. Wiley, London
Fetter, C.W. (2001). *Applied Hydrogeology 4th Ed*. Prentice Hall, New York.
Shaw, E.M., Beven, K.J., Chappell, N.A. & Lamb, R. (2011). *Hydrology in Practice, 4th Ed*. Spon Press, London.
Chadwick, A., Morfett, J. & Borthwick, M. (2004). *Hydraulics in Civil & Environmental Engineering, 4th Ed*. Spon Press, London.

Prerequisite Module: EOS104

Target Groups: Highly recommended for EOS and undenominated science students who wish to take EOS in fourth year.

Third Year	EOS323 Sediments and the Sedimentary Record	Semester 1 5 ECTS

Aims: This module will take a detailed look at the characteristics of clastic, chemical, biogenic and volcaniclastic sediments and sedimentary rocks. Students will investigate how the sediments and rocks originate, learn about the range of depositional environments in which they accumulate and/or form, and examine their potential importance as an economic resource.

Module Convenor: Shane Tyrrell **Lecturers:** Shane Tyrrell

Format and Duration:
18 lectures, 18 hours practical laboratory work and 1 day field trip. 6 week duration (Semester 1, weeks 1-6)

Assessment:
One two-hour theory examination (70%) and continuous assessment/practicals (30%)

Structure:

- Sedimentary petrography
- The origin of limestones and carbonate reefs
- Volcaniclastic sediments
- Fluid mechanics and the formation of sedimentary structures
- Depositional environments through geological time
- Deltas, estuarine and shallow marine environments
- Sedimentary geochemistry
- Deep marine sedimentation and turbidites

On successful completion of the module, students will be able to:

- Interpret a range of sedimentary structures in rocks
- Describe the principles behind basic fluid mechanics
- Assess the petrography of a range of sedimentary rock types
- Interpret simple geochemical analyses of sedimentary rocks
- Reconstruct ancient depositional environments from observations made

Recommended Reading:
Reading, H.C. (1996). Sedimentary environments: Processes, Facies and Stratigraphy, 3rd Ed. Blackwell Publishing.
Collinson, J., Mountney, N. & Thompson, D. (2006) Sedimentary 3rd Ed. Terra Publishing

Prerequisite Module: EOS222

Target Groups:
• Compulsory for EOS students. Recommended for Environmental Science, Marine Science and undenominated students

Third Year	**EOS3101 *Geological structures and maps***	Semester 2 5 ECTS

Aims: Structural geology, the study of deformation in our planet's crust, is a core subject in the earth sciences. This module aims to cover the fundamentals of structural geology from both a descriptive and mechanistic perspective and will examine these processes at micro – (e.g. individual crystals) to macro-scales (global tectonics). Topics will include stress, strain, folding, faulting and plate tectonics. The course will be underpinned by practical work where the students will be introduced to methods and approaches used in interpreting geological maps, relationships and structures in 3-D.

Module Convenor: Tiernan Henry **Lecturers:** Tiernan Henry, Shane Tyrrell

Format and Duration:
12 one hour lectures and 12 two hour practicals over 12 weeks in semester 2.

Assessment:
2 hour written exam (50%); Continuous assessment of practical classes (50%)

Structure:
Topics will include stress, strain, folding, faulting and plate tectonics. The course will be underpinned by practical work where the students will be introduced to methods and approaches used interpreting geological maps and structures in 3 dimensions.

On successful completion of the module, students will be able to:

- Investigate large-scale earth structure and plate tectonics
- Discriminate and classify geological structures
- Describe how geological structures are formed
- Investigate and contrast stress and strain in rocks
- Use 2-D map data to create 3-D interpretations of subsurface geology
- Interpret geological relationship, structures and histories based on mapped data.

Recommended Reading:

Bennison, G.M., Olver, P.A. & Moseley, K.A. (2011). *An Introduction to Geological Structures and Maps* 8th Ed. Hodder Education.

Park. R.G. (2012). *Foundations of Structural Geology*, Springer Netherlands

Price, N.J. & Cosgrove, J.W. (1990). *Analysis of Geological Structures*

Lisle, R.J. (2003). *Geological Structures and Maps - A practical guide*

Prerequisite Modules: EOS222 and EOS225

Target Groups: Core for 3EH2, optional for 3BS9

Third Year	**EOS3102 *Environmental and remote Sensing***	Semester 2 5 ECTS

Aims: This module will introduce students to a series of geophysical remote sensing techniques for exploring the near-surface in both terrestrial and marine environments. The results will be used to explain key chemical, geological, hydrogeological and physical processes beneath the surface and how these can aid the monitoring of geo-hazards and management of near-surface resources. Specifically the course will introduce students to an array of Geophysical methods.

Module Convenor: Eve Daly **Lecturer: Eve Daly**

Format and Duration:
18 lectures and 6 three-hour practicals. Semester 2 weeks 7 to 12

Assessment:

Two-hour theory exam (70%) and assessment of practical work (30%)

Structure:

- Terrestrial and marine Gravity and Magnetic methods and case studies
- Terrestrial and marine seismic methods and case studies
- Terrestrial and marine electrical methods and case studies
- Topographic and bathymetric mapping

On successful completion of the module, students will be able to:
Describe the theory and field operation of a range of applied geophysical methods
Distinguish between each method and when they should be used
Interpret data from the above datasets in a geological context.
Design a geophysical survey to investigate a certain problem, given site history and regional geology.

Recommended Reading:

- Reynolds, J 1997, *An introduction to applied and Environmental geophysics*
- Mussett, A.E. and M.A. Khan 2000, *Looking into the Earth: An introduction to geological geophysics*
- Gibson, Paul J. 2004, *Environmental applications of geophysical surveying techniques*
- *Jones, E .J. W, 2004 Marine Geophysics*

Prerequisite Module: EOS104

Target Groups:
Core for denominated EOS students (3EH1), optional for Marine Science (3MR1), non-denominated (3BS1) and Environmental Science (3EV1) students.

Third Year	EOS3103 Palaeontology & Evolution	Semester 1 5 ECTS

Aims: This module will introduce students to palaeontology (the study of fossils). All of the major animal groups, who have left their mark in the fossil record, will be examined, along with trace fossils. Emphasis will be placed firmly on understanding form and function in organisms and how it has related to their habitat over time. The module will finish with the topic of human evolution.
Students will be trained to think both logically and critically; they will be shown how to develop arguments and answer questions based on the data available to them (or indeed collected by them in class). The background theme of the entire module will be to provide students with an appreciation for the story of evolution of life on Earth over the past c.541 million years.

Module Convenor: John Murray **Lecturers**: John Murray

Format and Duration:
24 lectures and 6 two-hour practicals. Semester 1 weeks 7 to 12

Assessment:

Two-hour theory exam (70%) and assessment of practical work (30%)

On successful completion of the module, students will:

- Label and describe the basic body plans of a wide range of invertebrate and vertebrate (fossil and living) groups.
- Explain some of the physical principles governing the body construction of organisms.
- Recognise the link between form and function in organisms and to then apply that insight to understanding how various creatures interact with their physical living environments (both at present and also in the past).
- Identify trace fossils and interpret their palaeoecological significance.
- Describe and appraise the history of life on planet earth.
- Collect, record and appraise scientific data.
- Apply biological data/information not just qualitatively, but also quantitatively.

Recommended Reading:

- Benton, M.J. & Harper, D.A.T. (2009). *Introduction to Paleobiology and the Fossil Record.* Wiley-Blackwell.
- Wyse Jackson, P.N. (2010) *Introducing Palaeontology: A guide to ancient life.* Dunedin.

Prerequisite Module: EOS222. **Co-requisite:** EOS323

Target Groups:
Core for denominated EOS students (3EH2), optional for Marine Science (3MR2), non-denominated (3BS9) and Environmental Science (3EV2) students.

Third Year	**EOS3104 *Field skills training***	Semester 2 5 ECTS

Aims: This module is largely field-based and will provide students with the basic field skills that are required for Earth and Ocean Sciences (both in research and industry). The approach to the field skills element of the course will be strongly 'hands on' with students gaining valuable experience in geological, hydrogeological and oceanographic methods of data collection. They will gain experience in dealing with a wide range of rock types and structures in the field and will learn how to subsequently digitise maps and logged sections (created in the field) for presentation purposes. This course is specifically designed to train and prepare Earth and Ocean Science students for their dissertation work in the final year.

Module convenor: John Murray **Lecturers:** EOS staff

Format & Duration: This module is almost entirely field-based. Students complete six days of intensive (residential) fieldwork at the end of Semester 2. There will be some preparatory briefing workshops prior to the fieldtrip and additional computer processing/work upon returning to NUI Galway.

Assessment: Continuous assessment of field sheets, maps & notebooks (100%). Three-hour practical examination for repeat students.

On successful completion of the module, students will be able to:

- Collect and record scientific data (qualitative and quantitative) in the field, and subsequently appraise it.
- Identify and describe a wide range of rock and sediment types at outcrop level.
- Interpret palaeoenvironments of different geological units using sedimentology and palaeontology (body and trace fossils).
- Apply standard methods for hydrogeological investigations.
- Determine the influence of tides and tidal patterns on coastal morphology.
- Appraise the degree to which the underlying geology of any given area influences landscape development and evolution.
- Construct a geological/geomorphological map for a given study area.
- Compile a digitised (computer) version of the map produced in LO7 for presentation purposes.

Recommended Reading:

Barnes, J.W. & Lisle, R.J. (2003). *Basic Geological Mapping* 4th Ed. Wiley-Blackwell.
Stow, D.A.V. (2005). *Sedimentary rocks in the field*. Manson.
Goldring, R. (1999). *Field Palaeontology* 2nd Ed. Longman.
Brassington, R. (2009). *Field Hydrogeology*, 4th Ed.

Prerequisite Modules: A minimum 20 ECTs from second-year EOS modules

Co-requisites: EOS3101 and an additional 30 credits of EOS courses in third year. This would bring students up to a total of 40 ECTS of EOS-related subjects in third year - which would qualify them to enter final year EOS.

Target Groups: Core for denominated EOS students and compulsory for non-denominated students who are considering continuing in EOS in 4th year. Undenominated students should carefully note the prerequisites and co-requisites required.

Third Year	**EOS3105 *The Crystalline Crust***	Semester 1 5 ECTS

Aims: This module looks at the crystalline (igneous & metamorphic) rocks of the Earth's crust. The mineralogy, texture, tectonic setting and origin of these rocks will be examined.

Module Convenor: Sadhbh Baxter **Lecturer:** Sadhbh Baxter

Format and Duration: 24 hours of lectures, 6 three hour practicals, 12 weeks Duration, Semester 1

Assessment:
Two-hour theory exam (60%); continuous assessment (25%); practical exam (15%)

Structure: The course starts with an introduction to the 'tools of the trade': the interpretation of geochemistry, mineralogy, textures, phase diagrams. The creation of oceanic crust at mid-ocean ridges (MOR) is then examined, with reference to melt production, and the hydrothermal alteration processes that occur at MOR. The third part of the course focuses on processes at subduction zones: the metamorphism of the subducting oceanic lithosphere, the generation of magma, and the creation of new continental crust.

On successful completion of the module, students will be able to:

- Describe & identify (in hand specimen & thin section) the main igneous & metamorphic rocks
- Interpret (in hand specimen & thin section) textural & mineralogical features of the main igneous & metamorphic rocks
- Classify global igneous & metamorphic processes & products and their links with plate tectonics
- Describe how the chemistry of an igneous rock determines it mineralogy.
- Describe how the chemistry of the protolith & the agents of metamorphism determine the mineralogy of the resultant metamorphic rock.

Recommended Reading:

http://www.open.edu/openlearn/science-maths-technology/science/introduction-minerals-and-rocks-under-the-microscope/content-section-0
Perkins, D & Henke, KR. *Minerals in Thin Section*
MacKenzie, WS & Adams, AE. *Rocks & Minerals in Thin Section*
Deer, WA, Howie, RA, & Zussman, J. *An introduction to the rock-forming minerals*
Best, MG. *Igneous & metamorphic petrology*

Prerequisite Module: EOS225

Target Groups:
Compulsory for EOS students, optional for other students who fulfil the pre- and co-requisites

Fourth Year	**EOS402 *Global Change***	Semester 1 5 ECTS

Aims: This module introduces students to multi-disciplinary studies of the physical forcings and earth/ocean system responses that induce and drive environmental change on different temporal and spatial scales. Emphasis is placed on understanding and communicating the basic science behind natural climate cycling (e.g. Milankovitch/ENSO) and more recent anthropogenic forcings (e.g. fossil fuel burning, agricultural practices).

Module Convenor: Peter Croot **Lecturer:** Peter Croot

Format & Duration:
24 lectures (4 hours/week, Semester 1 weeks 7-12) Students will also work in small groups to make a short report and two 15 minute presentations, one intended for scientists, the other to policymakers, on a topic covered in the module syllabus.

Assessment: Two hour theory examination (70%) and continuous assessment (30%)

Structure: This module introduces students to multi-disciplinary studies of the physical forcings and earth/ocean system responses that induce and drive environmental change on different temporal and spatial scales. Emphasis here is placed on understanding and communicating the basic science behind both natural climate cycling (e.g. Milankovitch/ENSO) and more recent anthropogenic forcings (e.g. fossil fuel burning and agricultural practices).

- Physical drivers of climate change over different temporal scales (e.g. Milankovitch theory, ENSO, anthropogenic CO_2)
- Paleoclimate research (ice cores, glacial environments, sediment records, isotopes, Heinrich events)
- Examining the science behind climate research (ocean and atmosphere)
- Global modelling of climate and the IPCC assessment process – communicating climate science to the public and policymakers
- How land/ocean use practices can alter ecosystems resulting in changes to climate, including climate mitigation/geoengineering strategies.

On successful completion of the module, students will be able to:

- Critically discuss the basic science behind the natural processes that impact global climate. Explain the role of the IPCC and how it works
- Recognize and interpret geological and chemical indicators of present and past global change in the environment (atmosphere, water, sediment/mineral).
- Evaluate and appraise how human activities can be drivers of global change
- Develop knowledge of current climate change adaptation strategies
- Compile scientific information from multiple sources and prepare a briefing document for a general audience
- Present scientific perspectives on global change to both a specific scientific audience and to the general public

Recommended Reading: To be supplied by lecturer.

Prerequisite Module: EOS104 (may be waived at the discretion of EOS)

Target Groups: All EOS students and students from other disciplines interested in the physical aspects of climate change

Fourth Year	**EOS403 *Field Project/ Honours Dissertation***	**Summer & Semester 1 20 ECTS**

Aims:

This module will provide students with the advanced field and computational skills that are required for Earth and Ocean Sciences graduates seeking employment in either research or industry. The underlying core philosophy is to have students

- Collect a wide variety original data in the field, in a range of environments
- Process & analyse this data (i.e. to solve problems) *and*
- Produce an original (dissertation) report.

In addition, students are required to carefully plan and organise the logistical side of their project (i.e. engage in project management) and to produce deliverables (presentations, drafts and a final report) according to deadline.

Module Convenor: Rachel Cave **Lecturers:** EOS staff

Format and duration:

Field and lab work will be completed in the summer months between third and fourth year. Workshops, seminars and presentations happen throughout Semester 1 of final year, along with any required additional lab analyses.

Assessment:

The thesis will be examined by continuous assessment based on: performance in field; data acquisition (evidence from notebooks etc.), data processing, data interpretation, poster and oral presentations, draft final report and the quality of the completed thesis. A detailed timetable for submission will be given to students at the start of fourth year.

Structure:

- Field data collection, processing and interpretation
- Generation of Maps and profiles
- Presentation of results in both oral and poster formats
- Report (thesis) writing and submission, along with field sheets and notebooks

Recommended Reading:

Contingent on the project topic being investigated – project supervisors will advise students accordingly.

Prerequisite Modules: EOS3101, 3104 and an additional 30 ECTS (minimum) from EOS 3rd year

Target Groups: Compulsory for EOS students unless taking EOS4103 Minor Project.

Fourth Year	**EOS407 *History of Life***	Semester 2 5 ECTS

Aims: This module will explore, in detail, the major events in the story of the evolution of life on earth, as relayed to us through the fossil record. Topics to be covered will include the origin of life, appearance of eukaryotes and development of metazoans (multicellular organisms) in the Precambrian; the Cambrian Explosion and Ordovician Biodiversification Events; the conquest of terrestrial environments); mass extinctions and the rise of mammals in the Palaeogene and Neogene. The ethos of this module will be quite holistic in approach (i.e. using a wide range of geological, palaeontological as well as biological data sources); however, the narrative will be from a palaeontological perspective.

Module Convenor: John Murray **Lecturers:** John Murray

Format and Duration: 24 lectures and 6 three-hour workshops. Semester 2 weeks 1-6

Assessment: Two hour theory exam (70%) and assessment of practical work (30%)

Structure:

The origin of life in a harsh primeval Precambrian world (setting the scene); origin of eukaryotes and the Garden of Ediacara; Cambrian Explosion and the Burgess Shale; Ordovician biodiversification; conquest of land; Mesozoic monsters and their feathered friends; mass extinctions; the rise of mammals in the Cenozoic

On successful completion of the module, students will be able to:

- Discuss and appraise the various theories relating to the origin of life on earth.
- Recount (in chronological order) and describe the significant events in the history of life.
- Discuss and appraise the effects the earth has had on influencing the evolution of the biosphere (and vice versa).
- Critically assess the currently accepted hypotheses and models, which attempt to explain the significant events in the evolutionary history of life.
- Compile scientific information, from a number of sources, and use this to prepare a script and storyboard for a documentary film.
- Employ the script and storyboard developed in LO5 to produce a short documentary-style film, which will communicate or explain an evolutionary idea or concept to a wider audience.

Recommended Reading:

Cowen. R. (2013) *History of Life (5th Edition)*. Blackwell Publishing.

Briggs. D.E.G. & Crowther P.R. (Eds) (2001) *Palaeobiology II*. Blackwell Science, 584.

Selden, P. & Nudds, J. (2005) *Evolution of Fossil Ecosystems*. Manson Publishing.

Prerequisite Module: EOS3103

Target Groups:
Optional for denominated EOS (4EH1) students. Also recommended for denominated marine science students and final year biologists (in particular zoologists and botanists) - provided they have fulfilled the prerequisites.

Fourth Year	**EOS409 *Biophysical & Biogeochemical Interactions in the Oceans***	Semester 2 5 ECTS

Aims:

This module examines biophysical and biogeochemical interactions in the ocean through critical reviews of a series of peer reviewed published literature on a number of topics related to ecosystem functioning at the continental margin and other topographic features. Linkage of physical processes to chemical cycling and biological distribution and habitat function will be demonstrated.

Module Convenor: Martin White

Lecturers: Rachel Cave, Robin Raine, Martin White

Format and Duration:

24 lectures (4 hours per week for ~ 6 weeks). The continuous assessment element of this module will involve students abstracting scientific papers and producing a short presentation and report on a topic covered in the module syllabus.

Assessment:

Two hour theory examination (50%) and continuous assessment (50%)

Structure:

The module focuses on seamounts and benthic ecosystems, seasonal fluxes to the deep sea, frontal processes, global influences and feedbacks. Tutorials are used to highlight the basic physical and chemical processes related to a number of case studies and elements are critically analysed through review of 3-4 publications on each topic.

On successful completion of the module, students will have acquired:

- Critical review/analysis skills of published reports/works
- Abstract writing and other writing/presentation skills
- Skills appropriate for a career in marine geoscience

Recommended Reading:

To be supplied by lecturers. Typically 3 topics with ~4 publications per topic

Prerequisite Modules: EOS313 OR both EOS303 and EOS304

Target Groups:
Optional for denominated EOS (4EH1) students. Also recommended for denominated marine science students and final year biologists (in particular zoologists and botanists) - provided they have fulfilled the prerequisites.

Fourth Year	**EOS417 *Petrotectonics***	Semester 2 5 ECTS

Aims: This module introduces petrotectonics which links the formation of igneous, metamorphic and sedimentary rocks with plate tectonics in space and time. It addresses the question of how and to what degree Archean plate tectonics differed from modern plate tectonics and what these differences mean in terms of Earth evolution.

Convenor: TBA **Lecturer: TBA**

Format and Duration:
18 one-hour lectures and 6 three-hour practicals, Semester 2 weeks 7 to 12

Assessment: Two-hour theory exam (70%); practical work assessment (30%)

Structure:

- Explores linkages between petrology (igneous, metamorphic and sedimentary rocks) and plate tectonics (i.e. petrotectonics).
- Interrogates the evolutionary history of the Earth's lithosphere with emphasis on cratons.
- Tracks plate tectonics with time by investigating well documented petrotectonic assemblages in the geological record.
- Addresses the question: how far back in time are the same petrotectonic assemblages found today, and are their time/space relationships, tectonic histories and chemical compositions similar to modern assemblages.
- Investigates petrotectonic processes using data (linked to quantitative modelling sessions), taken from geochronology, geothermobarometry and pressure-temperature–time (P-T-t) paths

On successful completion of the module, students will be able to:

- Link petrology (igneous, metamorphic and sedimentary rocks) in space and time with plate tectonics
- Apply the principles of geothermobarometry to estimate pressure and temperature of dynamo-thermal metamorphism
- Use geochronometric data to plot pressure-temperature-time (P-T-t) paths
- Compare Archaean cratonic rock assemblages with those present in recent orogenic belts
- Describe the petrology of granulites and komatiites in thin section and hand specimen. Tabulate the distribution of petrotectonic assemblages with time
- Present a petrotectonic model(s) for 100Ma from now.
- Discuss to what degree Archaean plate tectonics differed from modern day tectonics

Recommended Reading:
Best, M.G. (2003). *Igneous and Metamorphic Petrology*. Blackwell Publishing.
Yardley, B.W.D. *An Introduction To Metamorphic Petrology*. Longman.
Klein, C. & Philpotts, A. (2012). *Earth Materials* Cambridge U. Press.
Condie, K. (1997). *Plate tectonics and crustal evolution*. Butterworth Heinemann

Prerequisite Modules: EOS314 OR both EOS321 and EOS322
Target Groups: Optional for denominated EOS (4EH1) students

Fourth Year	**EOS418 *Applied Field Hydrogeology***	Semester 1 5 ECTS

Aims: Groundwater is one of our key water resources, yet it is also one that is stressed by natural processes and human activities. Managing groundwater is a mix of science, regulation and politics. This module focuses on understanding groundwater in its geological setting and explores the ways in which groundwater affects and is affected by the medium in which it is stored and through which it flows.

Module Convenor: Tiernan Henry **Lecturers**: Tiernan Henry

Assessment: Two-hour theory examination (70%) and continuous assessment (30%).

Format and Duration: 24 lectures and 6 practicals. Semester 1 Weeks 7 to 12

Structure:

- Analysis and explanation of pumping tests and pumping test outputs; Interpretation of data outputs in the context of geology and hydrogeology;
- Assessment and examination of groundwater chemistry data sets to generate hydrochemical facies;
- Contrast and distinguish between conflicting genetic models of mineral deposition;
- Critically examination of hydraulic fracturing as a means of resource extraction.

On successful completion of the module, students will be able to:

- Analyse and explain pumping test data outputs
- Interpret data outputs in the context of geology and hydrogeology
- Assess and examine groundwater chemistry data sets to generate hydrochemical facies
- Contrast and distinguish between conflicting genetic models of mineral deposition
- Critically examine hydraulic fracturing as a means of resource extraction
- Undertake critical evaluation and review of reports and research papers
- Frame research questions in the context of water resource management.

Recommended Reading:

Brassington, R. (2007). *Field Hydrogeology 3rd Ed*. Wiley, London

Fetter, C.W. (2001). *Applied Hydrogeology 4th Ed*. Prentice Hall, New York.

Freeze, R.A. & Cherry, J.A. (1979). *Groundwater*. Prentice Hall, New York.

Domenico, P.A. & Schwartz, F.W. (1998). *Physical and Chemical Hydrogeology 2nd Ed*. Wiley, London.

Prerequisite Module: EOS311 OR EOS305.

Target Groups: Recommended for students wishing to pursue postgraduate study in hydrogeology or to work in the practice.

Fourth Year	**EOS422 *Sedimentary Basins***	Semester 1 5 ECTS

Aims: Sedimentary basins comprise a long time-scale record of environmental change on the earth's surface and are hugely economically important. Almost all commercial hydrocarbons are contained within sedimentary basins – they also comprise groundwater aquifers and potential sites for sequestered carbon dioxide. This module will investigate the origin, evolution and architecture of sedimentary basins, and examine in detail the many techniques which are used in basin analysis.

Module Convenor: Shane Tyrrell **Lecturers:** Shane Tyrrell

Format and Duration: 24 lectures and a "sedimentary basins" workshop, 6 week duration (Semester 1, week 7-12)

Assessment: Two hour written paper (70%) and workshop presentation (30%)

Structure:

- Origin, formation and structure of basins
- External and internal controls on basin fill and architecture
- Sedimentary provenance analysis
- Use of geophysical techniques in basin analysis
- Correlation and dating of sedimentary sequences
- Thermal and burial history of basins
- Sequence stratigraphy
- Petroleum systems and hydrocarbon prospectivity in Irish offshore basins.

On successful completion of the module, students will be able to:

- Describe the origin and evolution of sedimentary basins
- Outline the fundamental elements of basin analysis
- Investigate the factors that control sediment dispersal into basins
- Assess hydrocarbon prospectivity in sedimentary basins offshore Ireland
- Plan independent research on a topic related to sedimentary basin
- Describe the elements of petroleum plays and the petroleum system concept
- Communicate the results of individual research to an audience of peer
- Describe the geophysical techniques used to characterise sedimentary basins in the subsurface

Recommended Reading:

'Basin Analysis – principles and applications' P. Allen & J.R. Allen, 1990
'Sequence Stratigraphy' by D. Emery & K.J. Myers, 1996, Blackwell Science
"Sedimentology and Stratigraphy" by G. Nichols, 2009. Wiley Blackwell, 2nd Edition
'Sedimentary environments: Processes, Facies and Stratigraphy' by H.C. Reading. 3rd Edition.1996, Blackwell Publishing

Prerequisite Module: EOS323
Target Groups: Strongly recommended for EOS students

Fourth Year	**EOS4101 *Earth Observation & Remote Sensing***	Semester 2 5 ECTS

Aims: This module will introduce students to an array of Remote sensing techniques used in Earth Observations. It will include Satellite, Airborne (plane and drone) and Marine based technologies. Students will be introduced to the theory of electromagnetic radiation, remote sensing systems, Multispectral scanners, Radar instruments, Photogrammetry. Image processing and image interpretation will also be covered. The data provided from these methods can be used to help understand the physical, chemical, and biological processes acting on the earth's surface. Applications include environmental monitoring climate change. Specifically geological mapping, marine and terrestrial habitat mapping, agriculture, coastal erosion, flood mapping, land use mapping and archaeology will be covered.

Module Convenor: Eve Daly **Lecturers**: Eve Daly

Format & Duration: 24 lectures, 12 hours field work/practicals. Semester 2 weeks 1-6

Assessment: Two hour theory examination (70%) and continuous assessment (30%)

Structure:

- Theory behind passive Electromagnetic remote sensing and Active remote sensing methods of Radar, Lidar and Acoustics
- Acquisition and image processing procedures
- Case studies

On successful completion of the module, students will be able to:

- Explain the concept of electromagnetic energy (EM) including the principles of remote sensing (sources of radiation, EM energy interaction with the atmosphere, EM energy interaction with terrestrial targets, spectral properties of terrestrial targets).
- Appreciate the variety of sensors available and their resolution properties (i.e. spatial, spectral, radiometric, and temporal)
- Grasp the principle of image acquisition from a variety of platforms. Satellite, Airborne and Drones and integration of remotely sensed images into a GIS environment
- Relate remote sensing technologies to successful applications of Earth observation and monitoring (e.g., geology, atmospheric sciences, water resources, oceanography, agriculture, and forestry)

Recommended Reading:

James B. Campbell 211, *Introduction to Remote Sensing,*, Fifth Edition Ed. [ISBN: 978-160918176]
Seelye Martin 2014, *An Introduction to Ocean Remote Sensing*, second Ed. [ISBN: 978-11070193]

Prerequisite Modules: EOS104 and/or PH101

Target Groups: All EOS and non-denominated students

Fourth Year	**EOS4102 *Minor Project***	Semester 1 5 ECTS

Aims: This is a computer/lab-based module which aims to give students a range of transferable skills, while completing a minor project based on existing EOS data.

Module Convenor: Rachel Cave **Lecturers**: Rachel Cave

Format and Duration: 12 weeks, 3/4 hours lectures/labs per week plus 12 hours independent work per week

Assessment: Lab notebook/diary of work in progress and work completed (20%), Oral Presentation of project & poster (10%), Skills assessment (20%), Project report (50%).

Structure:

- Setting up a database: Students will get an introduction to the international databases available to Earth & Ocean scientists, see how their data will add to these datasets, and learn how to construct data tables so they can be easily added to databases.
- Geographic Information Systems: Students will be introduced to geographic information systems, shown how to construct a base map and how to locate the sampling positions for their dataset on the map
- Data Analysis: Students will be given examples of how data of the type they are dealing with is analysed and will apply these analysis methods to their dataset
- Formulating and testing a hypothesis: Students will use their knowledge to generate hypotheses about their data and to test them. Concepts such as the null hypothesis will be explained and tried.
- Presentation of results: Students will create a poster and give an oral presentation on their data and results
- Report Writing: Students will be given a set of report writing criteria, information on report layouts and on correct referencing, and will generate a final report for the project.

On successful completion of the module, students will be able to:

- Set up a spreadsheet and populate a database
- Produce a GIS map for a given region and populate it with sampling locations
- Process and analyse a range of EOS datasets/samples
- Carry out statistical and trend analysis on datasets
  Produce a detailed correctly formatted report on their dataset and the results of their analysis.
- Create and present a talk on their results using presentation software

Recommended Reading: Depends on dataset, will be given by lecturer

Prerequisite Modules: EOS213 (or EOS229 and 230) plus EOS 3rd year

Target Groups: Final Year EOS only

Fourth Year	**EOS4103 *Advanced Field Skills***	Semester 1 & 2 5 ECTS

Aims:
This is a 5ECTS practical/field course designed to give students further exposure to applied techniques in their chosen specialist area. Students select one of the two options available. NOTE that student choice is constrained by completed pre-requisites and applicability, and all choices must be approved by the EOS academic team. The work will be completed across semester one (Oceanography) or semester two (Geology). There will be a cost per student associated with this module, which will be announced early in Semester 1 (cost was €250 in 2015/16 which covered all travel, accommodation, instrumentation etc.)

Module Convenor: Anthony Grehan (Oceanography), TBA for Geology
Lecturers: EOS staff

Format and duration:
Students take 1 field/practical components from a choice of 2, with the choice dependent on having the required pre-requisites. Semester 1 or 2.

Assessment:
This module will be examined by continuous assessment based on: data synthesis and presentation; performance in field/practicals; data acquisition data processing, data interpretation, report writing, online tests.

Option 1: Field Skills in Oceanography – SMART Shiptime (Anthony Grehan)
This option will provide students with advanced shipboard training in survey planning and oceanographic sampling techniques and data analysis for environmental impact assessment. This is a designated SMART (Strategic Marine Alliance for Research and Training) module, composed of self-guided on-line learning followed by 2 day shipboard training in environmental impact assessment techniques. Semester 1 weeks 5-12, shiptime training will be in November

Option 2: Advanced Geological Field Skills (Lecturer TBA)
This component will comprise residential field work, specifically the application of a variety of geological field skills including mapping, logging and the interpretation of sedimentological and structural data. Training, data collection and reporting will take place during up to six days in the field. This component will run in semester 2.

Recommended Reading: Reading lists will be supplied by the lecturers

Prerequisite Modules: EOS3101, EOS3104 and an additional 30 ECTS (minimum) from EOS 3rd year

Target Groups: Final Year EOS only

NOTES