UNIVERSITY OF LEEDS

WUN Workshop

Climate Resilient Open Partnership for Food Security (CROP-FS)

Saturday 2 April – Sunday 3 April 2016

Little Woodhouse Room
University House
University of Leeds

Climate Resilient Open Partnership for Food Security (CROP-FS)

Climate change has far-reaching implications for global food security and already substantially impacts agricultural production worldwide. As a result of changing climate, more frequent and intense precipitation events, elevated temperatures, drought, and other types of damaging weather are all expected to take tolls on crop yield and quality. This is happening at a time when global food demand is predicted to grow by 70% until 2050. It is of utmost importance to develop strategies to minimize the impact of changing climate on agriculture. Developing climate-resilient crops that can adapt to rapidly changing climate is critical to ensure global food security and political stability. Through the CROP-FS project, we will develop an international network of specialists across a range of relevant disciplines and regions to develop research strategies that will enable major food crops to grow under more extreme environmental conditions such as drought, high temperature, and irrigation with brackish or sea water. Strategic approaches include the following objectives:

1. Explore the effect of climate change on soil matrix and employ soil amendments such as biochar and other organic matters to increase soil moisture content and carbon sequestration.
2. Study the effect of changing climate on microbial communities in agricultural soils and their impact on crop yields and strategies to improve rhizosphere activity.
3. Understand the physiological and molecular basis of adaptation to drought, heat, and heavy metal stresses likely resulting from climate change, and target promising candidate genes/enzymes to improve crops' ability to produce better yield under multiple environmental stresses.

Expected outcomes: This interdisciplinary and international research collaboration will target opportunities for joint international funding from private, federal, and international funding sources to develop sustainable and climate resilient cropping systems with improved yields. CROP-FS will also facilitate joint peer-reviewed publications, exchange of students, postdocs, and faculty among participating institutions.

Participants in the Workshop

	Name	E-mail	Position	Affiliation
1.	Dr Om Parkash	parkash@psis.umass.edu	Associate Professor in Agriculture Biotechnology	University of Massachusetts
2.	Dr Frans Maathuis	frans.maathuis@york.ac.uk	Reader in Plant Biology	University of York
3.	Prof Ashwani Pareek	ashwanipareek@gmail.com	Professor in Plant Biotechnology	Jawaharlal Nehru University
4.	Prof. P.V. Vara Prasad	vara@ksu.edu	Director and Professor, Sustainable Intensification Innovation Lab	Kansas State University
5.	Prof Anna-Maria Botha	ambo@sun.ac.za	Professor in Genetics	Stellenbosch University, South Africa
6.	Prof Christine Foyer	c.foyer@leeds.ac.uk	Professor in Plant Science	University of Leeds
7.	Prof Karl Kunert	karl.kunert@up.ac.za	Professor in Plant Science	University of Pretoria
8.	Prof Chris Cullis	cac5@case.edu	Francis Hobart Professor of Biology	Case Western Reserve University
9.	Prof Klaus Nusslein	nusslein@microbio.umass.edu	Professor in Microbiology	University of Massachusetts
10.	Dr Baoshan Xing	bx@umass.edu	Professor in Environmental & Soil Sciences	University of Massachusetts
11.	Dr Marc Dumont	m.g.dumont@soton.ac.uk	Lecturer in Soil Biology	University of Southampton
12.	Dr Baoliang Chen	blchen@zju.edu.cn	Vice Dean and Professor, Soil Sciences	Zhejiang University
13.	Prof Lingli Lu	lulingli@zju.edu.cn	Associate Professor, Department of Plant Nutrition	Zhejiang University
14.	Prof Laurel Smith-Doerr	lsmithdoerr@soc.umass.edu	Professor in Social Sciences	University of Massachusetts
15.	Timothy Sacco	tosacco@soc.umass.edu	Graduate Student	University of Massachusetts

Programme

Saturday 2 April

8:30am	*Registration and coffee*
9:00am	Introduction
9:10am	Om Parkash
9:40am	Frans Maathuis
10:10am	Ashwani Pareek
10:40am	P.V. Vara Prasad
11:00am	*Coffee Break*
11:30am	Anna-Maria Botha
12:00pm	Christine Foyer
12:30pm	Karl Kunert
1:00pm	Chris Cullis
1:30pm	*Lunch Break*
2:30pm	Klaus Nusslein
3:00pm	Baoshan Xing
3:30pm	Marc Dumont
4:00pm	*Coffee break*
4:30pm	Discussion
5:00pm	Close

7:00pm – Dinner – Thai Edge, 7 Calverley Street, Leeds 1

Sunday 3 April

9:15am	*Coffee on arrival*
9:30am	Baoliang Chen
10:00am	Lingli Lu
10:30am	Laurel Smith-Doerr
11:00am	Brainstorming session for collaborative funding opportunities from International funding agencies or any other sources
12:00pm	*Lunch*
1:00pm	Breakout groups
1:30pm	Discussion about facilitating and extending collaboration among various CROP-FS interdisciplinary groups
2:30pm	Future workshops and activities for CROP-FS
3:30pm	*Coffee and close*

Abstracts

Abstracts for CROP-FS workshop at the University of Leeds (U.K.)

April 2-3, 2016

1. Developing Climate Resilient Crops for Enhanced Productivity under Extreme Environments

Om Parkash Dhankher
Stockbridge School of Agriculture, University of Massachusetts Amherst, MA 01003

Abiotic stresses including drought, heat, salinity, and heavy metal toxicity as a result of climate change have far-reaching implications for global food security and already substantially impact agricultural production worldwide. In order to increase crop productivity to meet the current global food demand, it is imperative to understand the underlying molecular and biochemical mechanisms for developing crops resistant to multiple abiotic stresses. We have characterized the members of Stress-Associated Proteins (SAP) gene family in plants for their roles in providing tolerance to multiple abiotic stresses. Overexpression of SAP genes in Arabidopsis and Brassica juncea provided strong tolerance to multiple abiotic stresses such as salt, drought, heat, and various toxic metals including zinc, cadmium, arsenic, nickel and manganese, without causing a significant difference in metals accumulation. Additionally, we are characterizing a novel gamma-glutamyl cycle in plants for its role in GSH homeostasis, oxidative stress tolerance and improved nitrogen use efficiency (NUE) in plants. Manipulation of the genes involved in the -glutamyl cycle in plants also showed strong tolerance to oxidative stress and enhanced NUE via glutamate recycling under stress conditions. Additionally, we are performing the metabolic engineering of oil seed crops such as Camelina sativa, Crambe abyssinica and Brassica juncea for improved oil yields for food as well as biofuels production. My lab is also studying the molecular mechanisms of uptake and transport of metalloids including boron and arsenic in plants and developing strategies for their phytoremediation as well as reducing the uptake of these toxins in rice and other food crops.

2. Increasing Resistance in Cereals to Abiotic Stress.

Frans Maathuis
Biology Department, University of York, York YO10 5DD, United Kingdom

Ion channel characterisation, e.g. plant vacuolar K channels: Previous work showed a role of AtTPK1 in guard cell functioning and overall K homeostasis. We subsequently studied the role of TPKs in rice. In rice two functional isoforms localise to different types of vacuole.

Mechanisms of plant salt tolerance: We have worked on Arabidopsis, wheat, barley and rice to study the role of a range of transporters (TPKs/AKT, SKOR, HKTs) in salt tolerance and K+ nutrition.

Cyclic nucleotide signalling in plants: Previous work showed a role of cGMP signaling in salt stress and potassium nutrition. We developed transgenic plants (Arabidopsis) and constructs for a GFP-based cGMP reporter in plants.

Plant Arsenic research: We were the first lab to identify specific NIP aquaporins involved in arsenite uptake in plants. We are currently studying Arabidopsis and rice NIPs and cloned and expressed the yeast arsenite efflux system, ACR3, in Arabidopsis and rice.

GWAS studies in rice: We used a 700k SNP array to identify rice gene candidates with a function in salt and drought tolerance, and in K, N and P nutrition.

3. From "Meta-OMICS" to "Muta-OMICS": towards raising crop plants for dry and saline lands

Ashwani Pareek
Stress Physiology and Molecular Biology Laboratory, School of Life Sciences, Jawaharlal Nehru University, New Delhi-110067, India

Abiotic stresses such as salinity, drought and heat are major constraints for global crop production in the current and more so in the future climate. Rice is a staple food crop for more than half of the world population. An estimated demand for rice would increase at least by 50 percent in the next 25 years to feed the growing population. Taking clues from naturally salinity tolerant rice genotypes, we are trying to understand the molecular basis of stress tolerance using an OMICS-based approach. This work has led to the identification and functional validation of key stress responsive genes, which may prove to be a suitable candidate for translational research. Taking an alternative approach of mutagenesis, we have generated several mutant lines through gamma-irradiation and screened them at seedling stage for different abiotic stress tolerance. Three screened mutant lines showed significant potential to survive under severe heat, drought and salinity stress at seedling stage. These mutant lines were further characterized for their mechanism of stress tolerance at reproductive and grain filling stage. Plants were grown in 15 L pots in the net house and phenotyping for heat, drought and salinity stress was done across the growth stages. Besides agronomic traits, key physiological traits such as photosynthesis, physiological water use efficiency, stomatal conductance, spikelet fertility, pollen germination, K^+/Na^+ ratio, spikelet fertility and source-sink regulation at grain filling were studied. These mutant lines could be used for improving rice production and varietal improvement for future climate.

4. Increasing Climate Resiliency of Crop Production Systems for Food Security

P.V. Vara Prasad
Feed the Future Sustainable Intensification Innovation, Kansas State University, Manhattan, Kansas 66506, U.S.A.

Response of Field Crops to High Temperature Stress:

The increased frequency and intensity of short episodes of high temperature (heat) stress in current and future climates is a major challenge for sustaining productivity of grain crops. The impact on grain yield depends on the timing, intensity and duration stress. Short durations of heat stress coinciding with either gametogenesis or anthesis leads to negative impact of seed-set, while stress exposure at post-anthesis stages decreased seed filling duration leading to decreased seed weight. Season-long heat stress decreased biomass production, seed number, individual seed weight and yield of all grain crops. Specific window of most sensitive stages to episodes of heat stress and also temperature thresholds for major field crops was identified. Physiological and biochemical mechanisms associated with reproductive failure were determined. However, better understanding of genetic variability and high throughput phenotyping techniques needs further investigation.

Role of Sustainable Intensification in Improving Climate Resiliency:

The Feed the Future (FtF) Sustainable Intensification Innovation Lab (SIIL) is a United States Agency for International Development (USAID) program that supports research, knowledge sharing, and capacity building activities aimed at sustainably transforming farming systems of smallholder farmers. Sustainable intensification (SI) is defined as a process that increases agricultural yields from existing farmland without adverse environmental impact. Our objectives are to develop research and capacity-building portfolios in collaboration with universities, international and national organizations to sustainably increase agricultural productivity, income and provide food and nutritional security to smallholder farmers in Africa and Asia. The SIIL supports Geospatial and Farming Systems Research Consortium and the Appropriate Scale Mechanization Consortium, and several research projects in Senegal, Burkina Faso, Tanzania, Ethiopia, Bangladesh and Cambodia.

P.V. Vara Prasad is the Director of Feed the Future Sustainable Intensification Innovation Lab and Professor of Crop Ecophysiology at Kansas State University. His research focuses on understanding responses of food crops to climate change and developing crop, water and soil management strategies for efficient use of inputs and improve crop yields.

5. Increasing resilience to climate change through the recruitment of SUMOylation

Anna-Maria Botha
Genetics Department, Stellenbosch University

Post-translational modifications of proteins play a critical role in cellular signalling processes. In recent years, the SUMO (Small Ubiquitin-like Modifier) class of molecules has emerged as an influential mechanism for target protein management. SUMO proteases play a vital role in regulating pathway flux and are therefore ideal targets for manipulating stress-responsive SUMOylation. It was shown that SUMOylation could be recruited to dramatically improve plant growth during salinity stress, drought and high temperature stress by overexpressing the SUMO protease gene OTS1 in Arabidopsis. Recently we identified and cloned wheat homologs of OTS1, OTS2 and ICE, suggesting that SUMOlytion may also be important in other crops. Thus, we transformed wheat lines with OTS1, OTS2 and ICE to enhance stress resilience. In a parallel approach, ethylmethanesulfonate (EMS) and Sodium Azide mutagenic lines were also developed, selected for water stress tolerance, and the mutagenic progeny tested for their stress responses. To elucidate the possible contribution of SUMOylation to the increased drought tolerance observed in these lines, they are screened for SUMO targets. The results obtained with the transgenic lines and mutagenic lines will be briefly discussed.

6. The function of WHIRLY1 in stress-induced senescence

Christine Foyer
Centre for Plant Sciences, Faculty of Biological Sciences, University of Leeds, Leeds, LS2 9JT, UK

The WHIRLY family of ssDNA binding proteins, which have a quaternary structure with a whirligig appearance, form much larger oligomeric structures in chloroplasts and mitochondria. WHIRLY1, which is targeted to chloroplasts but is also found in the nucleus, was first characterised as a binding subunit of the nuclear transcriptional activator, PBF2. WHIRLY 1 is required for the expression of chloroplast genes, senescence associated genes and salicylic acid-regulated genes. We have used RNAi-knockdown lines (W1-1, W1-7 and W1-9) that have very low levels of HvWHIRLY1 transcripts to explore WHIRLY1 functions in barley. We have characterized the influence of WHIRLY 1 deficiency on biotic and abiotic stress responses. The W1-1, W1-7 and W1-9 plants were phenotypically similar to the wild type but produced fewer tillers and seeds. Photosynthesis rates were similar in all lines but W1-1, W1-7 and W1-9 leaves had significantly more chlorophyll and less sucrose than the wild type. Transcripts encoding specific sub-sets of chloroplast-localised proteins such as ribosomal proteins, subunits of the RNA polymerase and the thylakoid NADH and cytochrome b6/f complexes were much more abundant in the W1-7 leaves than the wild type. While susceptibility of aphid infestation was similar in all lines, the WHIRLY1-deficient plants showed altered responses to drought and to nitrogen deficiency, maintaining higher photosynthetic CO_2 assimilation rates than the wild type under stress conditions. We propose that WHIRLY1 has a role in communication between plastid and nuclear genes encoding photosynthetic proteins that alters the stress-induced senescence response.

7. Soybean nodules: A drought stress target

Karl Kunert
Departments Plant Science and Plant Production and Soil Science, University of Pretoria

The Pretoria group works on legumes, in particular soybean, which is an important food and feed crop world-wide and a major protein source for a growing world population. However, predicted future changes in climatic conditions together with less water availability for plant growth will severely affect soybean growth. Processes affected will also include natural nitrogen fixation in soybean root nodules which form due to a symbiotic relationship with root-colonizing rhizobacteria. Our group has a strong interest in investigating specifically proteolytic processes induced by drought stress in these nodules and particularly focuses on the role of the cysteine proteases-cysteine protease inhibitor (cystatin) system in nodules. This system might provide a balance between stress-induced protein degradation causing premature nodule death and easier recovery from stress due to inhibitor expression. Our group has recently identified the different cysteine protease and cystatin genes involved in the system during natural senescence and after drought stress and we have also studied the interaction of these two components of the system during nodule senescence. These studies have already provided first insight about the role of various gene family members in both natural senescence and during drought stress which might allow for future development of a unique protein marker for drought stress.

8. Marama Bean – a possible new crop for arid regions

Chris Cullis
Francis Hobart Herrick Professor of Biology, Case Western Reserve University

Marama bean (Tylosema esculentum (Burchell) A. Schreiber: Caesalpinioideae) is a perennial non-nodulating legume of southern Africa (Namibia, Botswana and South Africa), growing in poor, arid soils surrounding the western, southern and eastern Kalahari. Marama produces large (2.5 g per seed without shell), protein- and oil-rich edible seeds, and extremely large (up to 200 kg) tubers, containing protein and carbohydrate. Whole genome sequencing using both Illumina and PacBio platforms have yielded a nuclear genome assembly and a complete chloroplast molecule. Although a legume, the plant does not nodulate but it appears to have a high nutrient utilization efficiency, being able to grow with very limited nutrients. The genomic resources are being applied to identify whether the pathway for nodulation is present in marama, the genes responsible for the high nutrient utilization and other important pathways. All the genomic resources are being applied to the development of seed orchards to produce improved seed to be supplied to resource poor farmers in the region.

9. Do Climate and Land Use change influence Soil Microbes?

Klaus Nusslein
Department of Microbiology, University of Massachusetts Amherst, MA 01003

Microbes in terrestrial environments are important catalysts of global carbon and nitrogen cycles, including the production and consumption of greenhouse gases in soil. Some microbes produce the greenhouse gases carbon dioxide (CO2) and nitrous oxide (N2O) while decomposing organic matter in soil. Others consume methane (CH4) from the atmosphere, thus helping to mitigate climate change. The magnitude of each of these processes is influenced by human activities and impacts the warming potential of Earth's atmosphere. Climate change will alter humanity's path, changing how we interact with the world. To better understand the role agricultural management or soil warming have on these microbial processes, my research is focused on the adaptation of microbial community structure and function to manmade external stress factors. Specifically, our systems are microbial shifts in response to land use change in tropical rainforests, or in response to climate change parameters in temperate forests. Much of his work is in collaboration with biogeoscientists, ecologist, and recently also bioinformatics experts.

10. Biochar as amendment to improve soil health and quality

Baoshan Xing
Stockbridge School of Agriculture, University of Massachusetts Amherst, MA 01003

Our research interests include: environmental behavior of engineered nanoparticles, sorption of organic contaminants in soils, biochar characterization and use for soil improvement, and application of spectroscopic and microscopic techniques in environmental and soil sciences. In this presentation, I will briefly discuss the agricultural and environmental benefits of biochar. Due to its resistance to decomposition, biochar can sequester carbon in soil and increase soil organic matter content. In addition, biochar can alleviate soil acid and Al toxicity problems in soil. Also, biochar can reduce N2O emission from soil when used properly. Moreover, biochar can adsorb and reduce bioavailability of organic chemicals and heavy metals to crops, thus, protect food quality and safety. Our results further show that biochar can increase nutrient (N) retention and utilization efficiency in soil. Finally, biochar is shown to improve soil moisture and facilitate soil aggregation.

11. Microbial communities associated with the roots and rhizosphere of rice plants

Marc Dumont
Centre for Biological Sciences, University of Southampton

Microorganisms associated with the roots and rhizosphere of rice play an important role in soil fertility, organic matter decomposition and the production of greenhouse gases. The objective of this work was to characterize the microbial community in the rhizosphere of rice and to identify those microorganisms using root exudates. We used high-throughput sequencing and stable isotope probing (SIP) methods to characterise the microbial communities. SIP is a technique to identify active microorganisms in environmental samples based on the assimilation of 13C-labelled growth substrates and the selective recovery and sequencing of labelled nucleic acids. Comparisons of the microbial communities in bulk and rhizosphere soil showed that the compositions within nearly all detected bacterial phyla were distinct between these zones, but the largest differences were observed for Proteobacteria, Gemmatimonadetes and Verrucomicrobia. A comparison of the rhizosphere communities at different plant growth stages identified a Herbaspirillum species enriched in the early vegetative stage of rice plant development. Microorganisms using root exudates were identified by growing plants with 13CO2, and indicated that distinct microbial populations incorporate plant carbon in the root and rhizosphere environments.

12. Structural Characteristics of Biochars and their Soil Pollution Remediation Application

Baoliang Chen

Department of Environmental Science, Zhejiang University, Hangzhou 310058, China

Biochars are a carbon-rich material formed when a biomass is pyrolyzed at relatively low temperatures. The substance receives increasing attention for uses in soil amendment and carbon sequestration. Soils amended with biochars reduce dissipation and leaching of pollutants as well as their bioavailability. In general, the uptake of a compound by a biochar depends on the composition and surface structure of the biochar that is affected by the pyrolytic temperature. The influence of the extent of carbonization in a biochar on the overall rate of sorption of a compound with different biochars were investigated. The biochars were characterized by FTIR spectra, elemental compositions, specific surface areas, pore size distributions, and SEM images. The carbon stability in the biochars and their mechanisms were evaluated. The chemical extractability and plant uptake of spiked polycyclic aromatic hydrocarbons were evaluated. The bioremediation of soil having a long history of PAH contamination by using an immobilized microorganism technique with biochars as carriers were exploited. The application of biochars for alleviation of Al phyto toxicity were initially elucidated.

13. Understanding mechanisms of heavy metals uptake and accumulation in plants for soil remediation and food security

Lingli Lu
Department of Plant Nutrition, Zhejiang University, Hangzhou 310058, China

Contamination of cadmium in soils poses a serious threat to both crop productivity and human health in many parts of the world. Hyperaccumulators are capable of colonizing soils contaminated with heavy metals and accumulating high concentrations of metals in shoots, and thus have potential for use in phytoremediation of contaminated soils. Elucidation of the mechanisms involved in the metal accumulation and tolerance of hyperaccumulators may facilitate the rational design of technologies for the cleanup of metal-contaminated soils. Sedum alfredii is one of a few Cd hyperaccumulators identified up to date. Co-plantation of vegetables with the plants of S. alfredii significantly reduced Cd accumulation in the edible parts of the vegetables. Enhanced rate of root-to-shoot translocation, possibly as a result of enhanced xylem loading mediated by a SaHMA2, was the pivotal process expressed in this hyperaccumulator plant species. Meanwhile, efficient vacuolar sequestration of Cd and the metal chelation with malic acid, in the parenchyma cells may represent the key process responsible for metal homeostasis and tolerance of the cells in shoots of S. alfredii. A highly competitive interaction between Cd and Ca was observed in the hyperaccumulator S. alfredii. Additionally, we are performing the rhizosphere characteristics of the plants of S. alfredii grown on the polluted soils. Physiological mechanisms of uptake and transport of Cd in rice is also studied in our lab for developing strategies for reducing the uptake of Cd in rice grains.

14. The Science of Scientific Collaboration

Laurel Smith-Doerr and Timothy Sacco
Institute for Social Science Research at University of Massachusetts Amherst, MA 01003

Smith-Doerr investigates how science is organized in contemporary knowledge-based communities. She conducts research on inter-organizational collaboration among biotech firms, implications of different organizational contexts for women's equity in science, scientific networks and scientists' approaches to social and ethical responsibilities, and tensions in the institutionalization of science policy. At the workshop in Leeds she will present some highlights of research relevant to understanding scientific collaboration across disciplines. For this project, with Timothy Sacco, the sociologists will be investigating the formation of this new, international collaboration. Understanding the processes of the formation and development of a collaborative project that crosses both disciplinary and international boundaries is important to building knowledge about both the positive impacts and challenges of collaboration.

Laurel Smith-Doerr is Professor of Sociology and Director of the Institute for Social Science Research at University of Massachusetts; she was formerly Program Director of Science, Technology & Society at the National Science Foundation. Results of her past research have been published in her book, Women's Work: Gender Equity v. Hierarchy in the Life Sciences, and scholarly journals, including Nature Biotechnology, Science, Technology & Human Values, Administrative Science Quarterly, Minerva, Regional Studies, American Behavioral Scientist, and Gender & Society. Her published work has been cited more than 11,000 times.

Timothy Sacco is Graduate Research Assistant to Smith-Doerr and doctoral candidate in Sociology at the University of Massachusetts. He will be collecting observational data on the formation and development of the international collaboration at the workshop in Leeds.

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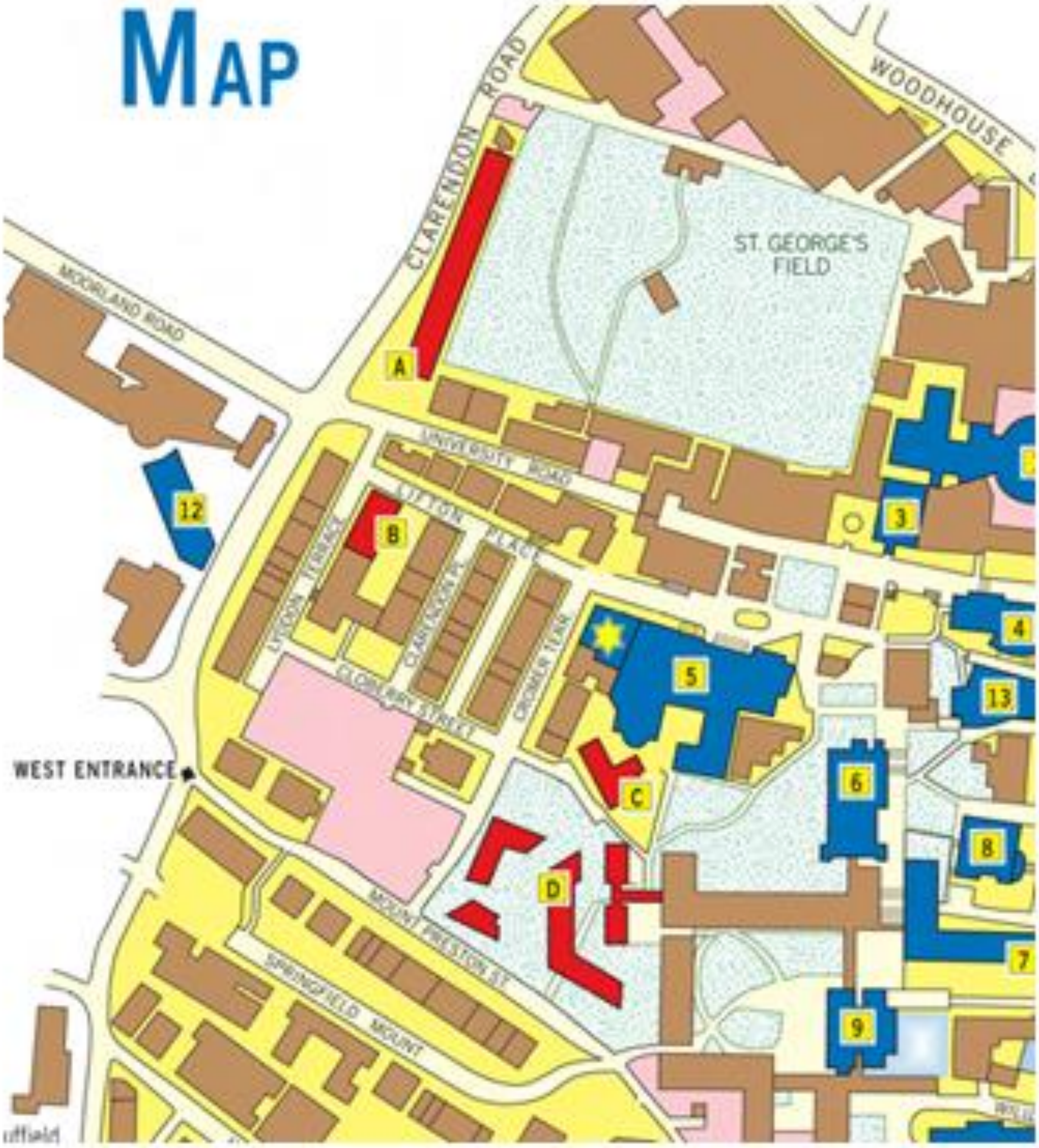

Building 5 shows University House