GEOL 10050: Earth and Humanity

MODULE COORDINATOR: Assoc. Prof. Patrick Orr

ADDITIONAL LECTURERS: Prof. Stephen Daly
Dr Eoghan Holohan
Dr Ivan Lokmer
Assoc. Prof. Julian Menuge

CREDITS: 5	**MODULE LEVEL**: 1	**SEMESTER**: I and II

PRE-REQUISITES/PRIOR LEARNING:

This is an introductory level module and no prior knowledge is required. It is offered in both Semester I and Semester II.

OVERVIEW OF MODULE:

This module considers how geological agents have shaped the pattern of human evolution, the development of agricultural and early industrial civilisations, and impact on the general health of these and today's societies. The lectures are supplemented by a comprehensive on-line learning resource. The first part investigates how environmental conditions (e.g. fluctuating climatic conditions, natural resource availability, geohazards and catastrophic natural events) influenced the evolution, migration and settlement patterns of hominid and early-modern human populations in the recent geological past. The second part of the module examines how, over the past ten thousand years, geology has influenced the development of agriculture, cities and an increasingly sophisticated use of metals, water and other earth resources up to the Industrial Revolution. The increasing effect of humans on the environment over time will be explored, including examples of civilisations ended by their own environmental impact; the collapse of civilisations as the result of external geological forces is also considered. The third part of the module focuses on how geological and related environmental factors continue to exert strong effects on the health and wellbeing of billions of people in the 21st century. Medical Geology, an emerging discipline in environmental and human health, is introduced. Case studies will be used to illustrate the beneficial and harmful effects of metals, metalloids and mineral dust on human health and their links with geological environments. The module complements GEOL10040, in which the current and future impact of humans on the global system is considered.

LEARNING OUTCOMES:

The goal of this module is to provide students with an appreciation of: (a) how external factors related to the Earth System, including regional and global climate change and catastrophic events, have shaped the record of human evolution, migration and, subsequently, the development and structure of societies;(b) the principal geological factors that have contributed to the development and structure of agrarian and industrialised societies;(c) how humanity has come in turn to exert major impacts on the Earth, and, in particular, how the health of societies in the past and today is inextricably interlinked with the geological context, both the solid Earth and its hydrosphere, biosphere and pedosphere.

ASSESSMENT:

Multiple Choice Questionnaire: 45%
(40-minute MCQ mid-term exam on first part of course)

Multiple Choice Questionnaire: 55%
(1-hour MCQ end of semester exam on second part of course)

LECTURES:

Lecture 1: Introduction to the module: key concepts. *(Dr P.J. Orr)*
Scope and structure of the course. Sources of data: the nature and quality of the fossil (geological and archaeological) record. The geological timescale. Principles of stratigraphy (Lithostratigraphy. Chronostratigraphy). Putting fossil distributions and environmental reconstructions in a temporal context: chronostratigraphy and absolute dating methods calibrate the geological timescale, Phylogenetic context of hominins.

Lecture 2: Geological context to hominin evolution. *(Dr P.J. Orr)*
The tectonic evolution of the east African region. What drives climate change over time? A review of the major mechanisms, fluctuations in which potentially impact on climate (astronomical cycles,biogeochemical processes, especially greenhouse gases, solar activity, volcanic activity, tectonics). Reconstructing ancient environments. The principles behind selected geochemical, biological and sedimentological proxies that have been used to assess climate change, with particular reference to hominin-bearing sections in eastern Africa. Sedimentological facies analysis, chemical signals, data from fossils including palaeobotany. Isotope-based reconstructions of diet and environment.

Lecture 3: Miocene-Recent climate change in eastern Africa. *(Dr P.J. Orr)*
A summary of the principal changes in climate in the region over the past 20 million years that have been identified using the various proxies described in L2. The early hominin fossil record. The distribution of species in time and space, and the palaeoecology of, and environments inhabited by, key taxa.

Lecture 4: The genus Homo: 1st steps in Africa. *(Dr P.J. Orr)*
A review of the early history of the genus Homo in Africa and its initial dispersal (H. erectus) into Eurasia. Main trends and patterns in hominin evolution. Having considered the principal taxa allows review of several key trends in hominin evolution to be identified, e.g. developing bipedality, changes in dentition, progressive increase in brain size.

Lecture 5: To what extent was human evolution driven by changes in climate and environment? *(Dr P.J. Orr)*
Changes in air temperature and rainfall amount/distribution. Impacts on agriculture, local and global ecosystems. Impacts on mountain glaciers and high latitude ice-sheets. Ocean circulation changes. Impact on sea-level. Ocean warming and acidification. Impact on corals reefs. Likely impact of climate change on species, disease and human populations.

Lecture 6: The final step: Out of Africa. *(Dr P.J. Orr)*
The sole living descendant species, Homo sapiens, originated in Africa and is now essentially global in its distribution. What were the initial stages of this dispersion? We consider the potential impact of the introduction of this invasive species on existing ecosystems by examining the extinction of the Neanderthals: Sex, genocide and climate change: the fate of the Neanderthals.

Lecture 7: Use of earth materials and energy from 10,000 to 6,000 years ago. *(Dr J.F. Menuge)*
Metals from the Bronze Age to the Industrial Revolution. The discovery of bronze and its use. Properties of alloys compared to native metals. The advantages of iron and problems of smelting and working it. Plate boundaries and the restricted geological sources of easily used metal ores. Fuel supplies and their constraints on smelting. Settlement and trade patterns related to metal production and use. Early mining and metal production in Ireland.

Lecture 8: Use of earth materials and energy from 6,000 to 2,000 years ago. *(Dr J.F. Menuge)*
Non-metallic minerals from the Bronze Age to the Industrial Revolution. The physical and chemical processing of rocks and minerals to create new products. Limestone and the manufacture and use of lime and cement; sea salt and rock salt; plaster from gypsum; glasses, glass technology and the quest for transparency; minerals as pigments. Geological sources of non-metallics in Ireland and elsewhere and their influence on settlement and trade.

Lecture 9: Use of earth materials and energy from 2,000 years ago to the start of the Industrial Revolution. *(Dr J.F. Menuge)*
Development of energy resources during the Holocene. The key importance of energy in the material world. Production of wood, charcoal and coal and their impact on smelting. Water mills – rivers, tides – and wind mills and their uses. Impact of increased diversity and quantity of energy on nutrition, technical development and health. Slaves as an energy source. The Industrial Revolution: positive feedback between energy use, mining, mineral processing and the use of materials.

Lecture 10: Earthquakes I: How and why they happen. *(Dr I. Lokmer)*
Earthquakes in the context of plate tectonics and the human obsession with prediction.

Lecture 11: Earthquakes II: Hazards versus Risk and societal response to hazard. *(Dr I. Lokmer)*
Earthquakes used to illustrate the concept of hazard versus risk and to explore the human response to and attitudes towards hazard.

Lecture 12: Volcanic Hazards: principles of volcanology and links to hazard. *(Dr E.P. Holohan)*
How and where do volcanoes form, and what fundamental processes control the principal volcano-related hazards?

Lecture 13: Volcanic Hazards: case studies of volcanoes and related hazards. *(Dr E.P. Holohan)*
Case studies of the most dangerous types of volcanic processes and volcanoes, including pyroclastic flows, caldera collapse and supervolcanoes.

Lecture 14: Landslides. *(Dr E.P. Holohan)*
Controlling processes and case studies of different types of landslide and associated hazards, including mudflows, debris avalanches and submarine landslides.

Lecture 15: Tsunami. *(Dr E.P. Holohan)*
Tsunami triggering and movement, and their effects on coastal areas. Case studies of ancient through to recent tsunami, and a consideration of tsunami hazard mitigation.

Lecture 16: Water Chemistry I. *(Prof. J.S. Daly)*
Basic hydrogeology. Controls on composition of seawater and groundwaters. Hard v soft water. Reading the labels. Influence on cardiovascular health.

Lecture 17: Water Chemistry II. *(Prof. J.S. Daly)*
Redox processes. Why the container is not inert. Focus on arsenic and other potential toxicity in natural waters.

Lecture 18: Mineral dusts. Weathering processes. *(Prof. J.S. Daly)*
Natural sources of mineral dusts. Asbestos, erionite. How we know about the health effects. Mining and Silicosis. Synergistic effects with smoking.

Lecture 19: Soil geochemistry. *(Prof. J.S. Daly)*
Natural variation and potential toxicity. "Organic" soils. Selenium.

Lecture 20: Physiological and pathological mineralogy. *(Prof. J.S. Daly)*
Ossification. Teeth. Magnetite and navigation. Calcite and hearing. Mineral hazards - Kidney/Gall stones. Plaster of Paris. Barium meals. Minerals and cosmetics. Fuller's Earth.

WEEKLY ONLINE EXERCISES:

Week 1: Introduction.
Basic principles that underpin the study of fossils including those of hominins. These include stratigraphy, geological time, relative ages and absolute ages. These are important concepts to grasp in order to understand the rock record, how it is interpreted and how it is applied to the study of human evolution. These are the tools used to place hominin evolution in a temporal context. The assignment begins with a brief reminder of the three main rock groups exposed at the Earth's surface. This is followed by an overview of the basic principles of stratigraphy and geological time before looking in more detail at some of the different branches of stratigraphy. Topics covered: (1) The rock cycle, (2) The basic principles of stratigraphy, (3) Geological time, (4) Relative age vs absolute age, (5) Lithostratigraphy, (6) Chronostratigraphy, including biostratigraphy.

Week 2: Bipedalism.
Bipedalism, one of the key distinguishing features of hominins of which we are a part. The differences between facultative bipedalism, characteristic of our nearest relatives, the chimpanzees, and obligate bipedalism, our own type of bipedalism. Skeletal adaptations that facilitate our upright, bipedal mode of locomotion and some of the main reasons put forward to explain why it is that we began to walk upright. Examination of the hominin fossil record for the evidence of how, when, and in what environmental context, bipedalism evolved in extinct hominins. Topics covered: (1) The difference between hominins and hominids, (2)The difference between facultative bipedalism, habitual bipedalism and obligate bipedalism, (3) The skeletal adaptations that allow us to walk upright, (4) The implications of some of those adaptations, (5) Some of the main hypotheses for why we walk upright.

Week 3: *Homo floresiensis*.
Homo floresiensis, a small-bodied hominin species, found on the Indonesian island of Flores. Review of the fossil evidence for H. floresiensis, its time range and whether it represents a new species within the genus Homo or a diseased modern human. Possible phylogenic relationships for H. floresiensis and their implications for our understanding of the evolution of modern humans. Geology of Flores and how it may have played a part in the evolution, and possibly the demise, of H. floresiensis. The (on-going) study of the Flores hominin is multidisciplinary - involving many different aspects of Earth Sciences: the tectonic setting; absolute dating methods to constrain the age of the fossils, analysis of the environmental context, as well as, of course, comprehensive analysis of the actual fossils. Topics covered: (1) the basic skeletal anatomy of H. Floresiensis, (2) the rationale behind assigning H. floresiensis to a new species within the genus Homo, (3) the geological setting of the island of Flores, (4) possible ancestors of H. floresiensis and evidence for their presence on Flores.

Week 4: The first humans in Ireland.
Earliest evidence for humans in Ireland. Various possibilities to explain how these early hunter-gatherers first reached Ireland and some issues that could affect the record of Ireland's earliest humans. Topics covered: (1) The Mesolithic site of Mount Sandel, (2) Some hypotheses to explain how the first humans reached Ireland, (3) Factors affecting the early human record in Ireland, (4) How some of these issues are being addressed.

Week 5: Early mining.
Discussion of some of the world's earliest mines, where our ancestors first began to extract useful earth materials on a large scale. What material was extracted, why it was extracted and some of the mining techniques used. Topics covered: (1) The Lion Cave mine, Swaziland, (2) The Rudna Glava mine, Serbia, (3) The Gavà Neolithic Mining Complex, Spain, (4) Grimes Graves Flint mine, England, (5) Roman hydraulic mining.

Week 7: Earthquakes in developed and developing countries.
Differences in seismic risk in developed and developing countries. Review of article by Brian Ticker (2004, *Seismological Research Letters*), which discusses the 'seismic gap' between rich and poor countries. Examination of three excerpts from *Nature Geoscience*, which focuses on the January 2010 earthquake that devastated Haiti. Approach adopted in California to improve earthquake preparedness. Topics covered: (1) Trends in global urban earthquake risk, (2) What is being done to reduce global earthquake risk, (3) Disaster mitigation versus disaster response, (4) The January 2010 earthquake in Haiti, (5) Earthquake preparedness in Haiti, (6) Disaster response in Haiti, (7) Earthquake preparedness in California.

Week 8: Eyjafjallajökull.
Discussion of the Eyjafjallajökull eruption in April 2010 that brought travel and commerce to a standstill. Although a comparatively small volcanic eruption, Eyjafjallajökull's position beneath an ice cap and upwind of mainland Europe, as well as the prevailing weather conditions at the time, all contributed to the shut down of European air space between the 15th – 20th April. Why Iceland is so volcanically active. Eyjafjallajökull volcano and its neighbour Katla, and we will discuss their eruption histories. Some of the techniques employed to monitor these volcanoes and the impact of volcanic ash on aircraft and public health. Topics covered: (1) The tectonic setting of Iceland, (2) The tectonic setting of Eyjafjallajökull and Katla, (3) Phreatomagmatic eruptions, (4) The 2010 eruption of Eyjafjallajökull, (5) The effect of volcanic ash on aircraft, (6) The health risks associated with volcanic ash.

Week 9: Odysseus' homeland.
Online assignment combining Ancient Greek literature, landslides and rockfalls! How landslides and rockfalls may have complicated the original geography of Homer's Ithaca, the supposed homeland of the Greek hero Odysseus, and how geoscience techniques have been applied to help solve the mystery. Homer was an epic poet of Ancient Greece whose poems the Iliad and the Odyssey are among the world's oldest texts. The Iliad describes events towards the end of the Trojan War, while the Odyssey tells the tale of the hero Odysseus' journey to his homeland of Ithaca after the Trojan War. The first part of this assignment introduces the crux of the problem, that the modern day Greek island of Ithaki does not fit the description of Homer's Ithaca. Rationale for proposing that the Paliki peninsula on the neighbouring island of Kefalonia is a more likely candidate. Examination of the geoscience techniques applied to investigate the proposed relocation of Homer's Ithaca. Topics include: (1) Arguments against modern day Ithaki as Homer's Ithaca, (2) The case supporting modern day Paliki as Homer's Ithaca, (3) The tectonic setting of Kefalonia and the geology of the Thinia Valley, (4) The geological processes that may explain how Paliki could have been a separate island from eastern Kefalonia, (5) The results of the geoscience investigations carried out to date.

Week 10: Radon.
Radon, a naturally occurring, radioactive gas that is emitted by rocks and soils and is the second leading cause of lung cancer after smoking. Topics covered: (1) How radon is formed, (2) The chemical properties of radon, (3) ^{222}Rn, (4) Radioactive decay and alpha particles, (5) Mechanisms of radon gas migration, (6) Health effects of radon, (7) Radon gas in Ireland, (8) Radon remediation measures, (9) Radon in water.

Week 11: Asbestos
The group of naturally occurring fibrous minerals collectively known as asbestos. Examination of the chemical and physical properties of these minerals before looking at how and why they were so widely used in our everyday lives. Health implications of asbestos inhalation as well as the controversy surrounding the complete ban of all asbestos materials. Topics covered: (1) The asbestos minerals, (2) The difference between serpentine and amphibole asbestiform minerals, (3) How asbestos is useful, (4) Asbestos-related diseases (asbestosis, mesothelioma, lung cancer), (5) The chrysotile controversy.

Week 12: Arsenic in groundwater.

The topic of this week's assignment has been dubbed by the World Heath Organisation as "the largest mass poisoning of a population in history". In Bangladesh and West Bengal, millions of people are drinking well water that is badly contaminated with arsenic, a well-known poison. This pollution is not caused by widespread development of irrigation or other agricultural practices in the region, such as increased use of phosphate fertiliser; the pollution is entirely natural. Topics covered: (1) The arsenic problem, (2) Health impacts, (3) Geological influence, (4) Remediation strategies.