The dog is one of the oldest domesticated animals and has probably been associated with man for at least 14,000 years. For many people their pet dog has a special status and is often considered as a member of the family. In consequence, the dog when used as an experimental animal receives special protection in some countries. For example, in the UK, special justification has to be provided before dogs can be assigned to a study involving pain, suffering or distress. Dogs used in studies in Europe have to originate from designated or registered supplying establishments, which in the UK are inspected by the Home Office.

A good day-to-day care person should have a sound understanding of the dogs' biology (e.g., Serpell, 1995), particularly of their social nature (Boitani et al., 1995; Macdonald and Carr, 1995). Moreover, experience and research show that both conspecific and human social contact are extremely important for the well-being of dogs. Dogs are inquisitive animals who actively seek information about their surroundings and so will react badly to barren or sensory restricted environments. They use a variety of modes of communication. Olfaction, one of the most important of these, is unfortunately one which we have the most difficulty in empathising with. Husbandry staff should be experienced enough to be able to identify the meaning of the various dog vocalisations, such as distress and threat vocalisations, the high pitched bark given by a dog who is separated from his or her social companions, and unspecific vocalisation in response to arousal. Staff should be able to identify visual signals, which include posture and facial expressions (Fox and Bekoff, 1975). For example, dogs who adopt a low posture are likely to be unsure of themselves and may require extra reassurance or training.

The attending care person is probably better at his/her job if he/she has experience with pet dogs outside the laboratory. This can provide valuable insights into the dogs' needs, variations in character, and a better understanding and rapport with the animals in her or his care.

Why good dog accommodation is good for welfare as well as science

Canine enclosures have often been designed primarily for easy husbandry and to maintain the animal's physical health. These considerations are of course essential, but the dog is the prime user of the enclosure and spends much longer periods in that environment than the staff who service it. It is vital, therefore, that designers consider the dog's normal behavior and are aware of the extent to which the enclosure might restrict such behavior. This is important not just from the point of view of animal welfare. It is well established that housing environments that do not meet the social or physical needs of an animal can lead to changes in physiology and behavior, thereby influencing research data. Dogs who are not able to cope with poorly designed laboratory housing are prone to develop stereotypical locomotory behaviors such as pacing, circling or wall bouncing (Hubrecht et al., 1992; Hubrecht, 1995a). In one case observed by this author, these behaviors were so extreme...
that the dog used three times his normal daily food ration to fund the metabolic expenditure resulting from the stereotypy. Clearly such abnormal behavior would have consequences for certain scientific outcomes. While extreme cases such as this are sometimes easily detected from patterns in the sawdust (Figure 1), others are often missed because the dog ceases to perform the stereotypy when care staff enter the kennel. To help identify stereotyped behavior, it can be useful to employ closed circuit television or video techniques to monitor the dogs from another room. Running a videotape in fast forward will make it easier to detect abnormally repetitive behavior patterns.

Figure 1. The pattern in the sawdust provides clear evidence that this dog has a stereotyped locomotor pattern. This is a cause for concern, and the housing design and management practices should be re-addressed. Stereotypies may not always be the product of the current housing, as once established they can be hard to eradicate.

It must be remembered that dogs have different personalities that are a product of their genetic make-up and personal experiences. There will be an inevitable variation in the dogs' responses to kennelling conditions which in turn may influence their responses to experimentation and testing. Ideally, the environment should be one in which the most nervous dog in the colony can live without being unduly stressed.

Social housing as the basis for kennel design

Primary enclosures should always be large and flexible enough to house dogs socially in harmonious groups. Single-housing for prolonged periods is apt to be deleterious to the dog and is associated with an increased incidence of behavioral abnormalities (Hetts et al., 1992; Hubrecht, 1995a). Single-housing may sometimes be necessary for clinical, behavioral or scientific reasons, but the duration should always be kept to a minimum, and the reasons for single-housing should always be challenged. For example, it used to be accepted that dogs used in toxicology were housed individually, but contract research organisations in the UK have for many years now routinely housed their dogs two or more to a pen (Hubrecht, 1995b). "Dogs on many GLP [good laboratory practice] toxicological studies can be housed in groups. This concept is, at the very least, worthy of consideration. In fact, we highly recommend it for most longer term GLP toxicological studies" (Hickey 1993, p. 77). While it is still common to separate the dogs for feeding and dosing, the period has been progressively
shortened [currently 4 hours or less]. With appropriate training and management, the separation of dogs for toxicology purposes should ultimately become unnecessary except where there is a specific justification on scientific grounds [e.g., drugs that have an effect on aggressiveness or that are expected to cause vomiting].

Aggression can cause serious complications when dogs are housed in groups. It is critical to ensure that there is an adequate husbandry routine to monitor the animals and forestall potential problems. A video and sound monitoring system can be very helpful.

![Housing accommodation at Novo Nordisk, Denmark, designed to meet the behavioral needs of dogs. Note that the pens are linked in pairs with access to an external run through the pop-hole at the back of the pen. Platforms offer visibility across the room. Suspended chews and other toys are provided as means of environmental enrichment. A dog bed with cushion offers a comfortable resting place.](image)

There are no clear data indicating what an optimum group size might be. Pair-housing seems to be a reasonable compromise, as dogs in pairs spend a similar proportion of their time interacting with each other as dogs kept in groups of 5-11 animals (Hubrecht, 1993). For this reason, the minimum dimension of all primary enclosures should be sufficient to house two dogs together in a space that allows them to express most of their normal behavioral repertoire and permits adequate enrichment (Figure 2). Pens should be designed so that management practices can be flexible. For example, groups of pens within a room should be arranged in such a way that it is possible to move an animal to another pen temporarily during wet cleaning, and so avoid exposing the subject to buckets of water, high pressure hoses or other aversive stimuli. It should also be possible to open doors or pop holes between pens so that larger "super-pens" can be created as desired, either to give the animals more space and increase its complexity or to allow groups of dogs to run together (Figures 2 & 3).
Space considerations

Provision of adequate space is essential for dogs as it affects not only their behavior, but also determines whether the animals can be housed in social groups and whether there is sufficient room for enrichment devices. Confinement intrinsically restricts the dog's ability to perform species-typical behaviors and to adjust social contact with other dogs (Bebak and Beck, 1993). Small or shallow-depth pens may also not allow the dog to retreat from events that he or she considers alarming at the front of the pen. Cramped enclosures are associated with a higher prevalence of circling and other stereotypies than relatively large enclosures (Hubrecht et al., 1992). This indicates that too small living areas affect the dogs' behavioral health and hence their general well-being. If dogs show stereotyped behavior, then there is good reason to re-examine the particular type of housing and attempt to improve it (Figure 1).

Minimum dimensions for primary enclosures are recommended as stipulated by the Home Office (1989; Table 1). The allocated floor areas provide a reasonable compromise between financial investment and provision of sufficient space for locomotion, socialisation and enrichment purposes. It is arguable whether pen size should be based on such a simple variable as body weight. For example, young animals are likely to require more space than old animals as they are more active and need extra space for play. The space recommendations listed in Table 1 are based on professional experience. They have the benefit of encouraging pair-housing, because the minimum sizes for single cages provide enough room for two adult dogs. For example, the minimum floor area for adult beagles of the weight category 10-25 kg is 4.5 m², both for a singly-housed dog and for two pair-housed dogs. The addition of a third dog, however, necessitates that the floor area be increased by 2.25 m², i.e., to 6.75 m². The area of minimum-size pens should never be reduced, even temporarily through the use of
partitions [e.g., for toxicology dosing of pair-housed subjects], as it then becomes extremely difficult to provide a structured and enriched environment. The preferred option would then be to double the size of the enclosure so that each dog has access to the minimum space at all times.

The height of the enclosure should at least allow the dog(s) to stand on hind legs without touching the roof (Table 1).

<table>
<thead>
<tr>
<th>Body Weight kg (lb.) of Dog</th>
<th>Minimum Floor Area m² (ft.²) per Dog</th>
<th>Minimum Height cm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Housed Singly</td>
<td>Housed in Groups*</td>
</tr>
<tr>
<td>less than 5 (11)</td>
<td>4.5 (48.4)</td>
<td>1.0 (10.8)</td>
</tr>
<tr>
<td>5-10 (11-22)</td>
<td>4.5 (48.4)</td>
<td>1.9 (20.5)</td>
</tr>
<tr>
<td>10-25 (22-45)</td>
<td>4.5 (48.4)</td>
<td>2.25 (24.2)</td>
</tr>
<tr>
<td>25-35 (45-77)</td>
<td>6.5 (70.0)</td>
<td>3.25 (35.0)</td>
</tr>
<tr>
<td>more than 35 (77)</td>
<td>8.0 (86.1)</td>
<td>4.0 (43.1)</td>
</tr>
</tbody>
</table>

* floor area must be not less than that specified for a singly housed dog.

Table 1. Minimum space recommendations for laboratory dogs.

**Exercise**

One obvious effect of confinement is to restrict locomotor behavior. Small enclosures not only discourage exercise because there is no possibility of travelling to another location, but they also restrict the type of locomotion that is possible and the ability of the dog to control his or her social interactions. Increasing pen dimensions beyond the minimum standards acceptable in the US (United States Department of Agriculture, 1991) does not seem to make much difference in terms of the dog's physical fitness (Clark et al., 1991), aggression, or play (Bebak and Beck, 1993). Nonetheless, an ethological study of mixed breed dogs housed in pens with spacious, outdoor runs [744 m²] has shown that both the activity of the animals and their range of species-typical locomotory behaviors was greater than that shown by dogs in small standard pens of less than 7 m² (Hubrecht et al., 1992).

It is reasonable to assume that space *per se* does not stimulate a dog to run around and exercise, but that the presence of structures or the presence of other dogs or care personnel will entice the dog to explore the available space and make active use of it. Any exercise program will have to take these basic ethological principles into account. It is highly recommended that laboratory dogs be exercised on a regular basis in a well-structured environment with other dogs and/or with friendly care personnel (Figures 4-8; United States Department of Agriculture, 1991; Loveridge, 1994,1998; Trussell et al., 1999; University of Florida, 2000).
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Figure 4. Walking dogs on a leash, while perhaps not possible in all institutions, provides enrichment for the animals, offers exercise, improves staff morale and, helps with re-homing.

Structures and enrichment within the dog enclosure

Sufficiently large enclosures offer possibilities for the provision of structures and enrichment devices (Figures 2,3,5,6,7). They also allow the provision of separate sleeping and exercise areas, so that dog(s) can defecate and urinate away from the sleeping area. This makes the environment more complex and interesting and gives the animal(s) some choice and the option of exercise. Most importantly, a large enclosure permits social housing.

Objections are sometimes made to enrichment items such as chews/toys because it is considered that they can trigger aggression and cause hygiene problems, or simply because the dogs lose interest in them. Appropriate presentation of enrichment items can address these objections. For example, the toys can be suspended from the ceiling by sprung chains (Figure 3), which prevents soiling and makes it impossible for one dog to monopolise them (Hubrecht, 1993). The toys should be suspended just off the floor of the enclosure so that the dog can hold and gnaw the chew while lying down in a species-specific fashion. Dogs are very motivated by food. Toys or chews that have an appetising aroma or taste, therefore, receive a lot of attention. Such items can reduce the time during which the animals are inactive and decrease destructive behavior of cage fixtures and furnishings. The benefits of enrichment of beagles' enclosures have been demonstrated (Hubrecht, 1993, 1995). Toys or chews [rawhide, plastic pipe and Gumabone tugtoy] were used by puppies for 64% of their time and by sub-adult dogs [7-13 months old] 24% of their time. No habituation effect was noticed over a two-month period.

Any enrichment device has to be practical, provide a measurable benefit for the animal and should not interfere with the aims of the research protocol.

Dogs are inquisitive animals who show a keen interest in their surroundings. Accordingly kennels should not restrict the animals' ability to obtain important information about their surroundings. High walls or solid partitions between pens result in the dogs being unable to see to the end of their rooms. This can cause them to
spend a relatively high proportion of their time on hind legs or in apparently repetitive, possibly stereotypical jumping behavior. Obvious ways around this problem include reducing the height of partitions between pens for at least a part of their length and providing platforms (Figures 2 & 3). Hubrecht (1993) has shown that platforms are extensively used [55% of the time] by laboratory dogs to play and rest on, and that they do not pose any risk, even for dogs with gastric fistulas. Platforms make the third dimension accessible and increase spatial complexity, thus allowing the dogs more choices within their environment. If properly installed so that they do not block the existing floor area, platforms also provide additional floor area (Figures 2 & 3).

Dog housing should always be designed so that the occupants can retreat to an area that gives them a sense of security. This need not cause a problem of visibility for the day-to-day care person, as it can simply be an area with a few barriers shielding the animal from view on two or three sides (Figure 3). It is particularly important to offer such structures when dogs are housed in groups so that the animals can better control their social interactions.

Indoor-outdoor pens are an option in some cases and it is generally believed that offering dogs access to the outside is an enriching experience for them (Figures 5-7). Objections on the grounds of noise nuisance to neighbouring residents can be countered by appropriate design of the kennel structures or through the use of noise reflecting barriers such as banks of earth.
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Figures 5-7. An outdoor exercise area at Novo Nordisk, Denmark, showing the large space [2000 m²] provided for the dogs, with structures and enclosures ["pig huts" with flat roofs and chutes, hills with drain pipes and trees] within the pen. Dogs have access to this area 5 times a week for a minimum of 1-2 hours daily.

Flooring

The choice between solid or grid floors was considered at the Berlin Workshop (Gärtner et al., 1994). Open floored systems are sometimes preferred because they are cheaper to maintain and clean, but the majority of the experts recommended solid or at least only partly gridded floors and agreed that dogs prefer solid flooring. Whatever the flooring type, a safe, solid area of sufficient size for all dogs to comfortably and simultaneously lie down should be provided. When solid floors are used, a substrate such as sawdust helps to soak up urine and some of the moisture in faeces. The sawdust is generally not used in sufficient quantities to provide bedding for the dog and is generally not required for this purpose. However, comfortable bedding is recommended, especially for puppies, sick animals and old animals (Figure 2; Loveridge, 1994; Eisele, 2001).

Wet cleaning of enclosures should not be necessary on a daily basis. Many establishments now carry it out weekly or at longer intervals, using regular dry cleaning to remove soiled patches of sawdust.
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Social interactions of dogs with animal care staff

Considering the strong social disposition of dogs, it is not surprising that socially restricted rearing leads to the development of behavioral abnormalities and crippled behavioral repertoires (Thompson et al., 1956; Fuller, 1967). Similarly, if dogs are not provided with an adequate early experience of humans they will later be fearful of people and as a result can be difficult to handle (Freedman et al., 1961; Scott and Fuller, 1965; Wolfle, 1987). Puppies go through a stage between the 3rd and 12th week of life - the so-called primary socialisation period - when it is particularly easy for them to develop relationships with other individuals (Scott and Fuller, 1965; Wright, 1980). At the same time, the puppy becomes attached to the familiar home area. While there is debate as to whether this is really a "critical period" it does seem to be a time of special importance in the puppy's development (Markwell and Thorne, 1987).

Although the general time of this socialisation period is agreed upon, there is surprisingly little known about how much human-contact time is needed to adequately socialise a dog with humans. Some studies suggest that socialisation with humans can be achieved through relatively small amounts of time: 40 minutes or less per week spent with a litter (Scott and Fuller, 1965), or 5 minutes per week spent with each puppy (Wolfle, 1990). Hubrecht (1995) worked with male beagle puppies who had been considered by a pharmaceutical firm to have already received adequate socialisation. Even so, an extra 2 minutes spent in the pen each weekday combined with 30 seconds of petting each puppy [i.e., 2.5 minutes intensive contact with the human handler per puppy per week] resulted in behavioral changes 6-11 months later. These changes could be interpreted as intensified seeking of human contact.

Dogs who have been socialised to humans while puppies readily socialise with them as adults. It is generally agreed by professionals that human socialisation with adult dogs improves handleability and provides an important form of enrichment (Fox, 1986; Loveridge, 1998). However, in kennels housing large numbers of dogs, the pressures on staff are often such that contact with the dogs becomes very limited (Hubrecht et al., 1992). Managers should be aware that this can be a serious problem and should implement a socialisation program.

Minimisation of stress during interactions between people and dogs

The easiest way to minimise stress in the dog is to ensure that he or she reacts well to handling. All dogs should, therefore, experience adequate socialisation with humans and other dogs during the "primary socialisation period" [approximately 3-12 weeks] and receive regular gentle and sympathetic handling thereafter. The same member of staff should always carry out the handling of an animal or, if this is not possible at times, by another person who applies the same handling techniques.
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Figures 8-11. Professional handling techniques of laboratory dogs should be based on a positive, trustful human-animal relationship. The dog should feel at ease when being approached (8), picked up (9), carried (10), and restrained (11).

Training dogs so that they become used to experimental and clinical procedures is essential in order to avoid stress (Figures 8-14). If, for example, a procedure involves temporary restraint - which is known to be potentially stressful (Knol, 1989) - the familiar handler should first gently introduce the dog to this situation. The handler should always remain with the animal during the procedure. If this is not possible, the person carrying out the procedure should also pick up the dog from the pen and return the dog afterwards in the same manner as the regular handler would normally do. It is now becoming accepted that there should be close liaison between the breeders and users of laboratory dogs to ensure that handling methods are standardised. Young dogs should become used to typical procedures such as weighing or the taking of temperature. Sometimes it might be beneficial to accustom puppies to more sophisticated procedures. In these cases a cost/benefit decision should be taken as to whether any short-term welfare costs to the puppy are balanced by welfare benefits later in life. Socialised dogs can be more difficult to work with as they tend to be more boisterous. It may be beneficial when training dogs to provide clear cues so that the animals can distinguish between "work" and "play" times.
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Figures 12-14. Laboratory dogs can readily be trained through positive reinforcement to accept routine procedures such as intramuscular injection, intravenous injection and oral dosing. Such training helps to reduce the stress involved in these procedures.

Staff should be proficient in basic handling techniques, such as those shown in Figures 8-14 (MacArthur, 1999). Care personnel should approach the dog steadily and quietly, make confident contact and should frequently reassure the dog by petting and talking quietly to him/her. The staff's demeanour while in the animal rooms should always be calm, confident and quiet. The aim is to establish a bond of trust with the dogs so that handling is a positive rather than a negative experience for all parties involved.

Noise in kennels

The noise in kennels resulting from barking can be a nuisance and is potentially damaging to human hearing (van der Heiden, 1992). Dogs often bark at each other through adjacent pens or at people passing by. Barking is also associated with feeding times and is probably a result of the generally high levels of excitement. Very often barking spreads to other dogs, and in some animals the act of barking may itself function as a self-stimulus to further barking (Scott and Fuller, 1965).
Dogs can detect sounds ranging in frequency from 0.04 kHz up to around 50 kHz, which is well beyond the upper frequency limit of human hearing. They can hear sounds that are up to four times quieter than the human ear can detect (Fay, 1988). In dog kennels, sound levels within the human hearing range can regularly reach values between 85 and 122 decibels (Ottewill, 1968; Peterson, 1980; Sales et al., 1997). Most of the high level noise is probably produced by the dogs themselves, although other events such as cleaning, high pressure hose, doors banging and pagers may also contribute substantially to the acoustic environment (Sales et al., 1988). The noise in dog kennels can often be at a level that has the potential of causing damage and stress not only to humans but also to other animals who have less acute auditory sensitivity than dogs (Gamble, 1982; Milligan et al., 1993). It is also known that noise stress in humans can lead to physiological and health problems (Raaij and Oortgiesen, 1996). It seems probable that dogs, like humans, are at risk of noise stress and possible hearing damage. Sound control should, therefore, be a priority when designing dog kennels. Noise can be limited by the use of sound-absorbent materials that must permit cleaning and should either be out of the dogs' reach or resistant to destruction. Efforts should also be made to reduce transmission of sound by the use of acoustic doors and the use of cavity walls. Corridors can channel the sound from one area to another, but as sound travels less easily around corners, the use of straight corridors should be avoided. Major noise-producing equipment should be sited as far away from the animals as possible.

Conclusions

Dog kennel design should:

- keep the animal(s) in good physical and mental health,
- permit easy handling of the dog(s) by personnel,
- be large enough to allow group housing of compatible dogs,
- be flexible enough to allow pens to be joined together to create larger runs,
- permit choice of location and provide interest within the enclosure,
- provide some refuge from kennel mates through the use of visual barriers,
- allow the dog good visibility of the room and of the area outside the pen,
- reduce to a minimum sound egress and ingress.

Dog supply and re-homing of "used" dogs

In Europe there is a requirement that dogs provided for scientific use are bred in, and obtained from, a designated or registered breeding establishment (Editors' note: These correspond to class A dealers in the US). There is much to be said for this provision as:

1. The dogs from registered breeders are likely to be of a good and standard quality and free of disease.
2. They will not have experienced anything other than an institutional life and, therefore, will not suffer due to separation from a family life or because of loss of freedom.
3. The standards of the designated breeding establishment can be maintained through a process of licencing and inspection.
4. The public has reasonable assurance that their pet will not end up in research establishments.

There can be problems in retiring laboratory dogs to homes. Any decision to do so should take into account the
fact that there may be welfare problems to the dog. Dogs who have spent a substantial portion of their life in institutions often show a number of behavioral disorders when being re-homed. These may include difficulties with house-training, separation-anxiety problems, and aggression triggered by fear-inducing unfamiliar experiences. On the other hand, there are some establishments that have successfully introduced re-homing programs, and others are currently examining the feasibility of such a scheme. In order to re-home research dogs safely and humanely, the institution must develop and maintain a comprehensive socialization and training program. As with any re-homing program, the proper matching of the retired dog with the new owner is the basic condition for success.

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