University of Leicester

Centre for Interdisciplinary Science

PA3015: Project

Student Handbook

Project Choices

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Contents

Project Descriptions

Preparation of Multimedia Learning Resources

Supervisor

Dr Dylan Williams

Project Description

In many cases students struggle to do problems, not knowing where to start, yet when they are shown the solution they think that it was relatively easy. In face to face workshops students can ask questions and staff can give hints on how to proceed at a particular stage however this requires a timetabled activity. It would be advantageous if this type of help were available "on student demand" rather than on "staff availability". This project will involve the development and evaluation of short, structured multimedia resources designed to illustrate the process of solving chemistry problems to be used as online tutorials and revision aids.

Students participating in this project will be asked to research part of the level 1 or 2 curriculum. Students will then develop a series of short, focused video tutorials that will demonstrate how to solve problems of this type. Students will learn about theories of learning styles and will assess the impact of the new resources using approaches adopted by educational researchers.

Project Aims

By the end of this project students will be able to:

- Demonstrate their understanding of theories of the learning and teaching process
- Demonstrate an ability to research selected concepts from the level 1 and 2 curriculum.
- Plan and record a series of short video tutorials based on material from the level 1 and 2 curriculum
- Evaluate the impact of resources developed as part of a project through analysis of appropriately selected data.
- Communicate project findings in both written and oral forms

Computational Design of Novel Proteomimetics

Supervisor

Dr Andew Jamieson
Center for Chemical Biology, Department of Chemistry
University of Leicester

Project Description

The design of novel therapeutics is essential to the future good health of the general public. Synthetic molecules that mimic the structural features of peptides and proteins, referred to as proteomimetics, have proven to be useful leads in the search for novel therapeutics. Due to the complex nature of these molecules, they must be designed using computational methods.

Project Aims

During this project you will learn about the design process and use state of the art computer software to design a biologically relevant proteomimetic molecule.

Mining genome project data to identify SPP2 gene orthologs and paralogs & sequence variation

Project Supervisor

Dr Raymond Dalgleish (Genetics)
ray@le.ac.uk

Project Description

There are genome projects for a wide range of vertebrate organisms producing freely-available data which can be mined in various ways. For some genomes, both genomic DNA and EST sequences are available, often in the form of the primary sequencing trace data. The project will involve mining public data sources to identify orthologs and paralogs[1], in other species, of the human SPP2 gene[2] which encodes secreted phosphoprotein 24, the precursor to bone morphogenetic protein.

Project Aims

The goal is to identify conserved domains in this enigmatic protein which might shed light on its function. Data from the 1000 Genomes project[3] will also be used to reveal the extent of sequence variation in the human SPP2 gene.

ANALYTICAL:

(Bioinformatics)

METHODOLOGY:

Computer-based methodologies: literature searching, sequence database searching, multiple sequence alignment & analysis, determination of evolutionary conservation

USEFUL LINKS AND PAPERS:

1. Koonin EV. 2005. Orthologs, paralogs, and evolutionary genomics. Annu Rev Genet 39:309-338. DOI: 10.1146/annurev.genet.39.073003.114725
2. Bennett CS, Khorram Khorshid HR, Kitchen JA, Arteta D, Dalgleish R. 2004. Characterization of the human secreted phosphoprotein 24 gene (SPP2) and comparison of the protein sequence in nine species. Matrix Biol 22:641-651. DOI: 10.1016/j.matbio.2003.12.001
3. The 1000 Genomes Project Consortium. 2010. A map of human genome variation from population-scale sequencing. Nature 467:1061-1073. DOI: 10.1038/nature09534

Multicolour fluorescent microscopy to analyse mammalian meiotic chromosomes

Project Supervisor

Dr T Schwarzacher
Room 201b, Adrian Building, Email: ts32@le.ac.uk

Project Description

LABORATORY PROJECT

Meiosis is an essential part of the life cycle of sexually reproducing organisms and involves two nuclear divisions: the first, reductional division, is characterised by a complex and lengthy prophase I, during which the homologous chromosomes (one from each parent) pair and synapse, the synaptonemal complex (SC) is formed and reciprocal recombination takes place. In mouse, it was shown that different sequence classes including genes and repetitive DNA either bind directly to the SC or are located in the chromatin loops depending on their function in particular pairing. The project will study the substantial reorganisation and behaviour of early meiotic chromosomes in pig, dog or cat using molecular cytogenetic techniques, particular the distribution, variation and epigenetic marks of repetitive sequences will be studied.

Project Aims

METHODOLOGY:

This lab based project involves meiotic chromosome preparation and staining, probe labelling, fluorescent in situ hybridisation and immunocytochemistry. In order to visualise several components of the meiotic chromosomes including specific DNA sequences and proteins, multicolour fluorescent techniques and image analysis are required to be developed.

USEFUL REFERENCES AND LINKS

1. Burgoyne PS, Mahadevaiah SK and Turner JMA (2009) The consequences of asynapsis for mammalian meiosis. Nature Reviews Genetics 10,207-216. doi:10.1038/nrg2505
2. Metzler-Guillemain C, Depetris D, Luciana JJ, Mignon-Ravix C, Mitchell MJ, Mattei MG (2008) In human pachytene spermatocytes, SUMO protein is restricted to the constitutive heterochromatin. Chromosome Res 16:761-782. doi:10.1007/s10577-008-1225-7
3. Moens PB, Pearlman RE, Heng HH, Traut W (1998) Chromosome cores and chromatin at meiotic prophase. Curr Top Dev Biol 37:241-262. doi:10.1016/S0070-2153(08)60176-3
4. Schwarzacher T (2008) Chromosomes, recombination and proteins at meiosis. Chromosome Res 16:679-682; doi: 10.1007/s10577-008-1251-5

Multicolour fluorescent microscopy to analyse chromosomes

Project Supervisor

Dr T Schwarzacher
Room 201b, Adrian Building, Email: ts32@le.ac.uk

Project Description

LABORATORY/ANALYTICAL PROJECT

Genomes vary substantially in the amount of DNA they contain. Much of this variation is caused by repetitive DNA sequences. Fluorescent in situ hybridization is the method of choice to visualise the distribution of these repetitive DNA sequences along the chromosomes. The project will study wheat, rye and barley chromosomes using the many different repetitive DNA families isolated in our laboratory. Fluorescent microscopy exploits different colours and to date we routinely use three and sometimes four colours including blue, green, red and far red. Different fluorochromes and labelling methods will be tested for their suitability to mix colours and use for multiple target detection. New developments in hyperspectral imaging will be explored.

Project Aims

METHODOLOGY:

This project is mainly lab based and involves plant chromosome preparation and staining, probe labelling and fluorescent in situ hybridisation. But it also includes a large analytical component to analyse fluorochrome behaviour and hyperspectral imaging potentials.

USEFUL REFERENCES AND LINKS

1. Heslop-Harrison, J. S., & Schwarzacher, T. (2011, April). Organisation of the plant genome in chromosomes.. Plant J, 66(1), 18-33. doi:10.1111/j.1365-313X.2011.04544.x
2. Fraser, G. W., Heslop Harrison, J. P., Schwarzacher, T., Holland, A. D., Verhoeve, P., & Peacock, A. (2003, April 4). Detection of multiple fluorescent labels using superconducting tunnel junctions. Review of Scientific Instruments, 74, 4140-4144. doi:10.1063/1.1599059
http://www.bioastral.com

Evolutionary trends in mammals

Project Supervisor

Dr T Schwarzacher
Room 201b, Adrian Building, Email: ts32@le.ac.uk

Project Description

ANALYTICAL (OR LABORATORY) PROJECT

Evolutionary trends in mammals

Closely related species often have the same or similar karyotypes and the sequence of rearrangements that occurred during evolution can often be traced with molecular defined probes by fluorescence in situ hybridization (FISH). For many nodes in mammalian phylogeny landmark chromosome rearrangements have now been identified that would discriminate ancestral versus derived chromosome changes and help to elucidate species phylogenies. Likely structures of ancestral primate genomes and even all mammalian species have been proposed. In different mammalian families different chromosomal rearrangement types have been identified. This project will examine whether these trends are significant and whether sequence data that are becoming available from genome sequencing projects support the cytological findings. Further is it possible to find of these phylogenetic system to behavioral and ecological data?

Project Aims

METHODOLOGY:

This is a mainly analytical project, including literatures and DNA sequence database searches, but the option for lab experiments is given if the student would like to perform his/her own chromosome painting experiments and experience multicolour fluorescent microscopy.

USEFUL LINKS AND PAPERS

1. Wienberg J and Muller S (2008) Chromosome Rearrangement Patterns in Mammalian Evolution. Encyclopedia of Life Sciences doi: 10.1002/9780470015902.a0005798.pub2
2. Ferguson-Smith MA and Trivinov Mammalian karyotype evolution. Nature Reviews Genetics 8: 950-962. DOI: 10.1038/nrg2199
3. Kemkemer et al (2009) Gene synteny comparisons between different vertebrates provide new insights into breakage and fusion events during mammalian karyotype evolution. BMC Evolutionary Biology 9:84. Doi: 10.1186/1471-2148-9-84
4. Siepel, A (2009) Phylogenomics of primates and their ancestral populations Genome Research 19: 1929-1941 Doi: 10.1101/gr.084228.108

Growth patterns in fossil planktonic colonies

Project Supervisor

Dr Jan Zalasiewicz (Geology)

Project Description

The graptolites were fossil marine colonies that lived in the early Palaeozoic era, between 400 and 500 million years ago, the most typical forms being planktonic. Their organic living-chambers are commonly preserved in strata of that age, and these have a modular architecture, being added successively to the growing colony. The controls on the construction of these remain largely mysterious, though undoubtedly involved genetic control (to determine overall colony design) and likely also some element of environmental control, from such oceanographic features as water temperature and nutrient content.

Project Aims

This project involves making careful and detailed observations and measurements of morphological characters of a suite of finely preserved specimens of one graptolite species, *Monograptus sedgwickii*, from the Silurian strata of central Wales, using the Leica binocular microscope apparatus. These characters will be plotted up and analysed to reveal the growth patterns of these colonies and the possible controls on these. The results should improve our understanding of the biology and ecology of these enigmatic extinct organisms.

Tracking tropical biomass burning from space

Project Supervisor

Dr Michael Barkley

Project description

The burning of terrestrial tropical vegetation, from wild and agricultural fires, is an extremely important process in the climate system. Biomass burning releases large amounts of aerosols and other trace gases into the atmosphere that can influence atmospheric chemistry and air quality. We can detect fires from space using satellite instruments such as ATSR or MODIS thereby enabling us to track seasonal burning patterns. Two important gases released from biomass burning are formaldehyde (HCHO) and nitrogen dioxide (NO_2), both of which are key indicators of air-quality and can be observed from space by the Ozone Monitoring Instrument (OMI). The objective of this project is to examine spatial and temporal correlations between HCHO, NO_2 and fires over Africa and the Amazon, to determine the seasonal variations in burning and their influence on troposheric composition.

Project Aims

1 To learn about the importance of biomass burning in climate
2 To investigate seasonal variations in HCHO and NO_2 owing to biomass burning

Nature of Project:
data analysis, computational

Skills, Courses & Publications:
Some knowledge of remote-sensing, IDL programming

Any particular requirements:
None

El Niño years: modification of precipitation patterns in the tropical region

Project Supervisor

Dr Alessandro Battaglia

Project description

The TRMM Precipitation Radar (PR), the first of its kind in space, is an electronically scanning radar, operating at 13.8 GHz that measures the 3-D rainfall distribution over both land and ocean, and defines the layer depth of precipitating systems (http://trmm.gsfc.nasa.gov/). It has been flying for more than one decade and can provide unique information about precipitation pattern variability. Spatial coverage is between 38 degrees north and 38 degrees south, thus providing extensive coverage in the tropics. The student will analyze 2A25 product specifically targeting the anomalies in precipitation partner during El Niño years. El Niño/La Niña-Southern Oscillation (ENSO) is a quasi-periodic climate pattern that occurs across the tropical Pacific Ocean roughly every five years. It is characterized by variations in the temperature of the surface of the tropical eastern Pacific Ocean and air surface pressure in the tropical western Pacific. ENSO causes strong modification of the weather and precipitation patterns in many regions of the world and particularly in those bordering the Pacific Ocean. This project will give students an opportunity to directly work with EO datasets, to get acquainted with and to interpret radar echoes and to get a deeper understanding of climate change.

Project Aims

1. To generate precipitation maps and anomalies during El Niño years derived from TRMM-PR
2. To study the vertical structure of precipitating systems.

Nature of Project:

Data analysis, computational

Skills, Courses & Publications:

Some knowledge of remote-sensing, IDL or Matlab programming (useful but not mandatory)

Any particular requirements:

None

Combining infrared galaxy searches: IRAS & WISE

Project Supervisor

Professor Andrew Blain

Project description

Less than a year ago, an infrared survey was made of the whole sky using the WISE satellite. The previous all-sky survey was made 25 years ago by the IRAS satellite (and a deeper, but still relatively shallow one about a decade ago by the Japanese Akari satellite).

Project goals

The project will involve understanding the populations of galaxies found in the IRAS survey, and firming up the properties of identified subsets of these objects using the WISE data.

Skills, Courses & Publications:

IDL programming (or other suitable programming language).

Nature of Project:

Data analysis, computation

Any particular requirements:

None

Red quasars with WISE, and the 2dF and SLOAN redshift surveys

Project Supervisor

Professor Andrew Blain

Project Description

Surveys taking optical spectra have acquired samples of thousands of active galaxies, many of which recently have infrared data available from the WISE satellite.

Project Aims

The project will start with an investigation of the catalogs from the optical surveys, and the fraction of these galaxies that are likely to be rendered tough to detect based on these central objects being reduced in intensity by absorption in dust in the host galaxies. A comparison with the infrared properties found by WISE will be used to test these ideas.

Skills, Courses & Publications:

IDL programming (or other suitable programming language).

Nature of Project:

Data analysis, computation

Any particular requirements:

None

Aerosol and cirrus clouds from the space-based CALIPSO aerosol lidar

Project Supervisor

Dr Hartmut Boesch

Project description

Aerosols and cirrus clouds play an important role for atmospheric chemistry and radiation/climate. However, their effect depends critically on vertical distribution, amount and type which are spatially and temporally variable and thus difficult to parameterize in current climate and atmospheric transport models. We have now a multi-year global dataset of vertically-resolved information on aerosols and optically thin clouds from the space-based aerosol lidar Calipso which also includes a classification of aerosol type. This dataset now allows developing climatologies for aerosol and cirrus clouds for different regions to characterise the regional aerosol/cirrus conditions, their trends and regional differences.

Project goals

1 Develop regional climatologies for aerosol and thin cirrus clouds from calipso data
2 Investigate regional characteristics and trends and regional differences

Nature of Project:

Data analysis, computational

Skills, Courses & Publications:

Knowledge of remote-sensing and IDL programming (or other suitable programming language)

Any particular requirements:

none

Calculating the Flux of Extraterrestrial Material onto the Ancient Earth's Surface by Collecting Micrometeorites

Project Supervisor

Dr John Bridges

Project description

The flux of primitive asteroidal, dust and cometary material across the Solar System and onto the Earth's surface has varied since formation of the planet. Knowledge of the ancient flux can potentially help inform models of asteroid breakup and climate change. By separating micrometeorites from slowly deposited ancient sediments of known age (from Boulby, Yorkshire) and checking their composition on a scanning electron microscope we can calculate an ancient extraterrestrial flux and compare it to the modern one. Initial studies in a previous 3rd year project have made a first estimate of the ancient flux. This project will use different samples to gain a larger, more representative number of extraterrestrial particles and help constrain the flux calculations.

Project Aims

1. To separate the magnetic fraction from previously identified ancient sediments (260-300 Ma).
2. Learn the operation of a scanning electron microscope and energy dispersive X-ray spectrometer and use them to identify extraterrestrial material.
3. Calculate the ancient extraterrestrial flux and compare it to the modern one e.g. the Grün Model, LDEF.

Nature of Project:

Experimental with data analysis, literature review

Skills, Courses & Publications:

none

Any particular requirements:

none

Characterising the Martian Crust by SEM Analysis of a Newly Fallen Martian Meteorite

Project Supervisor

Dr John Bridges

Project description

In July 2011 the Tissint meteorite fell in meteorite and was quickly recovered. Initial observations suggested that it was one of the rare martian meteorites. However we do not yet know some critical bits of information. Was it altered by water on Mars, which type of martian meteorite is it, what are its mineral compositions?

Project goals

This project will involve learning the principles and practical applications of Scanning Electron Microscopy (SEM) imaging together with Energy Dispersive X-ray microanalysis to determine its composition. The project will also involve in the early stage, a literature review of how we know some meteorites came from Mars and the theory behind SEM-EDX analyses.

Nature of Project:

Experimental with data analysis, literature review

Skills, Courses & Publications:

none

Any particular requirements:

none

Observing transiting planets

Project Supervisor

Dr Matt Burleigh

Project description

You will use the Oadby telescopes, and the remotely operated Pirate telescope on Majorca, to observe extra-solar planets transiting their parent stars. You will determine the radius of the planets by measuring the drop in light from the star as the planet passes in front of it.

Project goals

To gain experience of practical astronomy, e.g. planning and carrying out observations, and learning how to reduce and analyse data. To understand, through astronomical observations, how we can measure fundamental physical parameters of planets around other stars.

Skills, Courses & Publications

Computer programming skills an advantage. Relevant Papers or Books: Introductory Astronomy and Astrophysics by Zeilik and Gregory; An Introduction to Astrobiology by Gilmoir and Sephton; Transiting Exoplanets by Carole A. Haswell.

Nature of Project

Observational astronomy, data analysis, computation, literature review

Any particular requirements:

Travel to Oadby observatory. Departmental computer labs, home computer (when using the remotely operated Pirate telescope on Majorca). THIS PROJECT MUST BE UNDERTAKEN BY A PAIR OF STUDENTS.

Automated identification of micro-embolic events (MEEs): the directional analysis approach

Project Supervisor

Dr Lingke Fan

Project description

Micro-emboli are small elements that are foreign to the blood stream. Solid emboli may consist of pieces of atheromatous plaque, platelet aggregates, or thrombus. Gaseous emboli usually occur when the circulation is breached during surgical procedures. If such emboli become trapped in an end-artery they may prevent blood-flow, and possibly cause irreversible damage to the tissue supplied by the vessel. Perhaps the most dangerous site where this may occur is in the brain, where embolic events can lead to major strokes. It is possible to detect microemboli in the cerebral circulation using Doppler ultrasound techniques, and the Department of Medical Physics in Leicester has had a major interest in this method for many years. One area of interest has been in the automated detection of emboli (ADE) as they propagate through the middle cerebral arteries. A novel directional analysis method has been proposed and implemented, to identify the MEEs using the energy and perceptual features Doppler signals. This project will be focused on clinical evaluations of the new ADE method.

Project goals

1. To test and evaluate the new ADE algorithm using clinical data previously acquired. 2. To gain first-hand clinical research experiences in monitoring or data acquisition procedures.

Skills, Courses & Publications:

Basic analytic and computational skills

Nature of Project:

experimental, data analysis

Any particular requirements:

None

Measuring black-hole masses using reverberation mapping

Project Supervisor

Dr Mike Goad

Project description

Reverberation mapping has been shown to provide accurate estimates for the central SMBH in nearby AGN. Students will determine broad emission-line region sizes and mean velocities from spectrophotometric data and thereby the mass of the central compact object for some well-studied sources.

Project goals

Measure continuum-emission line delays and line FWHM for AGN. Use virial theorem to determine mass of central black hole. If time, relate mass-luminosity to accretion rate.

Skills, Courses & Publications:

Nature of Project:
Data analysis

Any particular requirements:
None

Emission-line responsivity as a constraint upon the physical conditions within the broad emission-line region of Active Galactic Nuclei

Supervisor

Dr Mike Goad

Project description

One constraint upon the properties of gas lying close to the central supermassive (10^8-10^9 M_{sun}) black holes in the heart of AGN derives from their observed broad emission-line strengths. These point to at least two regions, one producing the strong UV resonance lines, the other, the optical recombination lines. However, photoionisation models only indicate the conditions under which these lines form, not their exact location relative to the source. Students will investigate how emission-line reponsivity, that is, how the lines vary as a function of continuum level, can be used to place more stringent contraints upon gas properties.

Project goals

Students will investigate how emission-line responsivity, that is, how the lines vary as a function of continuum level, can be used to place more stringent constraints upon gas properties.

Skills, Courses & Publications:

Nature of Project:

Data analysis

Any particular requirements:

None

Modelling the femoral head from medical images

Supervisor

Professor Peter Maksym, Dr Mark Horsfield

Project description

The head of the femur is a very common site for bone fractures in elderly people, due to weakening bones and frequent falls due to frailty. In order to understand the structure of the femur, its weak points and how it can best be protected, it is necessary to create a structural model of the bone and the surrounding tissues. This project aims to extract the surface shape and some of the internal structure of the femur from medical images, so that these can used to model the behaviour of the femur under impact loads.

Project goals

1) To review of the literature on semi-automated extraction of the femoral surface.
2) To test existing methods for surface extraction.
3) To develop and implement strategies for improved surface extraction.
4) To create a 3-D surface and internal structural model of the femur.

Skills, Courses & Publications:

None

Nature of Project:

Literature survey, computational, modelling

Any particular requirements:

Location of Project: Leicester Royal Infirmary / Physics and Astronomy

Good Vibrations

Supervisor

Professor Steve Milan

Project description

Oscillators are ubiquitous in the universe, from the simple pendulum to the vibrating atoms of crystal lattices. An isolated oscillator can show interesting behaviour, but a whole wealth of fascinating phenomena occur when oscillators are coupled in pairs, chains, or lattices. These include resonance, wave phenomena, and the thermal properties of solids. This project will involve computer modelling of simple and coupled oscillatory systems, and investigating their properties.

Project goals

1. Learn about simple harmonic motion, coupled oscillators, waves, and simple thermal physics
2. Learn about computer modelling of simple physical systems in IDL (or equivalent language)
3. Learn about mathematical techniques for analysing coupled systems

Skills, Courses & Publications:

IDL programming, or equivalent language.

Nature of Project:

Computational, interpretation

Any particular requirements:

None

Complex Systems – Agent based modelling with NetLogo

Supervisor

Professor Derek Raine
jdr@le.ac.uk

Project Description

Netlogo is a computer programme (and programming language) that is used to model interacting 'agents', that is objects that can receive and process information and act on it independently. An interesting application in physics is to magnetic systems (the agents are the spins on a lattice), but these methods have been extended to other sciences (including social sciences). The project will investigate the use of NetLogo in the context of various complex systems, depending on the interests of the students.

Examples

- 'SugarScape' – Investigating artificial societies
- Magnetic systems
- Evolution of Altruism in artificial societies
- Technological innovation and wealth distribution in artificial societies

Project Aims

To investigate agent-based models using NetLogo

Pre-biotic Ecology

Supervisor

Professor Derek Raine
jdr@le.ac.uk

Project Description

Pre-biotic ecology is a new approach to the origin of life. One particular highly simplified but tractable model of pre-biotic ecology envisages 2D-'cells' inhabiting a torus. The cells contain molecules (the 'food set') that can attach themselves to the cell boundaries where they can polymerise according to certain rules. The boundaries between cells can be removed (fusion of cells) or added (fission of cells) according to various rules. The idea is then to develop a computer model of the evolution of the molecules in this picture, to see how spatial and chemical structures can develop which will represent the first steps towards molecular coding. Previous projects have produced a code in the NetLogo programming language which is ideally adapted to agent-based modelling of complex systems. (A guide to programming in NetLogo will be provided.) The code implements a simplified form of the model and shows how a pre-genomic coding can arise which allows inheritance of the information for an autocatalytic network of reactions. (See e.g. Segre and Lancet (2000) Proc Nat Acad Sci., 97, 4112).

Project Aims

This project will investigate the range of behaviour for different rules for polymerisation, for attachment and detachment of molecules, and for fission and fusion of cells in order to extend the model to more complex reaction networks.

Fractal dimensions in nature

Supervisor

Professor Terry Robinson

Project description

Self-similarity is one of the most powerful symmetry principles in physics and many important phenomena, from earthquakes to the structure of living organisms are governed by such laws. Fractals are the basic building blocks of self-similar systems and provide a systematic way of characterising and explaining them. This project is concerned with the fractal structure of trees, which provide a readily accessible and familiar example of self-similarity in action. This project aims to explore the fractal structure of trees experimentally and to examine the physical models which underlie it. One of the oldest models of tree morphology is due to Leonardo da Vinci. He formulated the first example of a continuity law of fluids in devising his theory of trees. The student will devise his or her own experimental strategy to test this theory and to uncover the fractal dimensionality of a number of tree forms.

Project goals

The aims of this project are

1) To assess quantitatively Leonard da Vinci's theory concerning the morphology of trees - you will need to devise your own experiment - there are two restrictions:
    (a) you may not climb trees [your safety],
    (b) you may not cut down any trees [the trees' safety] - remote sensing is the only option!
2) To interpret the theory in terms of the hydraulics involved [This is probably the earliest formulation of the continuity principle]
3) To explore the fractal basis of tree morphology.
4) Identify the Hausdorf dimensionality of tree branching geometry

Skills, Courses & Publications:

None specified

Nature of Project:

Experimental, theoretical, computational, data analysis, simulations

Any particular requirements:

None

Comparing Jupiter's infrared and ultraviolet auroral images

Supervisor

Dr Tom Stallard

Project description

Images of ultraviolet aurora on Jupiter have allowed us a great deal of understanding about the conditions in the planets surrounding space environment. However, far less is known about the infrared aurora - in particular how the infrared aurora differs from the ultraviolet. We now, for the first time, have images of both the infrared and ultraviolet aurorae taken simultaneously. In comparing these, we can gain significant insight into the processes that control both.

Project goals

Using observations of H^{3+} ion from NASA's InfraRed Telescope Facility and images from the Hubble Space Telescope, this project will directly compare the two aurora. As these two sources of data differ, the data will need to be converted so that a direct comparison can be made, including some modelling of the effects of differing conditions in the atmosphere at Jupiter and the effects of the Earth's atmosphere (since Hubble lies in orbit, while infrared observations are taken from the ground). Once this is done, direct comparisons between the two data can be made. Skills, Courses & Publications The project centres on data analysis (principally using IDL) and interpretation, and is suitable for those with good computing skills or those wishing to improve such skills. The project will use computing equipment and software provided by the Radio & Space Plasma Physics Group.

Nature of Project:

Data analysis, literature review

Any particular requirements:

None

Probing Jupiter's ionosphere: Altitude profile

Supervisor

Dr Tom Stallard

Project description

While our understanding of the upper atmospheres of the Gas Giants has greatly improved over the past decade, one significant gap remains largely unanswered: how does the upper atmosphere change with altitude? This is a difficult question to answer, since, in the past, ground-based telescopes do not have the resolution to observe the atmosphere itself and so we have had to rely on previous observations from spacecraft. However, such observations are also notoriously difficult. This difficult impasse has recently been dramatically reversed following an observation, made by the VLT in Chile, that took spectral observations of Jupiter's upper atmosphere using Adaptive Optics, the first time such observations have ever been made. This project will investigate this new data for the first time, looking at two spectra that examine the light near and above Jupiter's limb, one in the equatorial region and one within the aurora.

Project goals

The main aims of this project are to produce an altitude measurement for emission from the H3+ molecule, a principle component in the upper atmosphere of Jupiter. This will allow us to compare and contrast the physical conditions within the auroral and equatorial regions for the first time.

Skills, Courses & Publications:

The project centres on data analysis (principally using IDL) and interpretation, and is suitable for those with good computing skills or those wishing to improve such skills. The project will use computing equipment and software provided by the Radio & Space Plasma Physics Group.

References:

Jystrup et al., The Astrophysical Journal 677, 790-797, (2008) Nature of Project data analysis, literature review

Any particular requirements:

None

Surface Photometry of Elliptical Galaxies

Supervisor

Dr Gordon Stewart

Project description

The project involves using the CCD camera on the Oadby telescope to obtain multi-colour images of bright elliptical galaxies. It is also hoped that the new PIRATE remotely-operated telescope on Mallorca will be available for use. These data must be reduced and calibrated in order to derive colour gradients within the galaxies using software packages available on the local STARLINK computers. This information can then provide insight into the formation and evolution of elliptical galaxies. The project will involve the development of appropriate software.

Project goals

Gaining experience of real astronomical observing and data analysis techniques (mainly using standard packages)

Skills, Courses & Publications:

Must be able to work at night; basic computing skills required.

Nature of Project:

Experimental, computational, data analysis

Any particular requirements:

None

Investigating waves in the upper atmosphere using shortwave broadcasts

Supervisor

Dr Darren Wright

Project description

The project requires testing/calibrating a PCB representing the detector stage of a sensitive shortwave receiver. Once that is done this will be connected to a receiver and data recorded from broadcast stations which will act to monitor waves in the ionosphere. The waves could be atmospheric or magnetospheric in origin. The data will be logged and a signal/time series analysis will be carried out.

Project goals

To be discussed with supervisor

Skills, Courses & Publications

Experimental skills.

Nature of Project

Experimental, computational

Any particular requirements

Can be run with more than one student (discuss directly with supervisor)

An ultrasound radar simulator

Supervisor

Professor Tim Yeoman

Project description

Radar systems have a wide variety of uses in industry and commerce, as well as environmental and geo-science and space exploration. Ultrasound has with a frequency of tens of kHz and a wavelength of order one cm, Such a wavelength is similar to those used in a number of radar systems, although the frequency and wave speed are very different. Ultrasound can thus be used to simulate the operation of radar systems in the laboratory. In this project a simple ultrasound radar simulator will be constructed and tested, using both individual transducers and a phased array of transducers to form the transmitted and received beams. The use of continuous wave, pulsed and chirped transmitted signals will be investigated. The performance of the radar in beam-forming and steering, and in the location, identification, and tracking of objects will be investigated and optimised.

Project goals

The design and construction of the basic elements of a radar system using ultrasound. The driving signals will be produced by a flexible signal generator, while an analogue-to-digital conversion system will log the transmitted and received signals on a computer. This digital output will then be used to test, quantify and optimize the performance of the system under a number of configurations. The performance of the system will be compared to the expected performance of radar systems using basic radar theory.

Skills, Courses & Publications:

Design of suitable experimental configurations, collection of digital data, quantitative analysis of collected data, comparison with theory

Nature of Project:

Experimental

Any particular requirements:

None

The Evolution of Fruit Forms

Supervisor

Dr S Drea
Room 3, Adrian
sd201@le.ac.uk

Project Description

Fruits and seeds come in many shapes and sizes and can be filled with nutrients or pharmacological compounds that are important economically. This project aims to investigate the genes that influence fruit development in species with very different fruit forms. We focus on important crops: the capsular fruit of the opium poppy (source of alkaloids like morphine) and the grain of wheat (source of bread and pasta flour). The project will involve the sequence and expression analyses of important fruit genes in these species.

Project Aims

Experimental

LOCATION OF LAB WORK (IF APPROPRIATE):

Lab 319 Adrian

METHODOLOGY:

Lab-based methodologies such as PCR and in situ hybridisation; database-searching and basic bioinformatics.

USEFUL LINKS AND PAPERS:

1 Wang et al. 2005 The origin of the naked grains of maize. Nature 436; 714-9.
2 Millgate et al. 2004 Analgesia: morphine-pathway block in top1 poppies. Nature 431 413-4.

Plants and People: Economics and Health

Supervisor

Dr S Drea
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sd201@le.ac.uk

Project Description

This project may suit a student interested in the areas of science communication, science history and public awareness of science.

It involves in depth searching and analyses of research and policy literature to assess the health and economic impact of two very different crops, wheat and opium poppy. Wheat is the source of our bread and pasta flour – a staple food crop; opium poppy is the source of licit and illicit pharmaceuticals morphine and heroin. The student will produce a review of the botany, biology and agriculture (including genome sequencing, breeding and GM technologies) of these crops that make them so important to humans and then exploring and assessing their economic importance and impact on human health.

Project Aims

PROJECT TYPE:
Analytical

METHODOLOGY:
Database searching mainly for research papers and policy documents relevant to the topic.

USEFUL LINKS AND PAPERS:
1 Eisenstein,M 2010 Of Beans and Genes. Nature 468; S15.
2 Sanderson, K 2007 Special report: Opiates for the masses. Nature 449; 268-69.

Genomic Imprinting in a social insect

Supervisor

Dr E Mallon
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Project Description

Genomic imprinting is the inactivation of one allele in diploid individuals, inactivation being dependent upon the sex of the parent from which it originated. When imprinting goes wrong in early development, it has been associated with a number of developmental syndromes (e.g. Prader-Willi), errors occurring later have been implicated in cancer. When an evolutionary biologist sees a cost, as above, they look for the benefit which keeps the phenomenon from going extinct. What is the benefit of silencing one copy of a gene, making the organism functionally haploid at that locus?
Haig's conflict hypothesis is the leading explanation. In species with multiple paternity, a patrigene has a lower probability of being present in siblings that are progeny of the same mother than does a matrigene. As a result, a patrigene will be selected to value the survival of the organism it is in more highly, compared to the survival of siblings. In mammals and angiosperms, this conflict is played out in the provisioning of offspring with resources taken from the mother.

Project Aims

The aim of this project is to perform the first independent test of this hypothesis using the bumblebee. The conflict hypothesis has a number of unique predictions regarding resource allocation in social colonies.

PROJECT TYPE:

Experimental

LOCATION OF LAB WORK (IF APPROPRIATE):

Lab 219 Adrian

METHODOLOGY:

The student will be working with frozen samples using single strand conformation polymorphism (SSCP) and next-gen sequencing to indentify maternal and paternal genomes and RT-PCR and qPCR to quantify expression of interesting genes.

USEFUL LINKS AND PAPERS:

1 Queller, D.C. 2003. Theory of genomic imprinting conflict in social insects. BMC Evolutionary Biology 3:15. http://www.biomedcentral.com/1471-2148/3/15/

Genetic epidemiology of chronic disease

Supervisor

Dr N Suter-Giorgini
Room 207D, Adrian
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Project Description

Different chronic diseases have different risk factors associated with them and some diseases are more common in some populations than in others. This analytical project will ask the student to choose a particular disease for study, to research current literature to discuss genetic and environmental risk factors and if possible, to account for differences in disease incidence in different populations.

Project Aims

PROJECT TYPE:
Analytical

PLACES AVAILABLE:
More than one student providing different diseases are chosen

METHODOLOGY:
Possibly survey writing, statistical analysis of results, database searching, literature searching.

USEFUL LINKS AND PAPERS
Since the student will choose the exact subject matter for the thesis, usually based on a specific disease, these papers are just examples of the types of papers a student might look at:

1 Prostate cancer epidemiology review:
http://www.bioscience.org/u37153137/gaDTRQo7632rgysaGWQYT64356/2006/v11/af/1891/1891.pdf

2 Original research paper:
Holt, S. K., Kwon, E. M., Koopmeiners, J. S., Lin, D. W., Feng, Z., Ostrander, E. A., Peters, U. and Stanford, J. L. (2010), Vitamin D pathway gene variants and prostate cancer prognosis. The Prostate, 70: 1448–1460. doi: 10.1002/pros.21180.

3 Diabetes papers:
http://journalofdst.org/worldpress/index.php?s=Volume+3%2C+Issue+4%3A+685+2009
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2924474/?tool=pubmed

Effective Science Communication

Supervisor

Dr Cas Kramer
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Project Description

In recent years there has been a significant trend to move from Public Understanding of Science to Public Engagement with Science. Government, Research Councils and the science community as a whole recognise the need to engage the general public with science rather than just telling them about it. Science Communication and Public Engagement are high on the agenda of many Research Councils and are therefore becoming increasingly important into today's competitive funding market. Science Communication should not just be fun; it should also be effective to serve a purpose!

Project Aims

GENIE, the Centre for Excellence in Teaching and Learning (CETL) in Genetics at the University of Leicester (www.le.ac.uk/genie), has a well-established and varied outreach programme. This project will look for development and evaluation of outreach activities for school and colleges and the general public. Working closely with GENIE staff the student undertaking this project will explore a range of Science Communication methods and their effectiveness in reaching target audiences.

From laboratory to the clinic - is the prospect of using stem cells to treat disease reality or fiction?

Supervisor

Dr R James
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Project Description

Hypothesis:

Can stem cells derived from either embryos or adults be used therapeutically for a range of hitherto untreatable diseases in humans?

Recently, increasing knowledge of how to derive and grow stem cells from both adults and embryos has given rise to a great deal of enthusiasm about their possible uses for clinical therapies. This project will discuss the principles (as we understand them) of how stem cells can regenerate themselves and yet still have the ability to generate a number of tissue types. Some things to discuss would be the role of telomerase in maintaining telomere length in such cells, potential advantages and disadvantages of embryonic versus adult stem cells and recent results from experimental and clinical applications of such cells as a therapeutic option.

Project Aims

DEPARTMENT:

Infection, Immunity & Inflammation

PROJECT TYPE:

Analytical

METHODOLOGY:

Literature researching a large and ever growing area of published data on the background and clinical applications of stem cell therapies.

USEFUL LINKS AND PAPERS:

http://www.actionbioscience.org/biotech/pecorino2.html

Interannual variability of the global atmosphere-biosphere CO_2 exchange

Supervisor

Dr J Kaduk (Geography)
jk61@le.ac.uk

Project Description

The aim of this project is to determine the variations of the global atmospheric CO_2 concentration and relate the observed variations to the variability of climate variables, e.g. temperature, precipitation and soil moisture as well as to determine those geographical regions which are most relevant for the observed variations.

This project builds on 18 years of NDVI (normalized difference vegetation index, a measure of the greenness of the land surface) and 20 years of global climate data and some existing R code. The task is to analyse these large data sets and to use appropriate simple mathematical operations to determine the relevant characteristics of the global variations in temperature, precipitation, soil moisture, CO_2 and NDVI and relate them to the atmosphere- biosphere CO_2 exchange.

Required for project

- Ability to use R code and develop small models in R
- Using basic statistics
- Working with large data sets

Measuring and modelling soil respiration and its spatial and temporal distribution

Supervisor

Dr Jörg Kaduk (Geography)

Project Description

This projects aims at identifying the patterns of soil respiration (soil CO_2 efflux) and its dependence on environmental conditions and relationships to soil carbon content and fine root biomass. It is well known that soil respiration responds to temperature in an exponential fashion. However, less is known about its spatial distribution and its response to soil moisture.

Project Aims

The project should comprise measuring soil moisture at a large number of locations as well as soil temperature and moisture. In the lab fine root biomass and soil carbon content should be determined for a representative number of soil cores. Optionally the soil and root nitrogen concentrations can be determined in addition. The analysis should determine relationships between measured soil respiration, soil temperature and moisture, fine root biomass and soil carbon content as well as examine the question whether there are spatial patterns in soil respiration and possible causes for these patterns.

Required for project

- Learning to use the IRGA (infrared gas analyser), which is used to measure CO2 flux
- Ability to develop small models in matlab or maple
- Using basic statistics
- Field work in Wicken Fen (2-3 visits, ~ 2h drive from Leicester, no public transport, no hotel, if no own transport, then significant flexibility to visit the site whenever somebody else goes (about once a month) is required, potentially cattle and ponies on site)

For organisational and safety reasons all projects in Wicken Fen could be conducted together and students could also share equipment workload. The idea would be to obtain the field measurements for the projects in a team of students. Students could go to Wicken with a PhD student or technician from the Department of Geography.

The carbon and water fluxes of South Africa

Supervisor

Dr Jörg Kaduk (Geography)

Project Aims

The aim of this model is to use a land surface model to simulate the carbon and water exchange of South Africa and compare the simulations to observations at selected locations as well as regional estimates. The project builds on 25 years of climate data available to drive the model. The task is to analyse the simulation results and compare them to observations. Some observations are available, some however need to be extracted from the literature.

Required for project:

- Ability to or to learn to work efficiently in a software environment, some computing experience (linux, bash, linux file system concept) desirable
- Willingness to use the University's HPC – either SPECTRE or ALICE
- Willingness to engage with the land surface model JULES (http://www.jchmr.org/jules/). This model mainly operates in batch mode. i.e. the simulation is submitted and results become available at some time but cannot generally be monitored in real time.
- Willingness to learn and program in the Data Visualization and Analysis tool ferret (http://ferret.wrc.noaa.gov/Ferret/).
- Ability or willingness to learn quickly to work with very large data sets – facilitated by ferret

Benefits:

- Gaining experience with a state of the art HPC computing system.
- Develop data analysis capabilities
- Learn about the atmosphere-biosphere exchange fluxes in South Africa

Measuring and modelling photosynthesis and its spatial distribution and plant community dependence in a regenerating fenland

Supervisor

Dr J Kaduk (Geography)

Project Description

This project aims at identifying the patterns of photosynthetic capacity and their dependence on environmental conditions and relationships to nutrient status in different plant communities in a regenerating fenland near Cambridge. For example it is well known pioneer species have a higher photosynthetic capacity than climax species. However, it is not clear how exactly the photosynthetic capacity changes within more or less flooding tolerant species.

Project Aims

The project should comprise measuring light saturated photosynthesis and incident light levels in the field in different locations and plant communities. Leaf nitrogen concentrations should be determined in the lab. The analysis should determine relationships between measured light levels, N concentration, light saturated photosynthesis and species. Finally a spatial extrapolation of photosynthesis based on the species map of the fenland should be conducted using a standard photosynthesis model and weather data from the weather station of the fenland.

Required for project

- Learning to use the IRGA (infrared gas analyser), which is used to measure CO2 flux
- Ability to develop small models in matlab or maple
- Using basic statistics
- Field work in Wicken Fen (2-3 visits, ~ 2h drive from Leicester, no public transport, no hotel, if no own transport, then significant flexibility to visit the site whenever somebody else goes (about once a month) is required, potentially cattle and ponies on site)

For organisational and safety reasons all projects in Wicken Fen could be conducted together and students could also share equipment workload. The idea would be to obtain the field measurements for the projects in a team of students. Students could go to Wicken with a PhD student or technician from the Department of Geography.

Measuring and modelling soil heat fluxes and moisture as well as surface temperature and its spatial and temporal distribution in a regenerating fenland

Supervisor

Dr J Kaduk (Geography)

Project Description

Soil heat fluxes are an important part of the energy budget of an ecosystem. They are important in evaluating the quality of the other measurements of the other energy fluxes, as the sum of all energy fluxes at the surface should be zero (with due attention to a proper sign convention). The spatial heterogeneity of the surface (topography, soil, vegetation…) make a determination of the soil heat flux over a larger area very difficult.

Project Aims

This project aims at identifying the patterns of soil heat fluxes and temperature and moisture as well as soil surface temperature and its dependence on environmental conditions

The project should comprise measuring radiation, soil temperature and moisture as well as soil surface temperature at a large number of locations. The analysis should determine relationships between measured radiation, soil temperature and moisture, soil surface temperature and vegetation and soil conditions. As well as examine the question whether there are spatial patterns and possible causes for these patterns.

Required for project

- Learning to use a data logger, measurement sensors and their physical principles.
- Ability to develop small models in matlab or maple
- Using basic statistics
- Field work in Wicken Fen (2-3 visits, ~ 2h drive from Leicester, no public transport, no hotel, if no own transport, then significant flexibility to visit the site whenever somebody else goes (about once a month) is required, potentially cattle and ponies on site)

For organisational and safety reasons all projects in Wicken Fen could be conducted together and students could also share equipment workload. The idea would be to obtain the field measurements for the projects in a team of students. Students could go to Wicken with a PhD student or technician from the Department of Geography.