An introduction to how scientific research is helping to identify factors that influence animal welfare and to provide a basis for improving the welfare of livestock and other animals.
Animal welfare is a complex issue that impinges to varying degrees on the many different ways that humans use and control other animals, for example in farming and food production, in pest control and as companion animals. Whilst most people in the UK would probably agree that animal welfare is important, individuals may differ considerably in what they regard to be the most appropriate level of welfare for different animals in different situations.

Measuring animal welfare and evaluating different welfare issues can be very difficult. For example, battery cage, perchery and free-range systems for hens each pose their own welfare pros and cons. How these should be compared and “scored” for welfare is not always obvious. Most farm livestock and companion animals are quite different from their ancestors that faced a variety of threats from predators and disease. What is the impact on an animal’s well being of removing such natural threats through domestication? Is this more or less harmful to animal welfare than the stresses associated with intensive farming, or those suffered by animals, bred for intensive systems, that are moved to more extensive situations?

Some welfare issues are counter-intuitive: animals may fare better under conditions that seem less attractive to humans than under those that we would prefer; and we may misinterpret animals’ responses and so wrongly attribute motivation or stresses to them.

This booklet presents some examples of how current and recent scientific research is helping to identify factors that contribute to animal welfare, and how such research can also provide a basis for practical measures for improving welfare generally and solving specific problems. Although this booklet focuses to a considerable extent on issues of livestock welfare, a topic that covers a very large number of animals - for example, a total of over 30 million cattle, sheep and pigs are slaughtered each year in the UK, - much of the basic research is also highly relevant to the welfare of other animals, including laboratory animals, animals in zoos and companion animals.

This booklet is aimed at enhancing public awareness and debate about animal welfare. It draws largely on research that is funded by the Biotechnology and Biological Sciences Research Council (BBSRC) or undertaken at BBSRC-sponsored research institutes. It is published as a companion to two other BBSRC publications: “Ethics, Morality and Animal Biotechnology” and “The Use of Animals in Biological Research”.

Science and Animal Welfare
Difficulties in evaluating animal welfare
Everyone is familiar with the scene: a parent calls in frustration to a child “Didn’t you hear me calling you to come in?”

There is uncertainty about whether:
(a) the child heard and chose not to respond and return (perhaps because it wanted to stay outside, or because it was frightened to go in);
(b) the child heard but could not return (perhaps because it was lost or injured);
(c) the child did not hear its parent calling; or
(d) the child heard but did not understand.

Interpreting human behaviour can be difficult. Inevitably, it is even harder to interpret the behaviour of other animals correctly. At least a parent can ask and receive a reply from a child, whether or not the reply is accurate or believed. But it is clearly futile for a vet to ask a fish to “Tell me what you want to do” or ask “Why do you feel like this?”

Knowing what different types of animal, and different individual animals, need in order to experience good welfare is not straightforward. It may be reasonably easy to recognise overt cruelty to animals that can reasonably be expected to induce pain and distress, for example, beating or starvation. It is much harder to recognise distress that may arise from an animal’s inability to do something that it would otherwise do, for example nest building in the case of a caged bird.
Difficulties in evaluating animal welfare

Part of understanding what contributes to animal welfare involves evaluating the extent to which events which humans would find unpleasant, painful or distressing are experienced in the same way by other animals. We also need to be able to identify events that are distressing to other species even though they seem harmless to us. In other words, we need to adopt approaches for assessing animal welfare that are animal-centred, rather than human-centred.

It cannot be assumed that any single environmental or other factor will always be associated with a particular level of stress. The level of stress caused may differ in different animals, in different breeds and in different individuals.

We need to consider:
- factors that cause distress e.g. acute and chronic pain, fear and deprivation, including boredom
- positive factors that improve well-being, including an animal's ability to avoid distressing conditions.

Good welfare is more than simply an absence of pain, and it is intimately related to good health. It is reasonable to expect that welfare includes both physical health and mental “well-being”. It is difficult/impossible to define an animal's subjective feelings, and so in this case mental well-being may equate more with an absence of stress than human concepts of happiness.

Animals are able to detect and respond to environmental factors such as temperature and light, but then so are plants and bacteria. Such behavioural responses can also be seen in computers and robot sensors. A key question in animal welfare is whether non-human animals are capable of conscious perceptions such as self-recognition, social communication, deceit and empathy. There is evidence of such behaviours in higher primates. If they were also to exist in animals such as sheep and pigs, there would be an even greater imperative to ensure high levels of welfare and to afford animals the appropriate protection.
Research approaches
In practice, attempts to understand animal welfare are often based on a combination of several different types of scientific research. For example, observing only the behaviour of an animal without measuring how its body is coping with a situation might be misleading. A chicken that is in pain may sit quietly and appear calm. Yet it may have a faster heart rate and a higher concentration of the stress hormone, corticosterone, than a bird that is apparently panicking.

An example of an integrated approach is the study of the welfare implications of rapid growth in broiler chickens. A problem with modern broilers is that they grow so fast their body conformation produces abnormal walking patterns and the animals develop a variety of orthopaedic diseases. A combination of approaches including genetics, nutritional studies, pathology, morphology and quantitative gait analysis is being deployed to identify ways that breeding companies can improve bird welfare.

**Neurobiology**

Correlating the patterns of activity in different parts of the brain with perception of important stimuli in an individual’s environment is a well-tested technique used for showing how both humans and other animals interpret, learn about and respond to different social and non-social objects.

Comparing the structure and function of the nervous systems of different types of animals in relation with humans can also provide clues about their potential abilities to exhibit complex cognitive abilities, consciousness and different emotional states, including pain.

**Animal behaviour**

Observations of animal behaviour under carefully controlled conditions can provide indications of how animals respond to threat or fear in their natural environment, and this information may improve understanding of how farm livestock and other domesticated species respond to conditions around them. But great care is needed in interpreting such behaviours.

Behaviour that indicates contentment in humans might mean something quite different in other species. It is also important to consider factors that might conceal an animal’s behavioural responses. For example,
an immobilised animal may experience pain but be unable to respond normally. Furthermore, the survival of a prey animal may often depend on its ability to hide the fact that it is in pain.

Cat owners may recognise that their pet may seem more distressed by what to humans is a relatively minor skin abrasion or abscess than by a broken bone which would be more distressing to a human.

We also need to avoid human-based ideas about, say, the relative intelligence of different species and how that might relate to their needs - for example we need to avoid making arbitrary and unscientific assumptions about say the relative environmental needs of a primate and a mouse.

Studies of animal behaviour can also provide clues about animals' needs and preferences. But such experiments must be carefully designed: fear and stress caused by, for example, overcrowded, unpleasant or alarming situations can impair an animal's ability to make decisions. Another complication is that an animal's requirements may be different, or its priorities may be different, in a captive or domesticated environment compared with the wild.

**Physiology**

Measurements of heart rate and levels of hormones and other chemicals in the blood can indicate the extent to which an animal is experiencing stress. But again, careful interpretation is needed.

A human being that is in pain or distress may have a faster than usual heart rate, rapid and shallow breathing, and higher blood levels of the hormone adrenalin. But precisely the same physiological changes may be seen in an individual who is greatly excited and happy, and not in pain at all. Moreover, in a person suffering pain over a long period of time, heart rate, breathing and hormone levels may return to normal. Such confounding effects can be expected in other species.

Pain is both a sensory and emotional experience and there is no single parameter that provides an unambiguous assessment of pain in animals. To assess pain in animals a multidisciplinary approach has been used combining physiology and behaviour. Monitoring the responses of the sensory receptors which measure tissue damage provides an indication of the information that is being relayed to the brain and in humans there is a correlation between this information and the experience of pain. Acute pain produces changes in blood pressure, heart rate and levels of stress hormones, measuring these physiological parameters therefore provides additional evidence of possible pain. The emotional aspects of pain can only be ascertained using behavioural measures such as avoidance, social and guarding behaviours especially shifts in attention. Many of these behavioural changes are species specific and behaviour displayed in an animal will vary depending on the extent, duration and bodily position of the injury or disease.

**Genetics**

Individuals differ in their ability to tolerate pain and stress, and this may have a genetic basis. We are also familiar with the idea that different breeds of cattle, dog or chickens are generally more or less docile.
Genetics research can shed light on the relationships between physical traits, such as body composition, behavioural traits and genetic make-up. An example from pig breeding research is the association between extreme body leanness and an increased sensitivity to stress, which can be explained by the influence of a single gene (the halothane gene, so called because pigs carrying it are extremely sensitive to the anaesthetic halothane).

Advances in molecular biological techniques both for identifying the role of different genes, and for “mapping” them so that their transmission between generations can be tagged, means that it is becoming more feasible to identify genes that contribute to particular behavioural traits, and to select for them. This will increase the precision of traditional breeding programmes.

Scientists at the Roslin Institute have explored how genetic factors contribute to poultry’s ability to adapt to their environment. For example, fear is more pronounced and feather pecking (see page 31) occurs more in some strains of poultry than in others. The researchers devised a simple test for predicting chicks’ propensity to a range of welfare problems including fear, social distress and, perhaps, feather pecking. This may be used to help to identify genetic markers that could be used by commercial breeders to select for birds with reduced fearfulness, decreased feather pecking and appropriate levels of sociality. This will augment existing selection programmes aimed at “breeding-out” some welfare problems faced by poultry producers. Similar studies at Roslin have shown that there is also a strong genetic basis to osteoporosis in poultry (see page 45).

Researchers at the Roslin Institute are using a special resource herd of 500 cattle to locate genes that affect fertility, disease resistance and welfare-related traits.
Research approaches

BBSRC priority area on Animal Welfare

The objective is to gain a greater understanding of welfare issues with particular reference to the current situation in the UK, in order to inform improved conditions and management of livestock, companion and laboratory animals. In order to do this, this research area aims to improve our knowledge of:

- the basic behavioural, neurobiological, immune, metabolic, physiological and tissue responses of farm, laboratory, companion and other managed animals to their environmental conditions, and
- the consequences of human intervention, genetic selection and management for the normal functioning of animals and the incidence of disease, pain, anxiety and mental disorders.

Specific priorities for research are:

COGNITION: including the ways that cognitive animals interpret the actions of others and how this affects their subsequent behaviour; the limits of learning and memory in different species; improved understanding of how animals establish and maintain social relationships.

MOTIVATION: development of better indices to assess the effects of conditions important to animal welfare including motivational behaviour as an index of contentment, fear or anxiety; the integration of behavioural, neurobiological or pathophysiological indices is particularly encouraged.

PAIN AND DISCOMFORT: understanding the mechanisms underlying different types of pain and their alleviation; methods for the objective assessment of discomfort and pain in animals; understanding individual and species differences in response including the phylogeny of pain mechanisms and pain suppression; the behavioural consequences of discomfort/pain and interactions with fear and anxiety.

Additionally, BBSRC’s Agri-Food Committee seeks to support research that increases understanding of the interactions between farmed animals and their environment at the level of the production system (including aquaculture). This may include basic studies of production diseases (e.g., lameness) that can be directly attributed to the system itself, the perception by and responses of animals to complex stimuli such as man or machines, and the welfare implications of more extensive animal production systems.

The aim is to support basic and strategic research that leads to welfare improvement through enhanced livestock fitness. Research is needed to provide knowledge that will underpin improvements in animal husbandry through better understanding and resolution of elements of production systems that are likely to impair fitness. This may be achieved by:

- identifying, quantifying and resolving specific elements of production systems which may compromise welfare through reduced fertility, chronic injury, disease, physiological exhaustion or psychological distress;
- breeding animals for improved lifetime performance and quality of life, achieved through improved fertility, resistance to injury or disease, or social behaviour.
What animals can tell us about how they perceive the world
While it is important to provide an understanding of how animals acquire, process and store information about their environment, a key question in the context of animal welfare is how they use their senses and stored information to guide behaviour i.e. to recognise and respond appropriately to what is experienced. Furthermore, the ability of animals to use complex sensory cues, knowledge of past events and to be able to interpret the significance of the actions of others immediately raises the issue of whether they, like us, are capable of being consciously aware of what they perceive.

**Recognition**

One of the most fundamental questions that needs to be addressed for understanding the perceptual abilities of any species is which senses they use for finding their way around their environment, to recognise palatable from unpalatable foods and recognise both friends and enemies. Scientists at the Babraham Institute for example have shown that, contrary to expectation, sheep do not rely on their sense of smell to discriminate between different palatable foods and other sheep and even humans. In fact, like us, they mainly use vision. Indeed, they have a visual acuity that is considerably better than companion animals such as dogs and cats. The one important exception to this is mother ewes recognising their lambs in the period immediately after giving birth where smell is the most important sense. However, even in this case, as the lambs get older their mothers can also recognise them by sight and by the sound of their voices.

One of the key areas where understanding the recognition abilities of animals is of importance for an appreciation of their welfare needs is the extent to which they are able, and need to, distinguish between other individuals. If it can be shown that any animal can recognise many different individuals in its social environment this immediately underlines the importance of its social environment for its welfare, otherwise why would it have developed such abilities.

Scientists at the Roslin Institute have demonstrated for example that domestic chicks and quail can discriminate between cage mates and strangers. Scientists at the Babraham Institute have shown that sheep can actually recognise at least 50 different sheep and 10 humans visually from their faces. Indeed, their face-recognition skills and the way their brains are organised to perform this difficult task show remarkable similarities to humans and monkeys. They can use cues from the internal features of the face (eyes, nose and mouth) to recognise highly familiar individuals and, like humans, make more use of the features from the side of the face appearing in the left visual field (i.e. the right half of a perceived face) for recognition. This is because both sheep and humans mainly use the right side of the brain for recognising faces and this is preferentially accessed by visual cues from the left visual field.

Research by the Babraham scientists has also shown that for sheep faces are not just used for recognition but are also a source of attraction and comfort. Thus, females will not only show a differential preference for male and female faces depending on their state of sexual receptivity but when they are sexually interested in males they will also show preferences for the faces of specific individual males. Also, both behavioural and physiological responses to the stress of being isolated are markedly reduced in animals just exposed to the sight of face-pictures of familiar sheep.

The importance that the sheep have not just for recognising individuals from their faces but also for assessing their relative attraction can
be seen by the way their brains actually encode faces. Cells in the temporal cortex that selectively encode face stimuli are actually sub-divided into groups responding to particular categories of face that have a similar emotional or behavioural significance:

- faces which have horns and how big the horns are (an important indicator of dominance and gender)
- faces of sheep of the same breed and particularly familiar individuals (sheep prefer to socialise with members of their own breed and need to be able to recognise familiar animals)
- faces of humans and dogs (the main species that represent a potential threat to the sheep).

Recognition of individuals from their faces clearly requires close proximity and for detecting potentially threatening individuals the animals need to use other cues that can be utilised at a distance. Thus, humans can be recognised by body shape and posture and another group of cells in this same region respond selectively to the human body shape. They respond in the same way even if the head and shoulders of the shape are covered, and regardless of whether it is viewed from behind or from the front. However, most of the brain cells respond only when the human shape moves towards the sheep and not if it is stationary or moving away. If the human shape moves towards the sheep by crawling "on all fours" rather than walking, there is less response. This suggests that the sheep's brain is processing information in a way that recognises not just a human shape but also the significance of its movements.

However, humans are clearly not always perceived in a negative way by sheep, and sheep will actually seek proximity with a highly familiar human carer. In this case it has been shown that the face of such a familiar human can become encoded by cells in the brain that normally only detect the faces of familiar sheep in their flock.
Science and Animal Welfare

Difficulties in evaluating animal welfare
Out of sight...

An animal's mental well-being may be determined, at least in part, by whether it can hold "mental pictures" independent of its surroundings i.e. if it understands that objects continue to exist even when out of its sight. The following examples raise the question of whether such cognitive ability increases an animal's potential to suffer stress.

*If nesting materials are withdrawn from a hen, will she still perceive their existence and search for them? Or not?*

*If one sheep is removed from a flock, will the others remember it, perceive its continued existence elsewhere and search for it? Or not?*

The Babraham research has shown that these visual cells in the temporal cortex of the sheep's brain that respond to the actual sight of an individual's face can also respond when that individual is expected to appear or is temporarily hidden from view or can only be heard through a recording of their vocalisations. In humans, this same specialised part of the brain is activated in a similar way...
What animals can tell us about how they perceive the world

when we see or imagine faces and perhaps therefore sheep also have some ability to imagine the faces of absent flock members or even humans. This possibility receives further support from recent studies at Babraham showing that sheep’s brain cells may still be "tuned" to the images of faces of individual sheep and humans even after one or two years of absence. Formal behavioural experiments also confirmed that sheep retained the ability to discriminate between 50 different faces even when they had not seen them for over two years.

There are other implications of an animal being able to hold "mental pictures", including its ability to navigate around its surroundings. If a mental picture exists, say of the site of a feeding container, then the animal will be able to navigate to it from any location nearby; otherwise it will be limited to finding the container by trial and error or by following a set route. This is important in determining how easily individual animals can find their way around their environment, and has welfare implications for the design of new housing or accommodation for animals.

Behavioural studies at the Roslin Institute, funded by the former Ministry of Agriculture, Fisheries and Food, showed that hens can form mental pictures of the location of objects which researchers had hidden behind screens, and can use these pictures to search for the objects. However, the results indicated that although the animals have this ability they do not always use it. Motivation is important. The Roslin study showed that hens can store a mental picture of the quality of the food hidden in this way and that this picture can influence how motivated they are to search for the food.

Researchers at Oxford ran a similar experiment on mink, as they were interested in seeing whether the sight, smell and sound of environmental enrichments affects the motivation animals have to interact with them. This is important because if such stimuli have powerful 'persuasive' effects, then investigating how hard animals will work for enrichments that are right under their noses (see page 23 on preference tests) would not give a very good picture of how much an animal in a barren cage would like them. The researchers measured how hard mink would work for toys, food, a water-bath and the chance to see another mink, both when they could see these resources from their home cage, and when they could not. The animals were more motivated to reach the toys when they could see, hear and smell them, but for all the other resources, in contrast, out of sight was not out of mind: the animals worked just as hard for them even when their stimuli were screened off. So just as with hens, the mink could learn and remember where resources are, even when they can't see them, and they also showed high motivations to reach them. But for some resources (the toys in this instance),
stimuli have a powerful effect on motivation. This means that we have to be careful when we design and run preference tests: preference tests with screened resources could give us quite different results from tests with resources the animals can see and smell first.

In a new research project at the University of Cambridge, scientists are exploring the ability of Western Scrub Jays, (a US native species of bird similar to the British Jay) to use memories of past experiences to plan for the future. These researchers have previously shown that birds with experience of stealing other birds’ hidden caches of food seem to use this knowledge when hiding their own supplies.

Social behaviour and understanding

If animals can both recognise each other, and retain mental images of each other, then the questions arise “Can they think about each other?” “Can they learn from one another?” and even “Can they understand what other animals are experiencing or know?” Answers to these questions will be important in understanding the complexity of animals’ minds, their potential for suffering and the extent to which it might be possible to provide conditions that promote desirable behaviours and inhibit those, such as stereotypic behaviours (see page 30) that are undesirable.

Scientists at the University of Bristol have studied whether hens are able to learn from each other, and whether such learning is a relatively simple innate response, or whether it indicates a cognitive understanding of what other birds are doing and the consequences of their behaviour.
These findings do not necessarily mean that observer hens understand what the tutor bird is doing, it could be that they simply copy its behaviour, regardless of outcome. Indeed, subsequent experiments showed that pecking is copied, even if the observers do not see the tutor getting its food reward. This suggests that hens are not taking consequences into account.

The Bristol team investigated whether hens can recognise and respond to chicks that are behaving in a way which may seem inappropriate to the mother hen. Hens perform a variety of innate behaviours to show chicks what food to eat, for example, they repeatedly pick up and drop the food in front of the chicks. Researchers trained hens to select food that was coloured red and reject food that was coloured green. They then trained half their chicks in the same way, and the other half with the reverse colour preference i.e. to select green and reject red. When the hens watched both sets of chicks foraging they performed their innate behaviours faster and in a more exaggerated way with the chicks that were selecting the green food. This indicates that the hens could recognise that the chicks were behaving “wrongly”. It does not necessarily mean that the hens found this stressful.

Other researchers at the University of Bristol are investigating potentially much more sophisticated social understanding in pigs. Their objectives are both to increase basic understanding of the mental abilities of pigs and to use information about these abilities to design husbandry methods that enhance pig welfare on the farm.

One of the biggest practical welfare issues affecting pigs that are kept in groups on farms is their propensity to fight and injure each other. Pigs differ greatly in temperament: some are naturally more aggressive than others. Individuals can even be “scored” for their tendency to fight: so-called “rapid responders” will fight much more quickly than “slow responders”.

In studies at Edinburgh and Bristol, fewer fights occurred in a newly mixed group of hens learn more quickly when watching other hens.
unfamiliar pigs that contained both fast and slow responders, than in groups containing either all fast responders or all slow responders. This suggests that when pigs of different aggressiveness are mixed they make some form of assessment of each other’s fighting potential and use it to sort out their social status, in preference to fighting. In other words, slow responders choose not to pick fights that they might lose.

The Bristol scientists have developed an experimental system to investigate whether pigs are able to assess the aggressive motivations and fighting ability of others without having to come into direct contact with them. Pigs of different temperament are given a choice to enter or avoid a pen that is adjacent to one containing a rapid or slow responder. Initial results suggest that pigs behave differently to, and hence may discriminate between, rapid and slow responders.

Studies on scent signalling by mice and other rodents, by researchers at the University of Liverpool, are beginning to reveal how a combination of marking behaviour and chemical information enables the animals to communicate about, for example, their sex, individual identity, kinship, and their social and reproductive status. Scent marks of male mice provide a continuous record of competitive challenges between individuals. By covering their defended territory with fresh scent marks and preventing other males from depositing competing marks, territory owners indicate that they are defending their territory successfully. If any other males deposit competing scents, the territory owner will counter-mark immediately, ensuring that his marks are the freshest. The researchers at Liverpool have found that mice assess the competitive ability of a territory owner from the presence of fresh counter-marks from competing males. Female mice prefer males that are able to counter-mark any intruder scents; while males are more likely to challenge owners of territories that contain fresh scents of other males. Crucially, this depends on the acute ability of rodents and other animals to recognise different individuals from their genetically-determined scents.
What animals can tell us about how they perceive the world
Odour cues, from saliva or urine, might be one mechanism by which pigs sense social status and behavioural characteristics in others. Researchers at Silsoe and Roslin found that pigs could differentiate between familiar and unfamiliar animals just on the basis of airborne olfactory cues. Recent research at Bristol has shown that young pigs are able to discriminate between urine from different unfamiliar individuals. The next questions to be addressed are whether rapid and slow responders can be discriminated according to differences in their saliva or urine. A better understanding of these processes may help farmers to provide conditions that minimise fighting, for example by facilitating the use of individual recognition and assessment behaviour. By combining behavioural information with genetic data, it might also be possible to breed pigs that are naturally less aggressive.

Bristol scientists and researchers at the University of St Andrews are investigating whether pigs can learn how to profit from the knowledge of others, whether individual pigs can change their behaviour to “deceive” others, and even whether they can develop “counter-deceptive” tactics to out-compete others. These are complex social behaviours that have previously been studied mainly in primates.

To do this, the researchers are using specially designed foraging experiments in which some pigs are trained so that they can repeatedly find food in the test area. These act as “informed” pigs: they know where the food is hidden (they are rather like the tutor hens in the experiments described above). An informed pig is then mixed with a “non-informed” pig that does not know where the food is, and researchers observe and record how the animals interact. Results indicate that non-informed pigs can use their informed partners to lead them to food, and that informed pigs can develop behaviours which act to decrease their chances of being exploited, such as visiting the food source more often when the non-informed pig is out of sight.

Related experiments are investigating whether pigs are able to discriminate between individuals that do or do not have reliable information about the location of food. This research requires rigorous design and interpretation in order for true social
understanding of the knowledge of others to be distinguished from situations in which animals respond to the behaviour, rather than the knowledge or mental states, of others. Some of the behavioural studies used with livestock species have been derived from those first developed for primates.

Information about how animals understand the knowledge of others will have practical applications – for instance in identifying how animals might be stressed by observing particular treatment of others, and therefore identifying what practices should be kept hidden from other individuals.

Recently, a large-scale study has been started by scientists at the University of St Andrews to examine how tool use and foraging skills are transmitted by observational learning between primates. This study will be based on observations of young wild-born chimpanzees living in African sanctuary enclosures.

**Remembering and forgetting**

If farm animals’ memory for information relating to husbandry procedures, how to locate and use resources, and the identity of conspecifics, is disrupted in any way, this may lead to stress, poor welfare and the need for re-learning or re-training. Several areas of research are pursuing ways of minimising interventions which could have such disruptive effects.

Research at Bristol has shown that everyday husbandry events such as moving to a new pen, or meeting an unfamiliar animal can disrupt short-term spatial memory performance in pigs. Whether this is also true for social memory now needs to be investigated. For example, taking away an individual sow from an established and settled group to give birth on her own, and returning her some weeks later, results in an initial period of fighting when the sow is re-introduced. It seems that she and the others have “forgotten” their relationships and need to re-establish the group’s social interactions. Understanding how long such social memory lasts, how it is disrupted, and whether it can be prolonged, are important research questions.

Conditions which enhance animal memory may thus enhance welfare and minimise stress. A better understanding of how animals establish and retain memories could aid the design of husbandry practices that minimise stress and the time required for management procedures.
What animals can tell us about their needs and preferences
There are several ways of assessing animals' preferences. These include:

- observing how an animal prioritises its activities and divides its time between different behaviours, and how this can be influenced by changes in its environment.
- measuring how much effort or time an animal is prepared to spend in order to obtain a particular "reward" or to avoid an unpleasant situation.
- testing how an animal's deprivation of different environmental features increases physiological measures of stress.

Interpreting the results can be difficult. It is not immediately obvious, for example, whether an animal that is behaving abnormally but has low physiological indicators of stress is better or worse off than one that is physiologically stressed but behaving normally. In each case, there may be additional subjective experiences such as frustration and anxiety that are important in human experiences but much harder to measure and assess in other animals. The relationship between motivation, stress and welfare can be complex. For example, an animal may not be motivated to visit a vet, but despite any associated stress, its welfare may be improved by doing so.

Scientists at the University of Oxford have made important advances in addressing some of these issues, not least in bringing together motivational and physiological measures to assess systematically how animals value different resources.

The Oxford researchers explored how the rearing environment, the provision of objects that stimulate a response and the opportunity to perform different behaviours influence how mink choose to spend their time.

The study was funded in part by the Universities Federation for Animal Welfare. It involved round-the-clock observation of mink which had been reared from birth under farm conditions, and which came from a line bred in captivity for over seventy generations.

Studies with mink have demonstrated their preferences for different environmental features.
The animals were given the opportunity to ‘pay’ to reach a variety of resources, by pushing doors weighted with increasingly heavy weights. They could choose to visit one of a selection of environmental features: “toys”, free space, swimming bath, raised platform and an alternative nest site. Responses to increasing costs were analysed using techniques from human economics.

The mink proved willing to pay in order to do many natural behaviours, such as investigating tunnels and exploring novelty, but rated swimming as their most preferred activity. When access to swimming-water was withdrawn, animals had levels of the stress hormone, cortisol, in their urine comparable to those associated with food deprivation.

Several new avenues of research are being explored as a result of this study. First, although these results showed that the animals were stressed when they were deprived of access to a bath in which to swim, they do not necessarily mean that farmed mink suffer in the same way. The mink in the study were allowed to swim in a bath and later denied access to it, whereas farmed mink never have such access, and for them it may be a case of “you don’t miss what you’ve never had”. Second, it is still unclear whether it is access to water or swimming itself that matters most to mink. This distinction will be important to regulators, animal welfarists and farmers in considering ways of reducing any stress that there might be on farms. For example, the introduction of spray/sprinkler systems alone could be beneficial.

This research offers some of the best methods so far developed for determining animals’ priorities. It has potential for understanding animal preferences, and for aiding the design of accommodation and conditions to meet them, for a range of species and situations including, for example, laboratory animals and animals in zoos.

At Silsoe Research Institute, scientists, vets and engineers have been identifying the environmental preferences of pigs, hens, ducks and turkeys. This research has led to guidelines on various environmental features such as air quality, and in some cases has overturned previous recommendations which were shown not to be in accord with the animals’ preferences.
Environmental stresses are rarely experienced individually. Researchers need to be able to recreate the various combinations of stresses that animals might encounter and then study how they respond to the different combinations. At Silsoe Research Institute a choice-chamber is used to see how poultry respond to combinations of heat and vibration typically encountered in transporter vehicles. The birds could choose between compartments with heat, vibration, heat plus vibration and a control with neither heat nor vibration. Broiler chickens avoided vibration, but not heat, at least initially; and combined heat and vibration did not affect them significantly more than vibration alone. Birds avoided entering the heat compartment for longer than ten minutes, suggesting that while they might find heat initially pleasant, it can become aversive as the birds begin to overheat. Under conditions where the birds could not move away from the heat this would obviously increase stress.

In a separate system for studying the way birds rate the unpleasantness of different situations, chicken have been trained to run along a corridor into a goal-box in which they receive either a food reward or experience a potentially stressful condition such as confinement or heat and vibration. The longer a bird takes return to the goal-box to seek the food reward, the greater aversion it had to the previous treatment. Confinement, for example, appears not to be particularly stressful: after being confined, birds rapidly return to the goal-box. This methodology provides a way of quantifying animals' response to different combinations of potentially stressful factors. The objective of the research is to understand how animals interact with their environment and to facilitate the design of conditions that minimise stress.
For some animals, performing a particular behaviour may be an important goal in its own right. Researchers at Roslin Institute investigated the relative value hens give to resources such as food, nest building materials, a dustbath and a social partner with whom they can interact. Nest building turns out to be very important to hens. They will willingly overcome different obstacles such as water baths or fans or doors and will walk considerable distances to reach a nest site. They will spend as long on a full repertoire of nest building behaviour when provided with a pre-formed nest they have made earlier, as they will on making a new nest (see also page 34). When given different materials, hens prefer nests that they can mould by body and foot movements rather than by their beaks. This suggests that having loose nesting materials such as wood shavings (which are moulded by both sets of activity) is less important to the hen than having a nest that allows moulding movements.

The extent to which animals will work to avoid unpleasant situations also provides clues about their priorities. For example, when fast growing broiler hens that have become lame will perform work in order to gain access to pain killers, this is strong evidence that the lame birds are in pain.

A similar approach in which scientists can identify what animals will endure in order to win a reward, e.g. a food treat, may be helpful in ascertaining how laboratory animals respond to, and rate, different experimental procedures such as having blood samples taken.

Studies at Roslin Institute showed that hens can learn to avoid an unpleasant experience. In this research, a light in the cage flashed shortly before the rapid inflation of a balloon. Hens learnt to move into an adjacent compartment when the light flashed in order to avoid the inflating balloon. Giving animals the opportunity to recognise and move away from potentially frightening experiences is an important element in improving welfare.
Some specific welfare issues
Maternal behaviour

Most animals, other than primates, do not behave maternally towards their offspring except when they have just given birth. But although the behaviour is short lived for the mothers, its impact on the offspring may be lifelong.

Scientists are trying to understand more about maternal behaviour by identifying the mother’s requirements for stress-free birth, and the impact of maternal behaviour on offsprings’ ability to cope with their environment. Results could contribute to optimising the quantity and quality of maternal care received by livestock and laboratory animals.

In semi-natural environments, domestic pigs isolate themselves from the herd one to two days before giving birth. They build a nest in which to rear the piglets. Collaborative research between scientists at the Universities of Bristol and Oxford on a commercial outdoor pig farm sourced by Cambac JMA Research is investigating how individual sows naturally vary in their maternal skills. A total of around fifty sows is being studied and the aim is to identify the key factors of maternal behaviour that benefit the piglets, for example in terms of their growth, health and subsequent tolerance of handling by humans.
Maternal bonding

There are sound practical reasons for wanting to understand more about the way mother animals recognise and bond to their offspring. Such understanding could help to improve the adoption of orphaned offspring by foster mothers and suggest ways of overcoming the reluctance of mothers to look after their offspring in captivity – a problem that often occurs in attempts to breed endangered species. Practical protocols for fostering orphan lambs are described on page 47.

Research at Babraham Institute and the University of Cambridge over the past decade showed that maternal bonding between a ewe and her lamb is induced and stimulated by two principal factors: hormonal changes of pregnancy and the stimulation and dilation of the cervix and vagina during birth. The latter operates at least in part by inducing release of the hormone oxytocin in the brain, and into the bloodstream from whence it stimulates contraction of the uterus.

Smell is the principal way a ewe recognises and bonds with her lambs following birth and many cells in parts of the brain that process smell become tuned to respond to the specific odour cues from their wool. This process is triggered by feedback signals from the cervix and uterus promoting the release of oxytocin and noradrenaline in the brain. This increases the activity of the cells responding to the lambs odour and they release more of the transmitter glutamate. This acts via the nitric oxide signalling pathway to further promote its own release and cause permanent changes to the synapses to make them more responsive to the lamb’s odours whenever they are encountered in the future. In this way, the chemical signals in the ewe’s brain help her to remember the smell of her lamb she has bonded with and to reject the attentions of all other lambs.

All of these processes, pregnancy, natural birth and smell are necessary to establish maternal bonding between ewes and their offspring. Maternal behaviour and bonding does not occur, for example, with lambs delivered by caesarean section. However, as described on page 47, ewes can be persuaded to foster lambs that are not their own.

Importance of maternal care

Scientists at the Babraham Institute have shown that both lambs and goat kids learn their preference for which species to socialise and mate with from their mothers. Thus, lambs raised by goats grow up preferring to socialise and mate with goats rather than sheep even if they are raised together with a lamb brother or sister and with other sheep in the flock. The same happens with goat kids raised by sheep, and in both cases the effects of maternal social education are much stronger in males than females. Indeed, the males continue to prefer their adoptive mother’s species even after 5 years of living only with their own species. The physical basis for this species preference has been shown to be visual cues from the mother’s face. This shows how important the maternal offspring bond is for determining the social likes and dislikes of the offspring in these two species and complements other work showing that strong and enduring dietary preferences are also learned from mothers. It also underlines, from a welfare point of view, how important it is for...
offspring to receive appropriate maternal care and delivers a note of caution to captive breeding programmes aiming to raise offspring from endangered species using foster mothers from other more common closely related ones. Animals produced this way may not grow up to be strongly attracted to their own species.

Scientists at the University of Oxford are investigating the effects of maternal grooming in rodents. There is evidence that maternal grooming of new-born rats lowers the sensitivity of the hormone system that is activated during stress. This effect lasts as the rats grow and develop; indeed, it lasts into old age. It is unclear, whether rats that receive maternal grooming find situations less stressful than those that have been deprived of maternal grooming, or whether they just react less. If the former applies, then ensuring high quality maternal grooming could be one way of enhancing the welfare of captive rodents, including laboratory mice and rats.

Maternal deprivation

Scientists at the University of Oxford are looking at the effects on juveniles of the early loss of their mothers. In many laboratory and agricultural situations, young animals are removed from their mothers earlier than would occur in the wild or in more naturalistic situations. In primates - including ourselves - the early loss of the mother can make individuals more vulnerable to stress. Researchers are therefore seeing if this is also true for other types of mammal. If it is, leaving young animals longer with their mothers could be an effective way of making them better able to cope with stress.

Overcoming broodiness

Broodiness is a hen’s natural tendency to cease laying and incubate a batch of eggs. It can cause regression of the ovary and poor egg production in broilers, turkeys and waterfowl. Broodiness is likely to become more of a problem as egg producers increasingly switch to more extensive systems in which birds can express natural nesting behaviour.

White Leghorn hens, unlike most other breeds of poultry, generally lack broody behaviour. This is of practical significance to poultry breeders as it offers them the opportunity to incorporate White Leghorn genes into their stocks to suppress broodiness. However this option is not open to breeders of other types of poultry. Attempts to eliminate broodiness by conventional selection have had limited success. Researchers at the Roslin Institute have identified the genes causing the broody trait and are now looking at the possibility of eliminating it by marker-assisted selection.

For some people, eliminating an innate behaviour in this way may be regarded as unethical, but it may reduce stress in layer hens that are unable to perform the behaviour in farmed conditions.

Abnormal behaviours

Animals in captivity commonly perform meaningless “rituals” or stereotypic behaviour. These may be new behaviours or a re-directed natural behaviour such as nibbling. Scientists are investigating the external environmental factors that might be involved in triggering stereotypic behaviour, and the genetic and physiological characteristics of individual animals that may make them more susceptible.
Whilst the overall aim is to aid the design of husbandry systems which enable animals to perform their normal behaviours, it is important to try to understand what causes stereotypic behaviours, and whether they can be transmitted from one animal to another through social interactions.

Horses, particularly those that are intensively managed, can show a variety of stereotypic behaviours including biting on part of the stable, or “weaving” (swaying from side to side). Up to around one in twenty horses may behave in such ways.

Many owners believe that horses copy these behaviours from each other, but this was not found to be the case in experiments at the University of Bristol. There, horses accommodated next door to one that was “weaving” showed very little if any likelihood to copy the behaviour.

There is evidence, however, that stable-biting is associated with dietary factors. It seems that stereotypic behaviours typically start in response to a welfare problem, such as an animal being thwarted from performing a particular behaviour, and that they later become habitual and continue even after the problem has passed. In other words, stereotypic behaviours may be “scars” from previous poor welfare rather than indicators of current welfare problems.

Stereotypic behaviour may not be directly harmful to an animal, although there may be secondary effects. For example, horses that “weave” and stable-bite can damage their leg and neck muscles respectively. There is however, a major welfare issue, and productivity problem, associated with feather pecking in poultry.

Feather pecking, in which a bird pecks at the plumage of another, seems to be a re-directed foraging or exploratory pecking behaviour. It is not caused by aggression, although it causes severe pain and can be associated with increased cannibalism in flocks.

There is some evidence that once a bird’s plumage has been pecked at and ruffled it becomes more attractive to other feather peckers. However, research at the University of Bristol, that allowed chicks to grow up watching commercial hens that feather pecked to a mild degree only, indicated that birds do not learn feather pecking from each other. Similarly, Roslin scientists found that feather pecking was not increased in chickens from an experimental line showing low feather pecking when they were reared with birds from a high pecking line.
Stereotypies are also common in laboratory animals. For example, in many strains of mice, some individuals perform stereotypies when kept in traditional laboratory cages, repetitively jumping up and down or repeatedly mouthing the bars of their cage. Research at the University of Liverpool has shown that these movements derive from attempts to escape. For example, if there is a lid on the cage-top that is regularly opened, that is the place where mice direct most of their bar-mouthing, particularly if they have been handled or have escaped via that route. Mice confined in traditional cages make more escape attempts, with the potential for developing stereotypies, than those housed in larger, open-topped enclosures. In rats, aggression between cagemates may increase their attempts to escape: those in groups where there are high levels of fighting spend more time trying to escape and show greater physiological signs of stress. Although evident in mice and rats of both sexes, the studies so far suggest that females often try harder to escape and may be more susceptible to developing stereotypies than males. Research at Oxford, again on laboratory-housed rodents, has also shown why it is these behaviours can be so strange-looking and so incredibly persistent. They investigated these behaviours using techniques from experimental psychology. Humans with autism or schizophrenia, and animals treated with stimulant drugs, show stereotypies that resemble those of caged animals, but in these subjects, the behaviours are known to arise from changes in parts of the brain responsible for organising and sequencing behaviour properly. These brain regions, known as the basal ganglia, can make individuals hyperactive, prone to rapidly-shifting between different activities, and yet also abnormally persistent, prone to getting stuck in pointless behavioural ruts. Could the same thing be going on in captive animals? The Oxford researchers showed that in caged voles (a mouse-like rodent), high levels of bar-mouthing stereotypy were similarly part of a whole suite of behavioural symptoms, including increased activity, increased rates of switching between different types of behaviour, and also abnormal persistence: the most stereotypic voles had no trouble learning to run a maze to reach a sugar reward, but when the sugar was removed, they took far longer than other animals to unlearn the task and give up trying. This work suggests that captivity can have profound effects on the how the brain functions.
Some practical issues for improving livestock welfare
Several areas of research are aimed directly at improving the welfare of farmed animals. These often draw upon and develop ideas, which have arisen from basic research into animal cognition, physiology and behaviour, but they are often characterised by experimental designs that simulate on-farm conditions.

Several research groups are investigating welfare issues surrounding animals’ accommodation, particularly in intensively housed pig and poultry units.

Space

There is no simple correlation between space and welfare. It cannot be assumed that more extensive systems of management necessarily offer better welfare for an animal. For example, pigs that have been bred intensively for decades may be poorly suited to live outdoors.

The welfare pros and cons of different housing systems can be illustrated by considering egg production. There are around thirty million laying hens in the UK and currently most egg production (over 80%) comes from birds housed in battery cages. The cage system provides a highly restrictive environment that prevents hens from stretching their wings fully, exercising and performing natural behaviours such as dust-bathing and nesting. Osteoporosis (see page 45) is most severe in hens kept in battery cages because their relative inactivity accelerates loss of structural bone. Together these factors lead to abnormal behaviour and development of bone weaknesses.

Battery cages are to be banned throughout the European Union by 2012, and no new systems are now being installed. One alternative is to keep laying hens in large loose-house colony systems, where the birds are kept in barns or aviaries and may have access to the outside. Because the birds can exercise more, bone quality is improved and osteoporosis is reduced. However, mortality rates are higher than for birds kept in battery cages, and most of these deaths can be attributed to problems of aggression, fear and stress rather than disease. There can also be a high level of bone damage in birds housed in perchery and aviary type systems as a result of them falling from, or banging into perches.

Research at Heriot-Watt University and the Roslin Institute has used video cameras to understand birds’ behaviour in perchery systems as a basis for designing safer housing. Birds kept in loose-house conditions can suffer significantly from feather pecking.

Hens in large groups often fail to make full use of the available space. Scientists at Roslin Institute found that behaviour appeared to be influenced by flock size. For example, birds in large groups with access to the outside still remain inside; only about 10-20% of the birds go out at one time. In contrast, small flocks will go outside. It is possible that in the larger flocks it is the stress of having to pass a high proportion of social strangers that keeps birds inside.

Commercial flocks are unnatural: instead of one cockerel and a dozen or so hens, commercial flocks contain several thousands of hens. As battery cages are phased-out, selection of optimum flock sizes and appropriate housing design will become increasingly important welfare issues.

Eggshell quality could be a good and non-invasive way of detecting stress in laying hens. Researchers at the University of Glasgow are exploring how shell quality might be used to identify “hidden” factors in poultry housing and handling that cause stress.

Scientists at Roslin Institute found that caged hens made full use of nesting materials provided to them, suggesting that this enabled them to carry out an important natural behaviour.
However, this may not be as simple as it sounds and there may be important implications for cage design. Providing nest sites in conventional cages might increase stress because birds may need to have their nest site in a separate area. The research showed that nest-building behaviour is not eliminated by providing birds with pre-formed nests. This may have important welfare implications because it suggests that birds might need space to perform this behaviour even if a nest is provided.

**Resources/Enrichment**

Adequate stimulation may be an important determinant of mental well being in animals. For example, foraging and exploratory pecking appear to provide important stimulation for chickens. Barren and unchanging environments in poultry houses are associated with increased fearfulness, depression, feather pecking and even cognitive impairment. There are good reasons, therefore, for assuming that environmental enrichment, through the provision of appropriate novel objects, can benefit poultry welfare.

Care is needed, however, in identifying effective enrichment. For example, novel objects are potentially frightening to animals, so an individual's apparent interest in an object may reflect its need to overcome fear, rather than a positive response. Some alleged enrichment devices for hens have been shown to elicit alarm and to increase feather pecking.

Rather than testing enrichment methods on a “trial and error” basis, using human perceptions of what animals might prefer, scientists are trying to understand how animals perceive different objects and what they find stimulating.
At Roslin Institute researchers found that pieces of string are a particularly attractive pecking stimulus for chicks and adult hens. They systematically offered the birds a variety of materials including beads, chains, baubles, feathers and bunches of string, and recorded their interest. The birds showed clear and specific pecking preferences. White string was the most stimulating. Yellow string also elicited a strong response. Red, green and blue strings were much less effective. Monochromatic devices were more attractive than multi-coloured ones, and static ones were pecked more than those that were moved occasionally. Providing chickens with string devices reduced feather pecking and improved plumage condition in the laboratory and at commercial farms.
There have been reports that music may have a calming effect on poultry. Scientists at Roslin Institute conducted a survey among farmers. Over one hundred farmers were asked whether they played music to their flocks and whether they noticed any benefits. 46% routinely played music to their birds. Of these 96% said it calmed the chickens, 52% felt the birds were less aggressive, 20% reported healthier birds and 16% claimed increased egg production. Of those farmers who did not play music 90% said they would consider it. Playing the radio to hens may prove to be an easy and practical way of enriching their environment and perhaps of helping to reduce their fear of new noises. However, this is an area that has received little empirical scientific investigation.

Many commercially reared poultry are housed in environments in which their vision is restricted, for example, by low levels of lighting. Researchers at Roslin Institute showed that chicks and adult hens are readily attracted to abstract video images that are presented outside their cages. So, enrichment of the environment around cages could contribute to improved welfare for poultry.

Smells, particularly those associated with predators, help to trigger a fear response in hens. Researchers at Roslin Institute and the University of Sussex reviewed evidence that hens’ sense of smell is important in their attachment to familiar objects, valuable resources, and their general environment, in a similar way to the odour cues used by rodents. The presence of a familiar smell reduced chicks’ fear of an unfamiliar environment and of strange birds; it also accelerated their acceptance of a food they had never experienced before. So, it is likely that incorporating a familiar odourant into a novel situation could reduce fear and anxiety in poultry - a sort of aromatherapy for birds. Such sensory enrichment might be especially beneficial in the rearing of young birds, by acclimatising them to smells that they will encounter later in life.

**Lighting**

Lighting in poultry houses strongly affects birds’ behaviour and so impacts on their welfare. Lighting levels are usually set according to human perception, but recent research at Silsoe Research Institute shows that poultry perceive the brightness of light sources differently from humans. It is now clear that lighting specifications that are optimal for humans are, in many cases, not suitable for poultry.

It might be that birds prefer to perform different behaviours at different light levels. The Silsoe studies show that 2-week old hens prefer higher light levels than 6-week old hens. The older birds prefer lower levels of light for resting and perching which accounts for 60% of their time, and higher levels for all other activities.

Lighting levels are probably important in enabling birds to recognise each other, and this recognition may reduce aggression and affect feeding behaviour and mate choice. Good lighting is also important in enabling birds to jump accurately between perches and so avoid injury. Researchers at Heriot Watt University and the Roslin Institute are investigating how the level and type of illumination in aviary and perchery poultry houses affect birds' ability to jump between perches. They are also investigating the effects of visual contrast of the perches, and of obstruction of perches and how birds may be distracted by other perching hens.
Some practical issues for improving livestock welfare

Handling

Animals tend to find novel experiences frightening and stressful. So, infrequent contact with humans, movement into new surroundings and mixing with other unfamiliar animals will be stressful to varying degrees. Such activities are, however, essential features of animal management on farms and, for example, in zoos. Several lines of research are aimed at identifying and minimising key stress factors.

Research at the Roslin Institute showed that handling chickens regularly, or even just letting them see people, was helpful in reducing their fear of humans. In some cases though, animals may prefer to interact with machines rather than people. Several research groups are exploring the development of “hands off” systems of moving animals and monitoring their behaviour.

Working in collaboration with the poultry industry, and with funding from the former MAFF, scientists at Silsoe Research Institute have designed improved systems for loading chickens on to transport vehicles. They have developed a wheeled module that holds around 60 birds in drawers and is small enough to be put close to the cages so that the birds can be transferred and wheeled directly onto the lorry with minimum handling. A major egg producer is testing the system.

Assessing the best forms of lighting to meet the visual and welfare needs of poultry.

Scientists at Silsoe Research Institute measured the vision of broiler chickens at different wavelengths using a behavioural test. Chickens were trained to peck one of two panels for a food reward. The panels were lit with filtered light at different wavelengths. The birds were also sensitive to UV wavelengths, implying that chickens see colour differently from humans.

Scientists at Silsoe Research Institute have developed a new apparatus for measuring light in poultry houses. The CLUX meter provides estimates of how chickens perceive the brightness, and makes measurement of the light sources. The researchers plan to combine the use of the CLUX meter with their knowledge of poultry responses to provide producers with strategies for overcoming production or behavioural problems. The apparatus can be used in growing houses for chickens, turkeys and ducks.
The RSPCA has funded further research to find a module system to improve turkey welfare during loading.

Scientists at Silsoe Research Institute are exploring a variety of remote-sensing technologies that deploy computers and mathematical modelling to monitor animal performance without the need for handling. A new system called Growth Rate and Conformation Evaluation (GRACE) uses image analysis techniques to monitor the weight, growth and condition of pigs without manual handling. A video camera mounted over the feeder, collects images of pigs as they enter. Each pig is identified by its electronic tag. The images are analysed to measure body area, ham width, and ham area. GRACE will allow farmers to spend more time looking after the health and welfare of their stock and it will alert them to any changes in condition and behaviour, for example, if one pig is not feeding. This could help in identifying health problems that might otherwise go unnoticed. GRACE is being taken up commercially by Hunday Electronics to bring this technology to the market place.

Biosensors are being developed for a range of automated, non-invasive ways of monitoring animal health as part of integrated management systems. For example, research at Silsoe has led to a prototype sensor for predicting ovulation and pregnancy in cattle, which is based on sensitive analysis of levels of the hormone progesterone in milk. Scientists at the Universities of Glasgow and Stirling have explored low-stress ways for fish
Some practical issues for improving livestock welfare

Researchers at Silsoe Research Institute and the University of Bristol, with funding support from industry, the Humane Slaughter Association and the former MAFF, have addressed the welfare implications of different methods currently used to kill trout. They assessed welfare both subjectively and by examination of behaviour, indicators of sensibility and indicators of brain stem reflexes. This suggested that the highest welfare standards and the lowest operating costs were likely to be achieved by electrically stunning the fish as they flow through a pipe. For humane killing, it is necessary for the electrical stun to render the fish instantly insensible and to ensure that it does not recover from insensibility before death occurs from lack of oxygen. The research has defined stunning parameters that meet these criteria.

farmers to grade salmon without having to handle them. This has involved exploiting natural behavioural differences in fish to move them between cages, and video imaging techniques to predict body mass and maturation.

Researchers at Silsoe have developed a remote sensing system for monitoring the health and fertility of dairy cows. In collaboration with Fullwood Ltd, they have adapted a feeder system so that feed is dispensed to a cow only after she has blown breath into an inlet above the trough. The breath is drawn into bags where an infra-red analyser detects the presence of gases that indicate the animal’s health. Cows learn to use the feeder in just a few visits.

The same research group is developing a system for monitoring poultry. In this, birds are weighed automatically by electronic perches. From the recorded data, a computer model provides information about the composition and quantity of feed required to meet the birds’ requirements.

Several research projects are aimed at improving pre-slaughter handling and welfare of animals. An example is research from Roslin Institute, which found that covering broilers heads with an opaque hood, and lowering light intensity could reduce wing flapping and struggling when the birds are shackled prior to slaughter.

Transport

The transport of animals to and from markets, to slaughter and particularly on export journeys, raises several welfare concerns:

- fear and pain associated with handling and mixing
- thermal or motion stresses during the journey
- thirst and exhaustion
- risks of infection

A central theme of research into improving animal transportation is to identify the animals’ physiological and mental well-being needs, and to devise procedures that meet them.

Pigs are particularly susceptible to stress during transport. Scientists at Cambridge University and Silsoe Research Institute have studied the effects of vehicle motion on pigs. They found that during both simulated and actual journeys the pigs showed signs of travel sickness. This research has resulted in new recommendations for the way pigs should be transported.

There are also welfare problems associated with the transportation of chickens, the worst of these being heat or cold stress, cramped conditions and the pain associated with motion of the vehicle on injured legs.
Scientists at Roslin Institute and Silsoe Research Institute, together with a major broiler producer and with funding from the former MAFF, designed a new transport vehicle aimed at improving the welfare of chickens during transportation. The fan ventilated vehicle named “Concept 2000” was launched in May 1999. It has been shown to reduce mortality substantially during journeys and to improve both animal welfare and product quality and value by reducing transport stress.

The new vehicle was designed using data from experiments in which the scientists monitored temperature and humidity of chicken transport vehicles during routine journeys. They found that there was a ‘thermal core’ of higher temperature and humidity, irrespective of the season or whether the curtains were up or down. The scientists also determined physiological indicators of stress in birds, such as deep body temperatures and panting. This enabled them to define combinations of temperature and humidity that are acceptable for birds in transit.

It was shown that the environment could be improved by controlled forced ventilation of the vehicle and hence the fan-assisted design of Concept 2000 was achieved. The trailer has its own generator to provide independence from the tractor unit and sensors to warn the driver if conditions in the vehicle approach critical limits.

Concept 2000 promises to be the design of choice when broiler producers replace existing broiler transporters over the next few years.

The researchers are conducting similar work with other farm animal species.

The Concept 2000 transporter.
Welfare and health
Good health is arguably one of the principal, if not the principal element, of animal welfare. In some instances, particularly with intensively reared livestock, conditions of handling and management that affect welfare are also intimately related to poor health.

Respiratory diseases and aerial pollution

There is increasing evidence that respiratory disease in intensively housed pigs is caused by aerial pollutants such as dusts and ammonia. Elimination of these diseases by medication, vaccination or by eliminating specific pathogens has proved costly and often ineffective. In future, control methods are more likely to depend on environmental and biological control methods.

Researchers at the University of Bristol, Silsoe Research Institute and Institute for Animal Health have worked together to analyse the relationship between infectious diseases of the respiratory tract and intensively managed housing. Their aim is to provide information that will help to improve building design and management, so that the incidence and severity of respiratory diseases are reduced. In order to achieve this they looked at the causes of the diseases, how pollutants might predispose animals to infection, as well the dynamics of the generation and clearance of aerial pollutants.

The Bristol team is aiming to identify hygiene tolerance levels for pollutants such as ammonia, and particles of protein dust, for maximum health, productivity and welfare.

The Silsoe team has identified key processes that can contribute to an integrated system for controlling aerial emissions in poultry houses. These are:
- dietary manipulation to reduce excretion of urea and pathogens
- cleaning of the exhaust air in mechanically ventilated buildings, possibly using a bio-filter
- drying of the manure from layer birds, both on belts and deep pits, using the ventilation system
- combustion of litter.
Welfare and health

Lameness in cattle
Lameness in dairy cattle is a major animal welfare issue. It is almost always a painful condition and it interferes with a cow’s ability to interact fully with her environment, in particular her social environment. Lameness is also an economic problem, it can cause loss of weight, eventual reduction in milk yield and reduced fertility: all of which may result in early culling. In the dairy herd, lameness is mainly due to foot problems but can also be caused by leg damage, including swollen knees and hocks caused by poor lying conditions and poorly designed housing.

Lameness is more common during calving. Scientists at the University of Bristol are looking at the reasons for this. They believe that as well as external mechanical stress, biochemical changes associated with calving and the onset of lactation compromise the connective tissue that supports the skeleton within the foot and cause the pedal bone to sink and progressively destroy the sole of the hoof from within. The biochemical mechanisms are, as yet, incompletely understood, but it appears that these primary changes are directly linked to events around calving. The practical consequence of this is that sole lameness in dairy cows can be significantly reduced by minimising external stresses on the feet only at this critical time.
Osteoporosis
Osteoporosis in laying hens is the progressive loss of structural bone during the laying period. It causes the bones to become fragile and easily fractured, for example when the birds are removed from their cages. It is estimated that bone fractures occur in about 25% of laying hens and it therefore constitutes a serious welfare problem.

Some nutritional approaches such as supplying a particulate source of calcium can be of some help, but research at Roslin Institute has shown that whereas poor nutrition can make the osteoporosis worse, good nutrition cannot prevent it. Roslin scientists have used image analysis of bone structure, radiographic data about mineral density and direct measurement of bone strength in post mortem samples from layers, to develop a “bone index” for the strength of bones in individual birds. This can be used in breeding studies with the hens’ offspring to select for birds with enhanced bone strength and greater resistance to osteoporosis. Such selection could form the basis of improved commercial breeding programmes.
Providing maternal care for orphan or triplet lambs

Farmers use a variety of approaches to rear orphan lambs or the third of a set of triplets that cannot be fed effectively by its mother. These range from persuading a ewe that has just given birth to adopt them alongside her own lamb to dispensing with maternal care altogether and rearing the lambs on milk-bars. Unfortunately, most techniques for using ewes as foster mothers are impractical on a large scale, labour intensive and have a poor success rate. Rearing on milk-bars is also an expensive option and normal behavioural development of lambs may be compromised due to absence of important maternal education.

Scientists at Babraham Institute and University of Cambridge have studied the physiological events that control induction of lactation, maternal behaviour and bonding between a ewe and her lamb. This research has led to two protocols for providing maternal care for orphan and triplet lambs:

1. Ewes that have recently given birth can be induced to act as foster mothers by simple manual palpation of the vagina and cervix for 2 minutes, even up to 3 days after they gave birth. This procedure works because it sets in motion the same chemical changes in the brain which normally induce maternal behaviour and bonding at birth.

2. Non-pregnant ewes can be stimulated to lactate in six weeks using intravaginal sponges impregnated with the hormones progesterone and oestradiol. Following manual palpation of the vagina and cervix they will rear orphan and triplet lambs through to weaning with identical growth rates to normally reared lambs.

Both techniques offer farmers a more effective and less labour intensive way of rearing the lambs and can be used to foster across breeds.

Heat stress in laying hens

Chronic heat stress, resulting from a hen’s inability to regulate its body temperature at high environmental temperatures and humidities can be a problem in well insulated poultry houses during hot summer days. As well as physiologically harmful effects such as metabolic changes and hormonal imbalances and tissue damage, heat stress also alters birds’ behaviour and depresses egg production and eggshell quality.

The effects of heat stress can be alleviated both by physical procedures such as increased ventilation but also by dietary manipulation. Vitamin C is commonly added to the diets of birds under heat stress. Scientists at the Roslin Institute found that treatment with this vitamin could also reduce fearfulness in chickens and quail. Other research at the Roslin Institute showed that adding extra vitamin E is also beneficial, provided the vitamin is added before the onset of heat stress: it is not effective if added only after the hot period has started. The findings suggest that adding vitamin E to the birds’ drinking water at the approach of hot weather could be particularly effective.
In this booklet we have attempted to give a flavour of current and recent research that relates to understanding and improving animal welfare. We have focused upon research funded by the BBSRC or undertaken at BBSRC-sponsored institutes. Inevitably, it has not been possible to include everything. Further details, including up to date list of projects and programmes of research are accessible via the BBSRC web site (www.bbsrc.ac.uk) and the web sites of the individual institutes which can be accessed from the BBSRC site.

Many areas of basic science, for example in physiology and genetics, provide information that can contribute to overall understanding of animal biology, including behavioural and welfare issues. Research in genomics and cell biology that is aimed at developing or improving alternatives to the use of animals in some experimentation may also be said to contribute indirectly to animal welfare. Again, further information is available on the web sites.

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