



Enlightenment

The Art of Science by photographer David McIntyre



David McIntyre is a professional freelance photographer who lectures in photography and digital imaging at Edinburgh's Telford College. David obtained an honours degree in Photography, Film and Television from Napier University in Edinburgh. He began his freelance career working for London based youth culture magazines and record labels travelling extensively as well as shooting for national publications including The Herald, The Scotsman and The Guardian. For the past 10 years David has focussed upon national design and advertising agency commissions. He currently combines his lecturing post at Telford College with his freelance work which allows him freedom to pursue personal photography projects which are now his passion.

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'The true sign of intelligence is not knowledge but imagination,' EINSTEIN.

Collaboration, inspiration and imagination describe the creative process used in developing this exhibition which brings together Art and Science.

Our inspiration came from the world class scientific research being conducted within the Scottish Research Institutes forming the knowledgescotland partnership. The knowledgescotland project aims to provide closer links between science and policy and we are very grateful to the Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) for funding this project. www.knowledgescotland.org

Research is helping to find solutions to some big challenges eg: changing climate; conserving biodiversity; providing sustainable energy sources; ensuring safe and sustainable food and water supplies; improving health and well being and prevention and control of infectious disease.

Our creative concept was to produce images that would act as signifiers to the stories behind the research. Some images are quite abstract in nature and show multilayered themes, while others involve a single bold concept. All are related to the scientific story that inspired them and we hope they may invite curiosity, provoke interest and lend themselves to imaginative interpretation.

Enlightenment

The title of the exhibition, *Enlightenment*, seemed appropriate as it perfectly encapsulated the evolution of the creative process involved. The images may initially be interpreted through imagination and then perhaps seen again in a different light after reading the accompanying caption which reveals more about the scientific story that inspired the photographic image.

David McIntyre had discussions with scientists and then created photographic images, selecting subject matter and materials to create an exhibition that has a true visual flow. *'The thoughts behind these images were reached throughout my journey. I tried to stray, identify the unfamiliar and choose new personal routes,'* DAVID MCINTYRE.

The philosopher Immanuel Kant described Enlightenment as, *'Freedom to use one's own intelligence'*. The Enlightenment period in Scotland in the 18th Century was known as a time of great intellectual and scientific accomplishments. Scots were among the most literate citizens in Europe and contributed to the great advances in science, medicine, agriculture, philosophy and the arts.

Scotland today continues to have a worldwide reputation for producing thinkers and innovators and the knowledgescotland partnership is working together with the Scottish Government to use this collective knowledge to help improve the quality of our lives and those of others around the world.

We do hope you enjoy the exhibition and that it may spark curiosity and debate about scientific discovery and its relevance to our everyday lives. Science can help us find solutions to many of the major issues we currently face and will profoundly influence how we shape our future.

David McIntyre, Hazel Simm and Elisabeth Innes

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Vampire Slayers

Haemonchus contortus, commonly known as the barber's pole worm, is a blood sucking parasite which is one of the world's most important pathogens of sheep and goats.

Infection with this worm is common in warm humid climates and as a result of climate change it is an emerging problem in the UK. Control of the parasite using drugs is not a sustainable option as worms have developed resistance to drugs in many countries.

The worm feeds by sucking blood from its host and scientists at Moredun Research Institute have developed a vaccine which targets the immune response to attack the gut of the worm. This vaccine helps to control infection and is currently being tested for its ability to protect livestock in Australia, South Africa and Brazil.

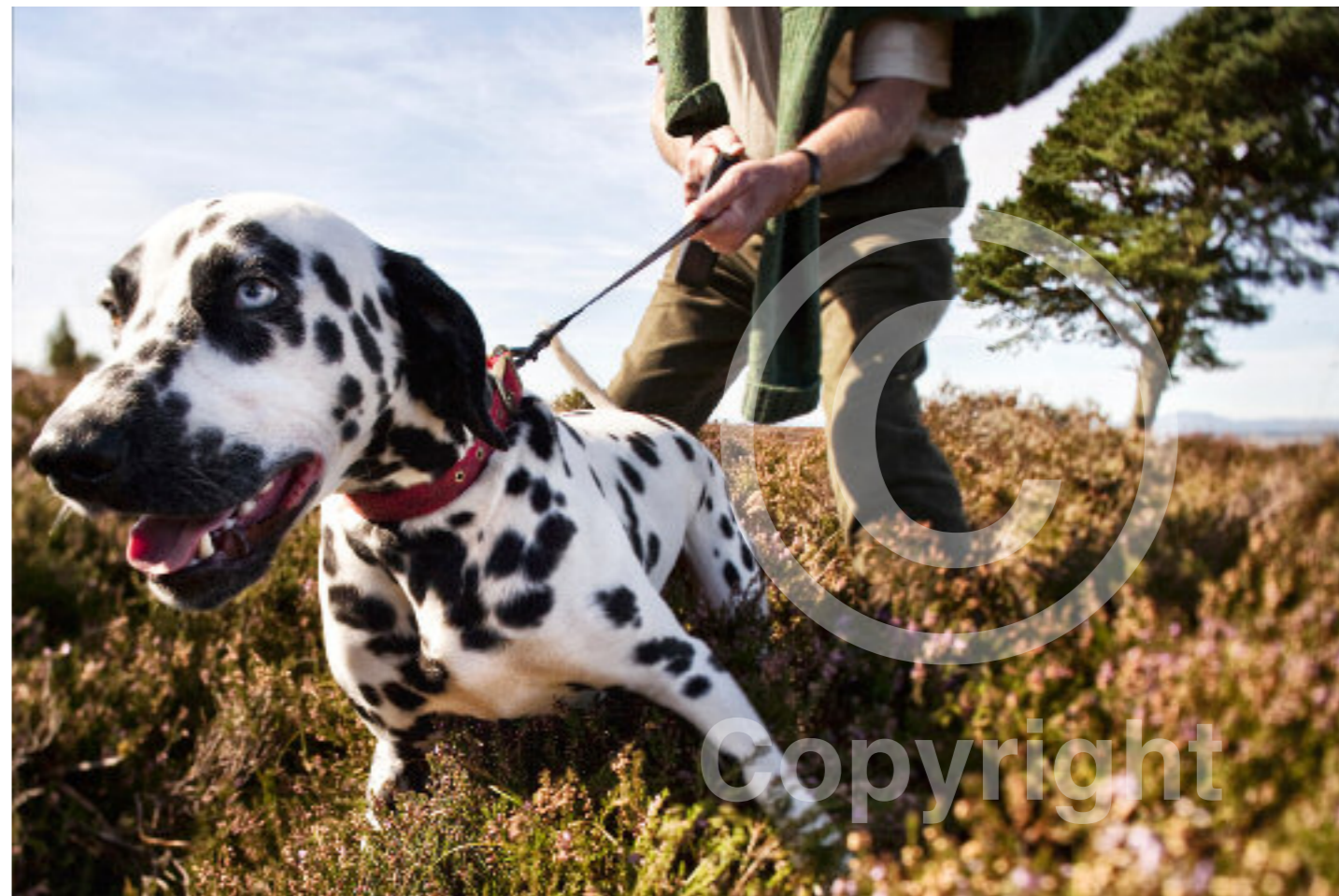


Right of Way

Scotland has some of the most beautiful outdoor recreational areas in the world and recent legislation has allowed even greater freedom to experience it. People can now access virtually all of the country's land and inland water using any form of non-motorised recreation.

However, these new rights are conditional upon individuals acting in a responsible manner with people using their own judgement to identify the limits of where they can go, what they can do and how they can do it. This room for interpretation of the access laws can lead to tensions between different users of the countryside who may feel their experience is being compromised by the activities of others.

Recent research at the Macaulay Land Use Research Institute has looked at the challenges posed by the redefined outdoor access rights and how this affects the interactions between the different user groups such as walkers, dog owners, horse riders and mountain bikers.



Priceless Pods

Potatoes are the world's most important non-grain food crop and are a valuable commodity for Scotland which has a worldwide reputation for producing good seed potatoes.

Growing potatoes in a sustainable manner is becoming more challenging with climatic changes, problems with pests and pathogens and shifts in agricultural practices. Solutions may be found within the amazing range of diversity present among different potato species.

The Commonwealth Potato Collection is held and maintained at SCRI and comprises around 1,500 lines of 80 wild and cultivated species. Each line can be traced back to a handful of berries or tubers from potato plants originating in South or Central America. This diverse genetic resource is invaluable to allow the production of sustainable, high producing and disease resistant crops.

Each of the potato seed pods will yield around 300 true seeds. These seeds are used by potato breeders to grow potential new varieties as each one is genetically distinct, like children in a family,

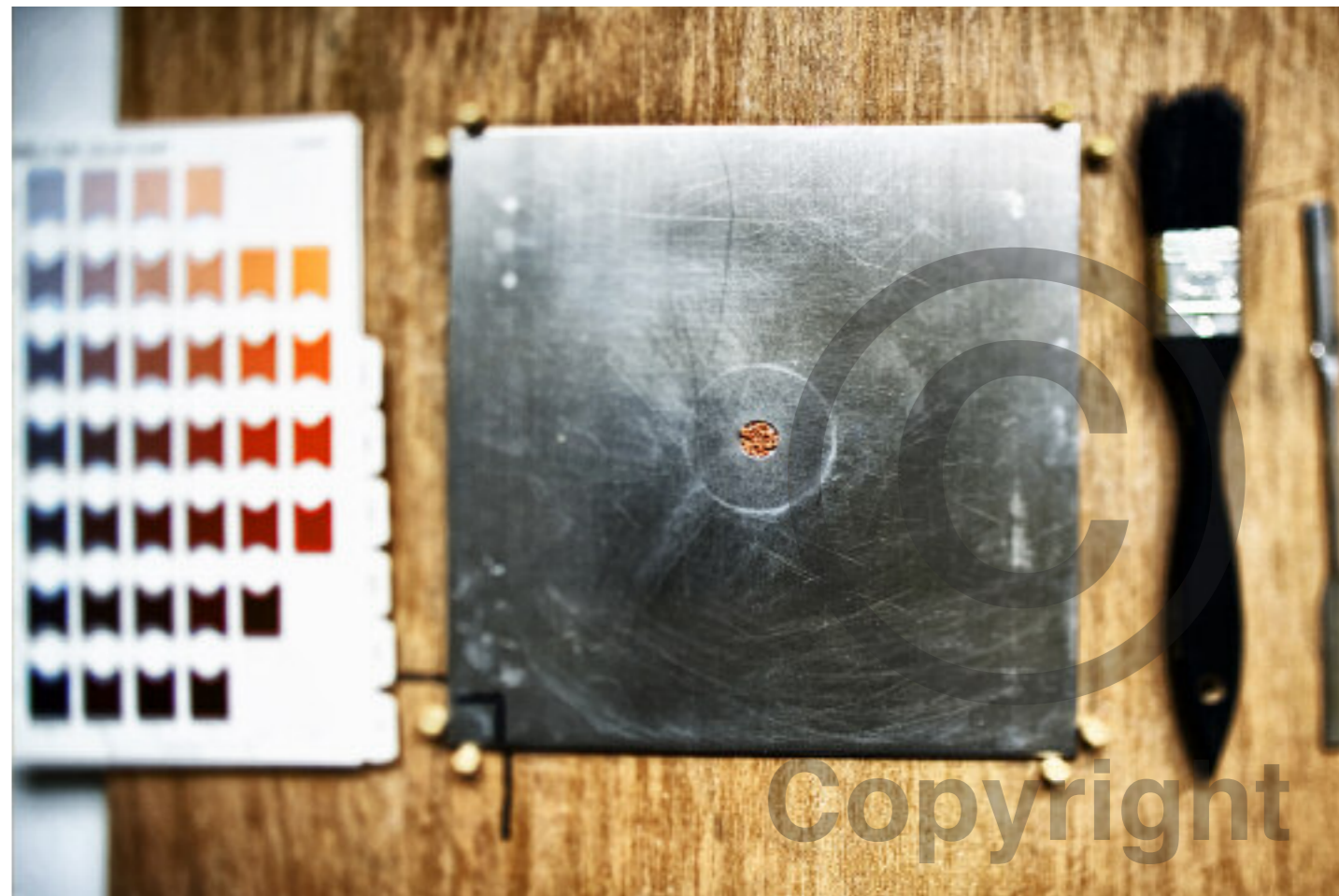


CSI-Soil

Soil can harbour many secrets, revealing important clues to help in forensic examinations. Commonly found on clothes, shoes, floors, vehicles and spades, soil can be linked to contact points such as at crime scenes.

Research at the Macaulay Land Use Research Institute, involves developing and applying new techniques to discriminate soil using organic analysis, high resolution X-ray diffraction and molecular microbiology, which can be sample matched with database information.

This new technology can assist police in forensic investigations of crime scenes such as narrowing down search areas, locating the graves of murder victims, uncovering buried items of relevance and as physical evidence in court.



Eating for Two

The UK has one of the highest pregnancy rates in Europe among young adolescent girls. Pregnancies in this age group are often complicated by birth of premature and low weight babies that have a higher risk of both immediate and life-long health complications.

Possible reasons for low birth weights include gynaecological immaturity of the mother but there is also evidence that diet during pregnancy may play an important and modifiable role.

Research at the University of Aberdeen Rowett Institute of Nutrition and Health is looking at nutrition in relation to the function of the placenta and growth of the foetus, in order to help provide appropriate advice on nutrition and diet to young mothers during pregnancy.



Diverse Markets

In the last 10 years Farmers' Markets have become a regular and popular feature in Scottish towns and cities. In these days of mass marketing, Farmers' Markets offer consumers an opportunity to meet the producers of the food they buy, much of which is local.

SAC Consultants have developed a Farm Diversification Database and a Local Food Marketing Guide to enable and encourage producers to find a profitable and sustainable way to develop their businesses. By working together with producers they aim to promote thriving rural communities.



Herbarium Secrets

Hidden deep within the grey metal cabinets of the Herbarium at the Royal Botanic Garden Edinburgh are a unique and extensive collection of nearly 3 million specimens dating back to the late 17th Century. The specimens were contributed over the years by collectors, scientists and explorers and each tells a fascinating story relating to their origins.

One of the most famous Scottish collectors or plant hunters was George Forrest, born in 1873, who undertook several expeditions to western China and brought back hundreds of seeds, roots and plants including primula, rhododendron and clematis. He travelled to remote, unexplored and sometimes highly dangerous regions. On one expedition, he made a daring escape in disguise when the rest of his group were murdered by Chinese monks.

The Herbarium remains a unique and rich resource for botanists and enthusiasts and is currently being re-organised to reflect current understanding of plant classification.



Conservation Cows

Wildflowers were once abundant in our meadows offering a wonderful habitat for butterflies, bees and birds. Traditionally the meadows were grazed by cattle, and their less selective grazing habits helped encourage this biodiversity. However, as farming intensified and artificial fertilisers produced more grass to feed more cattle, the habitat and the wild flowers disappeared.

Research at SAC is now studying how to restore those flower rich habitats and their links with other species. They still use cattle, but 'Conservation Cows' come in fewer numbers, at lower stocking rates.

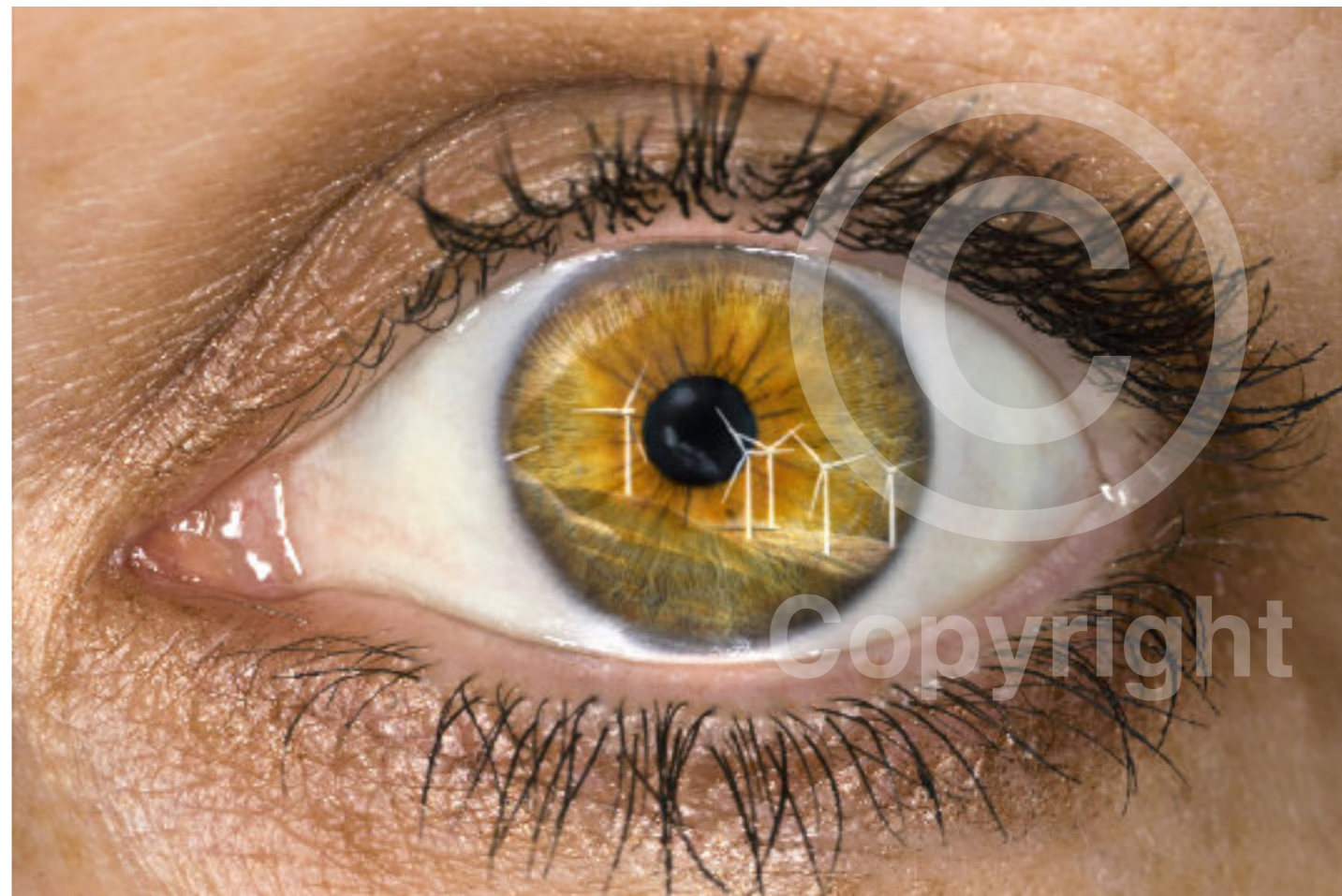


Foresight

When individuals and communities are faced with new planning proposals, such as the siting of wind turbines, which may significantly affect them and the area in which they live, it is important that they are fully involved in the decision making process and have an understanding of the implications of the proposed change.

Research at the Macaulay Land Use Research Institute has utilised a Virtual Landscape Theatre (VLT). This uses virtual reality technology to recreate landscapes and allow people to visualise and fully assess the impact of the proposed change. Electronic voting is used to enable instant feedback by audiences on such change, all of which supports wider discussion and sharing of opinions.

The VLT is an important tool in helping people to engage more effectively in land use planning through greater understanding of the different future alternatives.

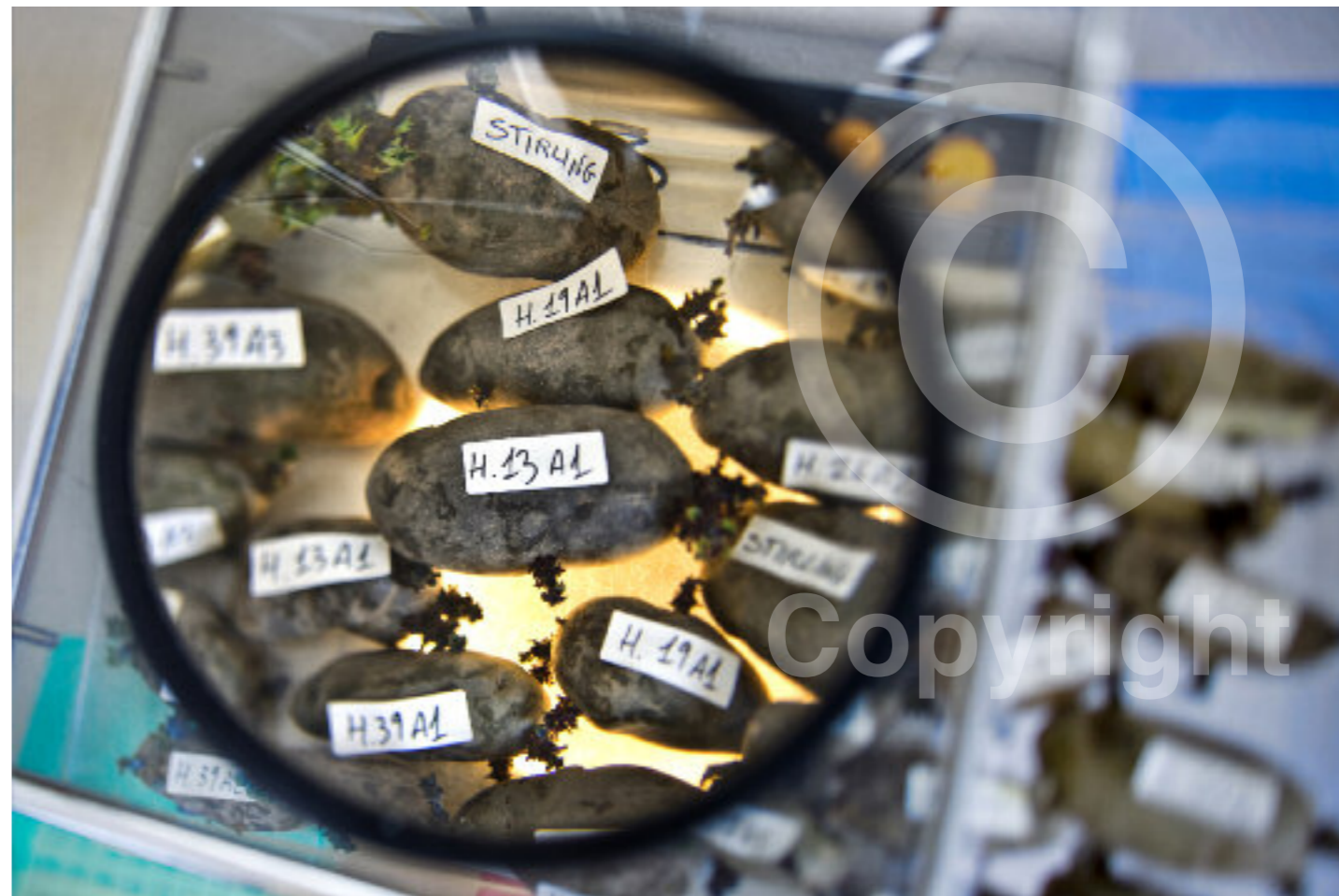


Immigration Control

Pests and diseases are a major constraint to sustainable and efficient crop production being responsible for up to 40% of crop losses.

Pressures from climate change and increased globalisation, with greater movement of plants and their products across borders, increases the risk of spreading pests and diseases into new areas, where they can rapidly become established and result in devastating losses for crop producers.

Research is being conducted at SCRI to develop new techniques for rapid detection and monitoring of potential pests and disease threats.



War of the Worms

Parasitic worms that live in the gut of cattle and sheep are a major cause of disease and production loss worldwide. The mainstay to control infection is treatment with anti-parasitic drugs (wormers or drenches), combined with pasture management.

The control of worms using drugs is not likely to be a sustainable option in the longer term as there is increasing evidence of strains of worms which have developed resistance to the few drugs available.

Scientists at Moredun Research Institute are looking at the genes involved in conferring drug resistance in these parasitic worms. This research has been used to develop new genetic tests which are being applied to examine the extent of drug resistance within parasitic worms on farms. This knowledge will help to devise optimal drug dosing strategies to maintain drug efficacy.



Resurrection

Many of our native plant and animal species are endangered due to pressures on habitats, pests and diseases, and changes in environmental conditions. Conservation scientists work to monitor and understand the biology and ecosystems of different biological species and, where deemed appropriate, will intervene to help restore habitats and protect endangered species.

Research at the Royal Botanic Garden Edinburgh is looking at the critically endangered Woolly Willow, a low shrub with woolly, grey-green leaves, now found only at sites at high altitude and inaccessible to grazers.

Seeds and cuttings have been collected and new plants grown at the Royal Botanic Garden Edinburgh. These are now re-planted back in the Corrie Fee National Nature Reserve which is one of the best sites in Britain for mountain plants.



Immune Protection

Infertility and reproductive failure in livestock results in significant economic loss. Infectious disease is a major cause of reproductive failure and many pathogens (disease causing micro-organisms) exploit natural changes in the immune system in pregnant animals to invade and multiply within placental and foetal tissues.

Scientists at Moredun Research Institute, are looking at how the immune system changes during pregnancy to allow the mother to successfully carry and support the growth of the developing foetus, which is essentially a foreign tissue graft, without rejecting it.

These natural changes in the mother's immune system during pregnancy provide a window of opportunity for certain pathogens to cause disease in the developing foetus. By understanding this relationship between the pathogen and the host in pregnant animals, Moredun scientists are able to develop vaccines to help protect against reproductive diseases.



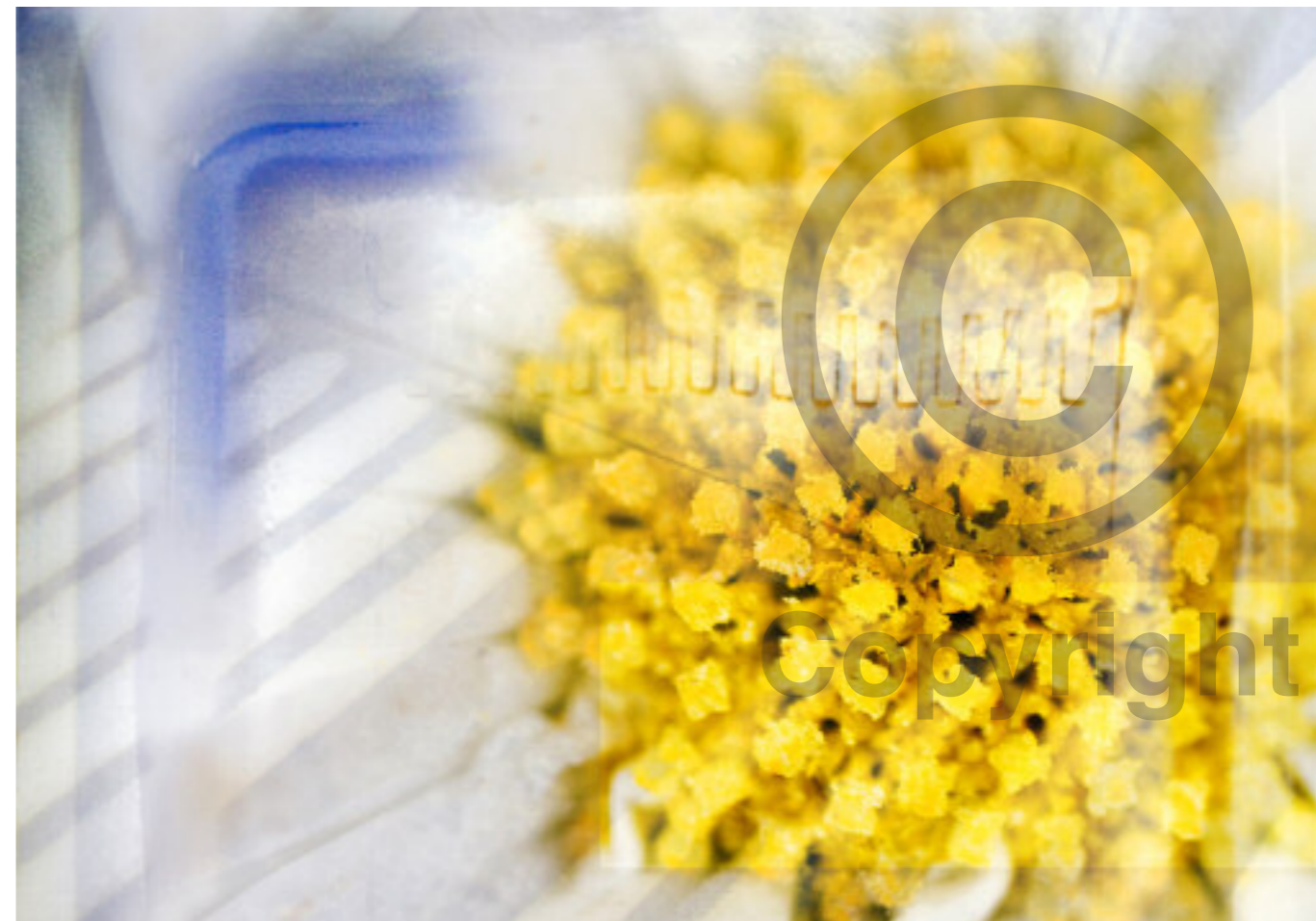
Flower Power

Consumers and health authorities across Europe are concerned about the use of chemical additives and growth promoting antibiotics in animal feed and several compounds are now banned from feedstuffs.

There is a need to find safer, more natural alternative products to benefit animal production and to safeguard human health.

Research at the University of Aberdeen Rowett Institute of Nutrition and Health, looked at testing a wide range of different plants for their ability to aid digestion in ruminants and to decrease methane production in the process. Methane is an important greenhouse gas and arises from normal rumen fermentation.

The benefits of this research will be a healthier, safer food chain; more sustainable animal production and a reduction in harmful greenhouse gases.



Silver Bullets

It is estimated that around 71,000 people in Scotland have Dementia, with the numbers expected to double by 2031. Although the precise causes of this disease are not fully understood current evidence suggests that brain cells in diseased individuals show significant oxidative stress.

Recent research has shown that diets high in natural antioxidants may reduce the risk of the development of Alzheimer's disease and other degenerative neurological conditions.

Compounds in blackcurrants, such as anthocyanins and other polyphenols, have antioxidant properties that help protect against nerve cell damage, the darker the blackcurrant the more potent the effect.

Research is progressing at SCRI, to study these compounds and look at ways they could be incorporated into our diets to help improve our health and well being.



Friend or Foe

The gut digests and absorbs nutrients from our food and it also acts as a barrier to protect us against infectious agents. There is a vast array of different micro-organisms living in our gut alongside mucosal immune tissues.

The immune system in the gut has developed alongside these micro-organisms and has learnt to respond to pathogenic agents but not to friendly commensal bacteria or to food. It is thought that some inflammatory diseases of the gut may develop as a result of inappropriate immune responses.

Research at the University of Aberdeen Rowett Institute of Nutrition and Health, is looking at the diversity of micro-organisms in healthy and diseased guts to try and identify friendly bacteria that can help to damp down an inappropriate inflammatory immune response. This may lead to the development of novel therapeutics to help prevent inflammatory diseases of the human gastrointestinal tract.



Floodgate

Extreme weather events such as flooding are predicted to become more common in the future due to climate change. They can cause real problems for farmers if these occur at critical times like lambing, sowing or harvesting. Productive land can be temporarily lost and permanently damaged.

Yet Scottish farming currently contributes around 13% of the greenhouse gases blamed for causing climate change. SAC Researchers are seeking to find ways of cutting this contribution while continuing to produce food and other goods for Scotland's communities and economy.



Selenium Wheat Sea

The mineral Selenium is an essential trace element nutrient for people and is important in effective immune system and thyroid function.

An important potential source of Selenium in our diet is from wheat. Researchers have observed a decline in our Selenium intake over the last 20 years related to the fact that we no longer import high Selenium milling wheat from the USA. UK soils are comparatively low in Selenium and therefore wheat grown in the UK does not contain sufficient quantities of this important trace element.

New methods have been developed at SCRI to effectively increase wheat Selenium concentration through the strategic application of controlled fertilisers making it possible to produce bread with the recommended levels of Selenium.



Same Difference

Identification and cataloguing different plant species can sometimes be more of an art than a science with some species of plants being very difficult to distinguish using traditional morphological characteristics.

Research at the Royal Botanic Garden Edinburgh is looking at a new technique involving DNA barcoding to provide a universally recognised tool to identify differences between plants.

The project aims to establish a reference DNA sequence database where new or unknown samples can be checked for identification and potential new species will be brought to the attention of botanists more efficiently.

The new DNA barcode tool has many potential uses such as; identification of plant fragments, verification of herbal medicines and foodstuffs, biosecurity, trade, inventory and ecological surveys.



Dead Red

Although red squirrels were once prevalent throughout the British Isles, there are now only around 140,000 remaining and most of these are in Scotland. The decline in the red population is thought to be due to loss of woodlands, competition by grey squirrels and disease.

Grey squirrels, originating from North America, carry a virus called squirrel pox virus. The greys rarely die as a result of infection as they have evolved with the virus, however they can pass it to the red squirrels which usually die within two weeks of becoming infected.

Pioneering work at Moredun Research Institute, has examined the genetic makeup of the virus and shown that it is a novel pox virus. When viewed using high resolution electron microscopy the virus structure resembles a tightly wrapped ball of wool. Scientists at Moredun are looking at the interaction between the virus and squirrels and whether it may be possible to develop a vaccine against this devastating disease in reds.



The Dark Stuff

Soil is a vital resource to the environment and to societies worldwide. It is used to grow plants and food crops; it stores and filters water; regulates waste and pollutants and sustains numerous micro-organisms.

Scotland's soils hold 40 billion litres of water which is more than all our fresh water lochs. Our soils are also an important carbon store which may help to prevent global warming.

The National Soil Archive is a valuable resource held and maintained at the Macaulay Land Use Research Institute. The archive consists of representative soil samples from all over Scotland and includes more than 43,000 air dried soil samples from 1,300 locations with samples collected from 1934 to the present day.

These archived materials are used in research to examine changes to soil composition over time and how this may relate to climate change, presence of pollutants and shifts in agricultural practices.



Pteridomania

The Victorians had a great passion for ferns and in the mid nineteenth century many amateur and professional botanists would visit far flung parts of the country in their quest to collect ever more different species and varieties of fern.

People from all different social backgrounds, and especially women, enjoyed a collection of ferns and associated paraphernalia, making *Pteridomania* or *Fern Madness* a popular social pastime in the Victorian age.

Research at the Royal Botanic Garden Edinburgh focuses on the discovery, evolution and conservation of fern species and how they adapt to survive in very different environmental conditions, such as rainforests and deserts. Walking through the glasshouses at the botanic gardens with the sun filtering through the lush green fronds of the tall ferns, may transport you, just for a while, to the forests of Australasia.



Enzyme Mining

The huge diversity among micro-organisms is a largely untapped resource in the search for new enzymes which may have useful industrial applications, and for compounds that may provide new anti-microbial therapeutic agents. New genetic technologies have allowed scientists to explore the vast biodiversity present in many environmental microbes without the need to isolate and grow the bacteria in culture.

Research at the University of Aberdeen Rowett Institute of Nutrition and Health has exploited these techniques to mine the genomes of gut dwelling micro-organisms, to discover new enzymes which are involved in breaking down complex plant materials.

These enzymes may provide new biological tools to help convert plant waste into an alternative source of energy.



Rare Breeds

The genetic diversity found in our livestock breeds reflects the different way each one developed in its local environment. Today modern farming uses just a few of these breeds while others have become rare. The environment is changing and it is recognised rare breeds might have genetic properties that could be important in the future.

Some farmers conserve rare breeds because their meat varies in texture and flavour and offers consumers variety, like different wines or cheeses. Meat from breeds that mature slowly on poor pastures is very lean and dense. Research at SAC has shown that it is often low in saturated fats, offering health benefits.

North Ronaldsay sheep from one of the Orkney Islands are unique. They eat seaweed as their main diet. Their dark, fully flavoured meat is highly sought after by chefs in many top restaurants.



Silent Witness

Lichens are a close partnership between a fungus and algae or cyanobacteria, and there are more than 1800 different species in Britain. They are a fascinating and diverse group of organisms; many species are very slow growing and long lived, with some individual colonies estimated to be over 9000 years old.

Lichens absorb water and minerals over their entire surface making them extremely sensitive to atmospheric pollution. Lichens can be used as powerful bio-indicators of environmental change whether it involves pollution, climate or habitat dynamics.

Research at the Royal Botanic Garden Edinburgh has examined the diversity and composition of historic lichen communities preserved within the structure of old buildings, to reconstruct the biological conditions present during time-frames preceding the industrial revolution. This information will help scientists understand the most appropriate environmental conditions for the restoration of biodiversity.



Miracle Foods

Inclusion of a wide variety of fresh fruit and vegetables in our diets is known to be beneficial in helping to protect us against heart disease and several types of cancer. However, we still do not fully understand which chemical compounds within the foods, known as phytochemicals, confer health benefits and how we absorb and use them in our bodies.

Phytochemicals have been used as health promoters for thousands of years. Hippocrates noted that willow tree leaves would reduce fever and inflammation and the phytochemical involved is now synthetically produced as Aspirin.

Research at the University of Aberdeen Rowett Institute of Nutrition and Health, is using human volunteers to study which compounds in food may confer health benefits and how effectively individuals absorb and metabolise these important nutrients.



Wind Shadows

The speed of wind is reduced as it filters through a windbreak giving numerous beneficial effects for soft fruit growers.

The main wind damage to strawberries is the production of lesions on the leaf, thus reducing the plant's capacity for exchange of air and photosynthesis. Research at SCRI has shown that significant increases in the yields of strawberry crops can be achieved by sheltering plants from the wind, in particular during September and October when the flower initials are forming.

A better quality and yield of fruit is achieved where windbreaks are used, as they also create a favourable environment for effective pollination by insects and increase the day time soil temperatures.



Welfare Protection

The animals in our care should be well looked after, free from stress and with proper attention paid to their natural needs. As consumers have become increasingly concerned about the way their food is produced, the welfare of farm animals has become even more of a priority.

Research at SAC seeks to gain a better understanding of the biological basis of welfare and, by investigating management practices, provide objective evidence for debates on animal welfare issues. Results so far indicate that there are real economic, as well as ethical benefits, from maintaining good welfare standards on our farms.



Dry River

Water is central to life on our planet but water resources are constantly under pressure from human consumption and sanitation, agriculture and industries. The health of our rivers, lochs and coastal waters are an important barometer for how we manage our environmental resources.

Research at the Macaulay Land Use Research Institute is looking at how some of these pressures may affect our future water supplies. The predicted shifts in climate change affecting temperature and rainfall are likely to lead to an increase in extreme events such as flooding and droughts. Understanding the consequences of the changes to the water cycle will allow the development of measures to help mitigate against extreme events and thus protect the quality and availability of our precious water supply.



Disease Detectives

Surveillance of disease in livestock and wildlife is important to understand disease risks in both animals and people, to detect emerging problems and to help design effective strategies for disease control.

Science conducted at Moredun Research Institute involves the design and application of specialist tools and techniques to enable the detection of a vast array of different pathogens (disease causing micro-organisms) and to understand how they cause disease.

New technologies have allowed the detection of pathogen genes, their products and functions. This has enabled the discovery of much more information on the sources of infection, how pathogens are spread in the environment and how they are transmitted to and interact with different hosts. This research will enable the development of effective strategies to control and prevent disease.



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Priceless Pods	Gavin Ramsay, SCRI	Immune Protection	Elisabeth Innes, Moredun Research Institute
CSI-Soil	Lorna Dawson, Macaulay Land Use Research Institute	Flower Power	John Wallace, University of Aberdeen Rowett Institute of Nutrition and Health
Eating for Two	Jacqueline Wallace, University of Aberdeen Rowett Institute of Nutrition and Health	Silver Bullets	Derek Stewart, SCRI
Diverse Markets	George Marshall, SAC	Friend or Foe	Denise Kelly, University of Aberdeen Rowett Institute of Nutrition and Health
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Conservation Cows	Christine Hall, SAC	Selenium Wheat Sea	Philip White, SCRI
Foresight	David Miller, Macaulay Land Use Research Institute	Same Difference	David Long, Royal Botanic Garden Edinburgh
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Thank you to Hercules the Dalmation our model in *Right of Way*.

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