Annotated Bibliography on Refinement and Environmental Enrichment for Primates Kept in Laboratories

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This bibliography offers animal caregivers, animal technicians, veterinarians, zoo keepers and students guidance to practical information on refinement and environmental enrichment for primates kept in research institutions.

The bibliography can also be accessed at
www.awionline.org/lab_animals/biblio/index.html

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Species-typical Behavior

The following reports provide excellent overviews of the species-typical behavior of wild primates.

Caldecott JO 1986. An Ecological and Behavioral Study of the Pig-tailed macaque. Karger, Basel, Switzerland

Chopra PK, Seth PK, Seth S 1992. Behavioural profile of free-ranging rhesus monkeys. Primate Report 32, 75-105

Hall KR 1968. Behaviour and ecology of the wild patas monkey, *Erythrocebus patas*, in Uganda. In Primates - Studies in Adaptation and Variability Jay PC (ed), 32-119. Holt, Rinehart and Winston, New York, NY

Hall KRL, DeVore I 1965. Baboon social behavior. In Primate Behavior - Field Studies of Monkeys and Apes DeVore I (ed), 53-110. Holt, Rinehart and Winston, New York, NY

Lindburg DG 1971. The rhesus monkey in North India: an ecological and behavioral study. In Primate Behavior: Developments in Field and Laboratory Research, Volume 2 Rosenblum LA (ed), 1-106. Academic Press, New York, NY

Poirier FE 1970. The Nilgiri langur *(Presbytis johnii)* of South India. In Primate Behavior: Developments in Field and Laboratory Research, Volume 1 Rosenblum LA (ed), 251-383. Academic Press, New York, NY

Roonwal ML,Mohnot SM 1977. Primates of South Asia - Ecology, Sociobiology, and Behavior. Harvard University Press, Cambridge, MA

Schaller GB 1965. The behavior of the Mountain Gorilla. In Primate Behavior - Field Studies of Monkeys and Apes DeVore I (ed), 324-367. Holt, Rinehart and Winston, New York, NY

Simonds PE 1965. The bonnet macaque in South India. In Primate Behavior - Field Studies of Monkeys and Apes DeVore I (ed), 175-196. Holt, Rinehart and Winston, New York, NY

Southwick CH, Beg MA, Siddiqi MR 1965. Rhesus monkeys in North India . In Primate Behavior - Field Studies of Monkeys and Apes DeVore I (ed), 111-159. Holt, Rinehart and Winston, New York, NY

Teas J, Richie T, Taylor H, Southwick C 1980. Population patterns and behavioral ecology of rhesus monkeys *(Macaca mulatta)* in Nepal. In The Macaques: Studies in Ecology, Behavior and Evolution
Lindburgh DG (ed), 247-262. Van Nostrand Reinhold, New York, NY

Van Lawick-Goodall J 1968. A preliminary report on expressive movements and communication in the Gombe Stream chimpanzee. In Primates - Studies in Adaptation and Variability Jay PC (ed), 313-374. Holt, Rinehart and Winston, New York, NY

Wheatley BP 1999. The Sacred Monkeys of Bali. Waveland Press, Prospect Heights, IL

Behavioral Pathologies (Abnormal Behavior)

The following articles describe abnormal behavior patterns commonly shown by captive primates.

Erwin J, Deni R 1979. Strangers in a strange land: Abnormal behavior or abnormal environments? In Captivity and Behavior Erwin J, Maple T, Mitchell G (eds), 1-28. Van Nostrand Reinhold, New York, NY

Fittinghoff NA, Lindburg DG, Gomber J, Mitchell G 1974. Consistency and variability in the behavior of mature, isolation-reared, male rhesus macaques. Primates 15, 111-139

Walsh S, Bramblett CA, Alford PL 1982. A vocabulary of abnormal behaviors in restrictively reared chimpanzees. American Journal of Primatology 3, 315-319

Extraneous Variables

(1) Definition

An extraneous variable is a factor that is not the object of investigation yet bears the potential of changing the research data in uncontrolled ways.

(2) Scientific Principles

American Medical Association 1992. Use of Animals in Biomedical Research - An American Medical Association White Paper. AMA Group on Science and Technology, Chicago, IL
"Biomedical experiments are conducted in accordance with the principles of the scientific method developed by the French physiologist, Claude Bernard, in 1865. This method established two requirements for the conduct of a valid experiment: (1) control of all variables so that only one factor or set of factors is changed at a time, and (2) the replication of results by other laboratories. Unless these requirements are met, an experiment is not considered valid. ... Stressed animals do not make good research subjects."

American Society of Primatologists 2000. American Society of Primatologists guidelines for the ethical treatment of nonhuman primates. ASP Bulletin 24(4), 4
"We should make use of information on a species natural history to improve management and enrich environments, because physical and psychological well-being are essential not only to the health of the animals but also to the validity of the research results."

Animal Welfare Institute 1979. Comfortable Quarters for Laboratory Animals, 7th Ed. Animal Welfare Institute, Washington, DC
"Whenever possible, primate conspecifics should be housed together in social groups because of their social needs, and these needs should not take second place to housing systems designed primarily for the convenience of animal care technicians. Independent of ethical considerations, to deprive a gregarious animal of its basic behavioral, emotional, and social needs is no less detrimental to the validity of many scientific investigations than deprivation of light, fresh air, food and water."

Bayne K 2005. Environmental enrichment: Potential for unintended consequences and research results. ILAR [Institute for Laboratory Animal Research] Journal 46(2), 129-139 http://dels.nas.edu/ilar_n/ilarjournal/46_2/html/v4602bayne.shtml
"Although it is unlikely that every possible variable can be controlled ... more detailed disclosure in journals ... of the living environment of the subject animals .. will allow for a better comparison of the findings, and contribute to the broader knowledge base of the effects of enrichment."

Brockway BP, Hassler CR, Hicks N 1993. Minimizing stress during physiological monitoring. In Refinement and Reduction in Animal Testing Niemi SM, Willson JE (eds), 56-69. Scientists Center for Animal Welfare, Greenbelt, MD
"Elimination of sources of variability (stress for example) may allow the use of fewer animals giving equally valid results."

Chance MR, Russell WMS 1997. The benefits of giving experimental animals the best possible treatment. In Comfortable Quarters for Laboratory Animals, 8th Ed. Reinhardt V (ed), 12-14. Animal Welfare Institute, Washington, DC
"If we use ethological sophistication to provide laboratory animals with the very best physical and social environment conditions for their well-being, we need to use fewer of them in research experiments or routine tests, and our results will be accurate and reliable."

Davis DE, Bennett CL, Berkson G, Lang CM, Snyder RL, Pick JR 1973. Recommendations for a standar-dized minimum description of animal treatment. ILAR News 16(4), 3-4
"It is clear [from this survey] that many investigators do not realize the influence of ... environmental variables [e.g., housing, handling, temperature, light] on experimental results or at least do not adequately describe the environmental history of the animals used for experimentation."

Fuchs E 1997. Requirements of biomedical research in terms of housing and husbandry: Neuroscience. Primate Report 49, 43-46
"Housing conditions are among the parameters which are important contributors to the nature, quality, and reproducibility of research obtained in laboratory animal investigations. ... It is absolutely important that the animals are able to display as many aspects of their natural behavioural repertoire and confounding factors such as abnormal behavior, injuries, diseases, and stress are excluded."

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK http://scienceandresearch.homeoffice.gov.uk/animalresearch/legislation/codesofpractice/housing-care
"Experimental results may be influenced by environmental conditions. ... To demonstrate any experimental response against such a variable background generates a requirement for greater animal usage if the result is to be statistically valid."

Lang CM, Vesell ES 1976. Environmental and genetic factors affecting laboratory animals: impact on biomedical research. Federation Proceedings 35, 1123-1124
The survey "suggests that many investigators do not fully recognize the influence of environmental and genetic variables on experimental results.... Failure to give an adequate description of these variables makes it difficult, if not impossible, to duplicate an experiment in other laboratories."

Meyerson BJ 1986. Ethology in animal quarters. Acta Physiologica Scandinavica 554 (S), 24-31
The requirements for 'carefully controlled conditions' counteracts its fundamental purpose if it results in housing conditions where the animals have difficulties in adapting (psychoneuroendocrine changes which may disturb the experimental results).

National Research Council 1996.Guide for the Care and Use of Laboratory Animals. National Academy Press, Washington, DC
http://www.nap.edu/books/0309053773/html/
"A good management program provides the environment, housing, and care that ... minimizes variations that can affect research. ... Animals should be housed with the goal of maximizing species-specific behaviors and minimizing stress-induced behaviors."

Novak MA, Bayne K 1991. Monkey behavior and laboratory issues. Laboratory Animal Science 41(4), 306-307
"Monkeys are socially complex creatures. When this aspect of their nature is accommodated in research settings, the benefit to science is a less stressed animal that provides meaningful scientific data."

Öbrink KJ, Rehbinder C 1999. Animal definition: a necessity for the validity of animal experiments? Laboratory Animals 22, 121-130
"'Material and Methods' section mostly reveals an obvious or almost total lack of information about the animals. ... The animal definition should not only include species, sex and age but also ... the environmental conditions to which the animals are exposed. ... The prerequisites for the use of fewer animals per project, while still retaining a sufficiently high degree of accuracy are high levels of reproducibility and precision in the experimental results. Factors that may affect these will be discussed in this paper. If a researcher, through carelessness or ignorance, should use more animals for a project than is necessary, it must be considered unethical. ...Without hesitation, it is a scientific demand that all factors that have not proven to be insignificant should be checked, controlled or kept constant."

Public Health Service (PHS), U.S. Department of Health and Human Services 1994. The importance of animals in biomedical and behavioral research. Laboratory Primate Newsletter 33(4), 12
http://www.brown.edu/Research/Primate/lpn33-4.html#state
"Like most people, scientists are concerned about animal well-being. ... Institutions receiving support from the Public Health Service are obliged to adhere to the highest possible standards for the humane care and responsible use of laboratory animals. And scientists themselves have adopted the principle: 'Good Animal Care and Good Science Go Hand in Hand'."

Reinhardt V 1991. Impact of venipuncture on physiological research conducted in conscious macaques. Journal of Experimental Animal Science 34, 212-217
http://www.awionline.org/Lab_animals/biblio/es34-2~1.htm
"Despite the fact that venipuncture often is a stressful event for research animals, 81% of the [58] studies [assessing stress-sensitive physiological data] did not account for this circumstance by providing no information as to how the subjects were caught and how they were immobilized during venipuncture. ... It was concluded that the description of the experimental animal's handling prior to and during venipuncture is a methodological issue that needs to be clarified in order to account for a dependent possibly data-biasing variable."

Reinhardt V, Reinhardt A 2000. Blood collection procedure of laboratory primates: A neglected variable in biomedical research. Journal of Applied Animal Welfare Science 3, 321-333
http://www.awionline.org/Lab_animals/biblio/jaaws2.html
"A survey of 75 biomedical articles dealing with stress-dependent blood parameters in caged primates revealed that the conditions under which blood collection occurred were in most cases [72%] described either not at all or so haphazardly that it would be impossible to determine if humane handling procedures were used and basic principles of scientific methodology applied. These findings were unexpected because not only is there ample scientific evidence that stress-sensitive research data are influenced by traditional blood sampling procedures, but also that those data-biasing effects can be avoided. If dependent variables of the blood collection procedure are not controlled, data variability will increase thereby automatically also increasing the number of animals needed for statistical analysis. For ethical and scientific reasons, it was recommended that editors of biomedical journals should require that authors provide sufficient information of the blood collection - and when applicable also of the sedative injection - procedure to assure that the experiment was done with the smallest number of animals possible to achieve statistical significance, and that the investigation can be replicated reliably in another laboratory and the research data interpreted with reasonable accuracy."

Reinhardt V, Reinhardt A 2000. The lower row monkey cage: An overlooked variable in biomedical research. Journal of Applied Animal Welfare Science 3, 141-149
http://www.awionline.org/Lab_animals/biblio/jaaws1.htm
"A survey of 96 primatological articles revealed that cage location of research monkeys is usually not mentioned (98%), in spite of the fact that the environment of upper- and lower-row housed animals markedly differs in terms of light quality, light intensity and living dimension. Not accounting for these uncontrolled variables may increase variability of data and, consequently, the number of experimental animals needed to obtain statistically acceptable results."

Russell WMS 1997. Shooting the clock: Timeless lessons of the past still guide today's refinement initiatives. WARDS Newsletter 8(3), 1-2
"Scientifically, we must ensure the validity of research results and a stressed animal is not a proper specimen for science."

Russell WMS, Burch RL 1959. The Principles of Humane Experimental Technique Methuen, London, UK
http://altweb.jhsph.edu/publications/humane_exp/het-toc.htm
"The wages of inhumanity" are "paid in ambiguous or otherwise unsatisfactory experimental results. .. If we can ... remove any unwanted source of variance, we reap our reward at once in smaller residual variance, greater precision, and hence fewer experimental animals."

Schwindaman D 1991. The 1985 animal welfare act amendments. In Through the Looking Glass Novak MA, Petto AJ (eds), 26-32. American Psychological Association, Washington, DC
"It is only common sense, for instance, that an animal will not respond normally if it is stressed or undernourished. ... Because the validity of research results is so dependent on the health of research animals, the future of science depends on the integrity of scientific methods and the treatment of animals used in research."

T-W-Fiennes RN 1972. Primates - General. In The UFAW Handbook on the Care and Management of Laboratory Animals Fourth Edition Universities Federation for Animal Welfare (ed), 374-375. Churchill Livingstone, London, UK

"An animal treated unsympathetically is liable to become aggressive and uncooperative; furthermore, unless care is taken over its comfort and needs, it is liable to become stressed and the results of the experiment may be vitiated for this reason."

Veira Y, Brent L 2000. Behavioral intervention program: Enriching the lives of captive nonhuman primates. American Journal of Primatology 51(Supplement), 97
"The most common behaviors reported were hair pulling, pacing, rocking and self-aggression." It was suggested "that baboons with abnormal behaviors do not cope well with their environment, are not good candidates for research or breeding purposes, and many [are] eventually euthanized. ... Abnormal and stress-related behaviors in nonhuman primates have a measurable negative impact on research and breeding program effectiveness."

Warwick C 1990. Important ethological and other considerations of the study and maintenance of reptiles in captivity. Applied Animal Behaviour Science 27, 363-366
"The majority of scientists seem to make great efforts to avoid being associated with 'animal welfarist' or to become open to allegations of being somehow 'scientifically soft'. However, awareness of actual and potential stress and distress among animals in whatever situation should not be regarded as subjective but as a sound scientific base for the study of animals. Whether an observer maintains a high personal respect of the well-being of the individual animal or holds classic concepts of animals as being experimental 'models', it should be more widely recognized that there is typically a scientific necessity to have animals at ease with their environments if studies are to remain objective."

Wolfle TL 1996. How different species affect the relationship. In The Human/Research Animal Relationship Krulisch L, Mayer S, Simmonds RC (eds), 85-91. SCAW, Greenbelt, MD
"The right technician instills qualities in the animals that make them better and more reliable research subjects. Stress, on the other hand, leads to profound physiological and behavioral changes that increase the variability of the data and decrease the reliability of the results."

(3) Insufficient/Inadequate Space

Boot R, Leussink AB, Vlug RF 1985. Influence of housing conditions on pregnancy outcome in cynomolgus monkeys (*Macaca fascicularis*). Laboratory Animal Science 19, 42-47
More successful pregnancies were recorded for females housed individually in large cages than for females housed in small cages.

Boyce WT, O'Neill-Wagner PL, Price CS, Haines MC, Suomi SJ 1998. Crowding stress and violent injuries among behaviorally inhibited rhesus macaques. Health Psychology 17, 285-289
A rhesus group of 36 animals was kept during 6 'warm' months in a large outdoor enclosure, during 6 'cold' months confined in a building. "During the 6-month period of confinement stress, a fivefold acceleration in [medically-attended] injury incidence was found."

Draper WA, Bernstein IS 1963. Stereotyped behavior and cage size. Perceptual and Motor Skill 16, 231-234
"It was concluded that spatial restriction which does not permit 'normal' locomotor behavior, e.g., running, climbing, etc., results in substitute motor expression which frequently takes the form of repetitive stereoptyped movement."

Faucheux B, Bertrand M, Bourliere F 1978. Some effects of living conditions upon the pattern of growth in stumptail macaque *(Macaca arctoides)*. Folia Primatologica 30, 220-236

"Confinement and prolonged lack of physical exercise are very probably responsible for the reduced weight and size of our monkeys bred in laboratory conditions. ... This is apparently due to the impaired development and resulting athrophy of the muscles, particularly those of the hind quarters. This athrophy was especially noticeable in lab-bred group II monkeys which have been kept in small individual cages for years. ... The ways in which most primates are bred and kept in many research laboratories are obviously far from ideal. Many 'normal' control subjects might well be in fact abnormal both somatically and behaviorally."

Kerl J, Rothe H 1996. Influence of cage size and cage equipment on physiology and behavior of common marmosets (*Callithrix jacchus*). Laboratory Primate Newsletter 35(3), 10-13
http://www.brown.edu/Research/Primate/lpn35-3.html#kerl
"The mean daytime heart rate increased with increasing cage size for the standard cages. This was expected because of the increased options for locomotor behavior."

Kitchen AM, Martin AA 1996. The effects of cage size and complexity on the behaviour of captive common marmosets, *Callithrix jacchus jacchus*. Laboratory Animals 30, 317-326
"Stereotyped behaviours, which occurred in the small cages, were never exhibited in the large cages."

Mendoza SP 1999. Squirrel Monkeys. In The UFAW [Universities Federation for Animal Welfare] Handbook on the Care and Management of Laboratory Animals Seventh Edition. Poole T, English P (eds), 591-600. Blackwell Science, Oxford, UK
"The most common form of stereotypic behavior in squirrel monkeys is an exaggerated head twirling, usually associated with pacing. ... The incidence of the behaviour seems to be more frequent in small cages, and frequent occurrence of this behaviour may indicate that more space is required."

National Research Council 1996. Guide for the Care and Use of Laboratory Animals. National Academy Press, Washington, DC
http://www.nap.edu/books/0309053773/html/
"For arboreal animals that normally flee upward and spend much of their locomotor time climbing, floor area might be secondary to vertical space in providing for postural and locomotor expression. The volume of space available, rather than floor area, might be critical for nonhuman primates."

Paulk HH, Dienske H, Ribbens LG 1977. Abnormal behavior in relation to cage size in rhesus monkeys. Journal of Abnormal Psychology 86, 87-92
"Observations were made of 24 monkeys that were introduced singly into a [barren] small and a [barren] large test cage. In a large cage, more normal but less stereotyped locomotion was shown than in a small cage."

Turnquist J 1985. Passive joint mobility in patas monkeys: Rehabilitation of caged animals after release into a free-ranging environment. American Journal of Physical Anthropology 67, 1-6
Housing in small cages had detrimental effects on joint mobility, which could be reversed by releasing the animals into a free-ranging environment.

van Wagenen G 1950. The monkeys. In The Care and Breeding of Laboratory Animals Farris EJ (ed), 1-42. John Wiley, New York, NY

"If sufficient room is not provided, some males will soon show depression, sitting quietly in the part of the cage which affords the best view. For a while this may be interpreted as an adaptation. ... Too often, however, this persistent posture apparently results in a pressure atrophy, bringing on a lower-limb palsy, the so-called 'cage paralysis'."

Westergaard GC, Izard MK, Drake JH 2000. Reproductive performance of rhesus macaques *(Macaca mulatta)* in two outdoor housing conditions. American Journal of Primatology 50, 87-93
"We conclude that, for rhesus macaques, outdoor corral housing leads to better reproductive performance than does semi-sheltered gang housing, probably as a result of increased individual space and relaxation of intense social stressors."

(4) Barren Environment

Bayne K, Dexter SL, Mainzer H, McCully C, Campbell G, Yamada F 1992. The use of artificial turf as a foraging substrate for individually housed rhesus monkeys *(Macaca mulatta).* Animal Welfare 1, 39-53
http://www.awionline.org/Lab_animals/biblio/aw1-39.htm
When their cages were not enriched, eight single-caged subjects exhibited "abnormal behaviors" approximately 37% of the time.

Bayne K, Dexter SL, Suomi SJ 1991. Social housing ameliorates behavioral pathology in *Cebus apella*. Laboratory Primate Newsletter 30(2), 9-12
http://www.brown.edu/Research/Primate/lpn30-2.html#bayne
"No specific enrichment devices were included in the [single-] cages." The seven subjects' mean percentage of occurrence of "stereotypic behaviors" was 13%.

Bayne K, Mainzer H, Dexter SL, Campbell G, Yamada F, Suomi SJ 1991. The reduction of abnormal behaviors in individually housed rhesus monkeys *(Macaca mulatta)* with a foraging/grooming board. American Journal of Primatology 23, 23-35
Prior to enrichment, individuals spent on average 25% of their time engrossed in abnormal behaviors.

Bayne K, Mainzer H, Dexter SL, Campbell G, Yamada F, Suomi SJ 1991. The reduction of abnormal behaviors in individually housed rhesus monkeys *(Macaca mulatta)* with a foraging/grooming board. American Journal of Primatology 23, 23-35
Prior to enrichment, individuals spent on average 25% of their time engrossed in abnormal behaviors.

Garner J 2002. Why every scientist should care about animal welfare: Abnormal repetitive behavior and brain function in captive animals. Fourth World Congress on Alternatives and Animal Use in the Life Sciences, 95 (Abstract)
"Barren laboratory housing also induces abnormal behaviors in many species, particularly stereotypies, fur and feather plucking, and self-mutilation. Similar behaviors in human mental disorder are correlated with dysfunction in brain areas that control the selection and sequencing of behavior. Experiments in several captive species will be reviewed, showing the same behaviors correlate with dysfunction in the same brain areas. For instance, in laboratory mice: like stereotypy in autism and schizophrenia, stereotypy correlates with impairments of basal ganglia function; and like hair pulling in trichotillomania and autism, barbering (hair plucking) correlates with impairments of prefrontal cortex function. Therefore, far from standardizing

laboratory animals, barren environments may induce severe brain abnormalities. These abnormalities call the validity of a wide range of experiments into question. Limits of current knowledge and pressing research directions will be identified. In particular, enrichments that prevent these behaviors may reduce variability between animals and produce animals that are better models of normal function. Thus, enrichment may actually improve the standardization of research animals and refine current animal models. In short, 'good welfare is good science'.“

Kessel AL, Brent L 1996. The effectiveness of cage toys in reducing abnormal behavior in individually housed pigtail macaques. XIXth Conference of the American Society of Primatologists, Abstract No. 519
Prior to the provision of environmental gadgets subjects exhibited "abnormal behavior" 24% of the time.

Lam K, Rupniak NMJ, Iversen SD 1991. Use of a grooming and foraging substrate to reduce cage stereotypies in macaques. Journal of Medical Primatology 20, 104-109
http://www.awionline.org/Lab_animals/biblio/jmp20-1.htm
"Animals exhibited idiosyncratic repertoires of stereotyped behaviour, including repetitive pacing, swaying circling, bouncing, cage charging, and rocking. These activities occupied on average 11% of baseline observation periods" prior to the introduction of the enrichment gadget.

Reinhardt V 1997. Refining the traditional housing and handling of laboratory rhesus macaques improves scientific methodology. Primate Report 49, 93-112
http://www.awionline.org/Lab_animals/biblio/pr-refi.htm
"A monkey housed in an empty cage is literally a behavioral cripple because s/he is chronically deprived of appropriate stimuli for the expression of species-typical behavior patterns. It is difficult to know objectively if a monkey experiences boredom when being kept in an understimulating environment. However, many such animals show signs of depression and/or engage in gross behavioral disorders."

5) Single-caging

Alexander S, Fontenot MB 2003. Isosexual social group formation for environmental enrichment in adult male *Macaca mulatta*. AALAS 54th National Meeting Official Program, 141
Thirty-one [38.8%] of a colony of 80, previously single-caged 4-10 years old male rhesus macaques had at least one incidence of self-injurious biting.. During the year prior to group formation, the clinical history of the subjects included a 12.5% incidence of severe self biting requiring pharmacological intervention and wound care. These animals were treated pharmacologically for 2-11 months prior to group formation. All of these cases were removed from treatment prior to group formation. No self biting was noted during a follow-up period of four months after the animals had been transferred to group-housing.

Bellanca RU, Crockett CM 2002. Factors predicting increased incidence of abnormal behavior in male pigtailed macaques. American Journal of Primatology 58, 57-69
"Abnormal behavior was unrelated to the subject's housing location (biocontainment vs. other facility) or invasiveness of research. Nursery-reared subjects displayed more abnormal behavior than mother-reared subjects. Across and within rearing categories, the proportion of the first 48 months of life spent singly housed was positively related to the amount of abnormal behavior at maturity. … Locomotor stereotypy, by far the most frequent form of abnormal behavior, was positively related to time in single housing but was unrelated to rearing.”

Canadian Council on Animal Care 1984. Non-human primates. In Guide to the Care and Use of Experimental Animals, Volume 2, 163-173. Canadian Council on Animal Care, Ottawa, ON
"Any primate housed alone will probably suffer from social deprivation, the stress from which may distort processes, both physiological and behavioural."

Chase WK, Marinus LM, Novak MA 2000. A behavioral comparison of male rhesus macaques *(Macaca mulatta)* in four different housing conditions. American Journal of Primatology 51(Supplement), 51 (Abstract)
Animals in socially restricted housing paced significantly more, locomoted significantly less and were more aggressive than subjects housed in groups.

Coelho AM, Carey KD, Shade RE 1991. Assessing the effects of social environment on blood pressure and heart rates of baboon. American Journal of Primatology 23, 257-267
In the social companion condition, a subject was able to have visual, tactile, and auditory interactions with his companion through the wire mesh walls of the specially designed cages. "When animals were housed with social companions their blood pressures were consistently lower than when they were either housed individually or with social strangers. ... Measurements of cardiovascular physiology obtained under social housing may more closely model normal physiology than ... individual housing."

de Waal FBM 1991. The social nature of primates. In Through the Looking Glass. Issues of Psychological Well-being in Captive Nonhuman Primates Novak MA, Petto AJ (eds), 67-77. American Psychological Association, Washington, DC
"Physiological, immunological, and neurological measures collected on isolation-reared (and hence psychologically deviant) nonhuman primates might not be representative, and therefore might be suboptimal for the development of models applied to the human species. Social housing would avoid that possibility. ... Social deprivation should not be considered any more normal than, say, water or food deprivation."

Gwinn LA 1996. A method for using a pole housing apparatus to establish compatible pairs among squirrel monkeys. Contemporary Topics in Laboratory Animal Science 35(4), 61
"During nine treatments with an identical test compound, singly housed animals lost significantly more weight on average than did pair housed animals."

Jorgensen MJ, Kinsey JH, Novak MA 1998. Risk factors for self-injurious behavior in captive rhesus monkeys *(Macaca mulatta).* American Journal of Primatology 45, 187
"Research has shown that approximately 10% of captive, individually housed monkeys have had some veterinary record of self-injurious behavior within their life-time." The incidence of self-biting was 14% [!] in a test colony of 188 male individually housed rhesus macaques. Self-biting animals had spent more time - starting at an earlier age - in single-cages than controls.

Lilly AA, Mehlman PT, Higley J 1999. Trait-like immunological and hematological measures in female rhesus across varied environmental conditions. American Journal of Primatology 48, 197-223
"Single housing can produce significant, long-term features of immunosuppression. ... Long periods of single caging produced significant increases in plasma prolactin concentrations, indicative of stress-induced anxiety. ... The observation that NE [norepinephrine] was significantly decreased during the latter portions of Single Cage Housing may be further, tentative physiological evidence for the occurrence of depression in these animals. .... As single

caging continued, an increasing percentage of the animals showed withdrawal and depression as witnessed by crouching, huddling, and overall inactivity, clearly indicative of an 'inactive' or 'despair' phase commonly described."

Line SW, Shively CA, Heise ER, Rabin BS, Cohen S 1993. Influence of single caging on cellular immune function in female cynomolgus macaques (*Macaca fascicularis*). American Journal of Primatology 31, 328
Immune responses are affected by housing condition. "These findings suggest that single caging modulates several aspects of cellular immune function in female cynomolgus monkeys."

Luck CP, Keeble SA 1967. African Monkeys. In The UFAW Handbook on the Care and Management of Laboratory Animals Third Edition Universities Federation for Animal Welfare (ed), 734-742. Churchill Livingstone, London, UK
"If housed in a small cage by itself the vervet may become listless and apathic, although it will survive."

Lutz C, Well A, Novak M 2003. Stereotypic and self-injurious behavior in rhesus macaques: A survey and retrospective analysis of environment and early experience. American Journal of Primatology 60, 1-15
"*Behavioral assessments of 362 individually housed rhesus monkeys were collected at the New England Regional Primate Research Center .. and combined with colony records. Of the 362 animals surveyed, 321 [sic] exhibited at least one abnormal behavior (mean: 2.3, range: 1-8).*"

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://books.nap.edu/books/0309052335/html/index.html
"Social interactions are considered to be one of the most important factors influencing the psychological well-being of most nonhuman primates. ... The common practice of housing rhesus monkeys singly calls for special attention. ... Although the causes of self-directed biting are poorly understood, prolonged individual housing is probably an influential contributing factor."

Novak MA, Kinsey JH, Jorgensen MJ, Hazen TJ 1998. Effects of puzzle feeders on pathological behavior in individually housed rhesus monkeys. American Journal of Primatology 46, 213-227
"Self-injurious behavior (SIB) occurs in about 10% of individually housed monkeys. Monkeys with SIB bite their own bodies frequently, occasionally inflicting wounds as a result. ... Of great concern is the development of a severe form of abnormal behavior in which a small [sic] percentage of monkeys (about 5-12%) engage in self-inflicted wounding.

Novak MA 2003. Self-injurious behavior in rhesus monkeys: New insights into its etiology, physiology, and treatment. American Journal of Primatology 59, 3-19
"In our study population, 14% of individually housed monkeys (the vast majority of which are males) have a veterinary record for self-inflicted wounding. Wounding is rare, but self-directed biting is common. SIB can be elicited during aggressive altercations and may be associated with husbandry events. Some monkeys appear to be more vulnerable to acquiring SIB. This increased vulnerability is associated with certain social experiences in the first 2 years of life and with exposure to a larger number of moderately stressful events as compared to controls."

Platt DM, Kinsey JH, Jorgenson MJ, Novak MA 1996. Factors affecting the expression of self-injurious behavior in rhesus monkeys *(Macaca mulatta)*. XVIth Congress of the International Primatological Society/XIXth Conference of the American Society of Primatologists, Abstract No. 768
"Approximately 10% of laboratory housed rhesus monkeys spontaneously develop self-injurious behavior (SIB) such as biting their own bodies with sufficient force to produce tissue damage. ... Monkeys with SIB tended to spend a somewhat greater proportion of their lives in individual cages than controls."

Rosenberg DP, Kesel ML 1994. Old-World monkeys. In The Experimental Animal in Biomedical Research. Volume II Rollin BE, Kesel ML (eds), 457-483. CPR Press, Boca Raton, FL
"Single or individual caging systems are the basic or staple housing used for primates. ... Almost all 'hard' scientific data .. have been acquired from singly caged primates."

Russell C, Russell WMS 1985. Conflict activities in monkeys. Social Biology and Human Affairs 50, 26-48
Isolated monkeys redirect violence against themselves. They "pinch the same patch of their own skin repeatedly until it is raw or even bite and tear themselves."

Schapiro SJ, Nehete PN, Perlman JE, Sastry KJ 2000. A comparison of cell-mediated immune responses in rhesus macaques housed singly, in pairs, or in groups . Applied Animal Behaviour Science 68, 67-84
"Since rhesus monkeys live socially in nature, and the immune responses of singly housed animals differed from those housed socially, there is considerable .. justification for suggesting that the use of singly housed rhesus macaques may complicate interpretations of normal immunological responses."

Shively CA, Clarkson TB, Kaplan JR 1989. Social deprivation and coronary artery atherosclerosis in female cynomolgus monkeys. Atherosclerosis 77, 69-76
"We conclude that these findings indicate that single cage housing promotes coronary artery atherogenesis in these monkeys."

Sokol KA 1993. Commentary: Thinking like a monkey - "primatomorphizing" an environmental enrichment program. Lab Animal 22(5), 40-45
"Solitary confinement is a severe punishment even for monkeys."

Stoinski TS, Czekala N, Lukas KE, Maple TL 2002. Urinary androgen and corticoid levels in captive, male Western lowland gorillas (*Gorilla g. gorilla*): Age- and social group-related differences. American Journal of Primatology 56, 73-87
"Animals housed socially .. had similar corticoid levels, whereas solitary males showed greater corticoid levels than their socially-housed counterparts. The increased levels of corticoids in solitary-housed males suggest this management strategy might not be optimal."

Tiefenbacher S, Fahey MA, Rowlett JK, Meyer JS, Pouliot AL, Jones BM, Novak MA 2005. The efficacy of diazepam treatment for the management of acute wounding episodes in captive rhesus macaques. Comparative Medicine 55, 387-392
"This study examined the effects of diazepam (Valium) on self-wounding and other abnormal behaviors in eight individually housed male rhesus monkeys (Macaca mulatta). Each monkey's response to an anxiolytic dose of diazepam (1 mg/kg or greater orally) was compared with the animal's behavior during drug-free periods. When examined across all animals, treatment with

diazepam did not significantly alter wounding frequency or rates of self-directed biting without wounding. However, closer examination of the data revealed that four of the animals showed significant decreases in self-biting and wounding frequency (positive responders, PR group), whereas the remaining monkeys showed a trend towards increased wounding frequency (negative responders, NR group). Subsequent examination of colony and veterinary records demonstrated that compared with NR monkeys, PR monkeys had spent significantly more years in individual cage housing and had experienced a greater number of minor veterinary procedures."

Yaroshevsky F 1975. Self-mutilation in Soviet prisons. Canadian Psychiatric Association J 20, 443-446
"Isolation "'cages' are so terrible that many prisoners prefer to maim themselves rather than stay there."

(6) Premature Weaning

Goosen C 1988. Influence of age of weaning on the behaviour of rhesus monkeys. Primate Eye 34, 16-17
"The rather early age of weaning of infants as practised in the course of the breeding procedure was an important factor in the induction of stereotyped locomotion and of self-directed infantile behaviour. Both these classes of abnormal behaviour persist into adulthood."

Reinhardt V 2002. Artificial weaning of Old World monkeys: Benefits and costs. Journal of Applied Animal Welfare Science 5, 149-154
http://www.awionline.org/Lab_animals/biblio/jaaws6.html
"The perceived benefits of permanent, pre-weaning mother-infant separation are not supported by scientific findings. ... As long as there is an excessive number of monkeys and insufficient cage space, there is no ethically legitimate reason for attempting to enhance the animals' reproductive output, especially when such measures are not proven to be effective but cause unequivocal psychological distress. ... It is conceivable that maternal-infant separation for the purpose of artificial weaning flaws primate husbandry to the extent of increasing - rather than decreasing - the total number of monkeys needed for research. Thus, artificial weaning is not only an avoidable source of distress but it may also be an economically unsound management practice."

Warniment A, Brent L 1997. Abnormal behavior in a captive chimpanzee colony. The Newsletter 8(3), 1-3
http://www.animalwelfare.com/Lab_animals/biblio/jo-9.htm
"The purpose of this study was to link abnormal behaviors often expressed by chimpanzees living in captive environments to factors related to their care and housing." Individuals who had spent more time with their mothers had less abnormal behavior.

(7) Enforced Restraint

Adams MR, Kaplan JR, Manuck SB, Uberseder B, Larkin KT 1988. Persistent sympathetic nervous system arousal associated with tethering in cynomolgus macaques. Laboratory Animal Science 38, 279-282
"Persistent elevation in heart rate associated with tethering appears to be the result of a persistent influence of the sympathetic nervous system on cardiac function. ... Other organs and systems, e.g., pituitary-gonadal system, also may be affected."

Albrecht ED, Nightingale MS, Townsley JD 1978. Stress-induced decrease in the serum concentration of progesterone in the pregnant baboon. Journal of Endocrinology 77, 425-426
Ketamine infusion did not prevent the reduction in the concentration of progesterone resulting from enforced restraint for blood collection.

Berendt R, Williams TD 1971. The effect of restraint and position upon selected respiratory parameters of two species of *Macaca*. Laboratory Animal Science 21, 502-509
"Restraint significantly affected the tidal volume and respiration rate."

Bouyer JJ, Dedet L, Debray O, Rougenl A 1978. Restraint in primate chair may cause unusual behavior in baboons: Electrocorticographic correlates and corrective effects of diazepam. Electroencephalic Clinical Neurophysiology 44, 562-567
"The prolonged drowsy-like ECoG [electrocorticogram] and behaviour may therefore underline a reaction to the 'stress' conditions brought on by restraint" in primate chair.

Brockway BP, Hassler CR, Hicks N 1993. Minimizing stress during physiological monitoring. In Refinement and Reduction in Animal Testing Niemi SM, Willson JE (eds), 56-69. Scientists Center for Animal Welfare, Greenbelt, MD
"Restraint itself affects the physiological functioning of the animal, measurement error and variability are introduced into the data."

Bush M, Custer R, Smeller J, Bush LM 1977. Physiologic measures of nonhuman primates during physical restraint and chemical immobilization. Journal of the American Veterinary Medical Association 171, 866-869
"Of 56 physically restrained primates, 30 (54%) experienced severe metabolic acidosis. .. The animals had more rapid respiration and pulse rates, higher rectal temperatures, and larger base deficit."

Cope FW, Polis BD 1959. Increased plasma glutamic-oxalacetic transaminase activity in monkeys due to nonspecific stress effect. Journal of Aviation Medicine 30, 90-94
"There can be a rise in SGO-T [serum glutamic-oxalacetic transaminase] in monkeys due to nonspecific stress such a fright, handling or clinical procedures."

Crockett CM, Bowers CL, Sackett GP, Bowden DM 1993. Urinary cortisol responses of longtailed macaques to five cage sizes, tethering, sedation, and room change. American Journal of Primatology 30, 55-74
"Cortisol levels remained ... elevated 2-4 weeks after catheterization. After the catheters were removed, the cortisol levels dropped rapidly although they remained slightly elevated through the recovery phase."

Ferin M, Carmel PW, Warren MP, Himsworth RL, Frantz AG 1976. Phencyclidine sedation as a technique for handling rhesus monkeys: Effects on LH, GH, and prolactin secretion. Proceedings of the Society for Experimental Biology and Medicine 151, 428-433
"These [restraint] monkeys, however, are readily alarmed, and it may be difficult to obtain stable control levels for hormones which are easily influenced by stress."

Fuller. G. B., Hobson WC, Reyes FI, Winter JSD, Faiman C 1984. Influence of restraint and ketamine anesthesia on adrenal steroids, progesterone, and gonadotropins in rhesus monkeys. Proceedings of the Society for Experimental Biology and Medicine 175, 487-490
"Determination of basal circulating hormone levels in nonhuman primates presents a problem since handling or restraint of the animal for venipuncture may introduce sufficient stress to change hormonal secretion. .. Each bleeding was made in conscious [female] monkeys after restraining the animal for 2 to 4 min with the squeeze mechanism of the [home] cage. The arm was manipulated through an opening in the cage mesh and the blood sample taken." Serum cortisol concentrations and adrenal androgens significantly increased from the initial bleeding to the second bleeding after 30 minutes. "Ketamine does not modify the stress-induced increase of either cortisol or adrenal androgens."

Gauquelin-Koch G, Blanquie J-P, Florence G, Milhaud C, Gharib C 1996. Hormonal response to restraint in rhesus monkeys. Journal of Medical Primatology 25, 387-396
"These experiments indicate clearly that placement in a restraining chair represents a stimulus of different systems in monkeys. The responses observed in the present study are predominantly psychoendocrine responses to unconditioned emotional stimuli associated with the chair-restraint situation, despite the fact that they were acclimated to this system."

Golub MS, Anderson JH 1986. Adaptation of pregnant rhesus monkeys to short-term chair restraint. Laboratory Animal Science 36, 507-511
"Heart rate and blood pressure values recorded immediately after the blood sampling [in restraint chair] did not decline with repetition of this procedure."

Goncharov NP, Taranov AG, Antonichev A, Gorlushkin V, Aso T, Ckan S, Diczfalusy E 1979. Effects of stress on the profile of plasma steroids in baboons (*Papio hamadyas*). Acta Endocrinologica 90, 372-384
Restraint stress affects testosterone, progesterone, and oestradiol.

Goosen DJ, Davies JH, Maree M, Dormehl IC 1984. The influence of physical and chemical restraint on the physiology of the chacma baboon (*Papio ursinus*). Journal of Medical Primatology 13, 339-351
Restraint leads to leukocytosis.

Hayashi KT, Moberg GP 1987. Influence of acute stress and the adrenal axis on regulation of LH and testosterone in the male rhesus monkey (*Macaca mulatta*). American Journal of Primatology 12, 263-273
"Acute restraint stress appears to cause the transient stimulation of LH release. ... While the stress-stimulated release of corticosteroids failed to affect the LH response to GnRH administration, it did act directly on the testes to prevent the normal release of testosterone."

Ives M, Dack GM 1956. "Alarm reaction" and normal blood picture in *Macaca mulatta*. Journal of Laboratory Clinical Medicine 47, 723-729
Authors observed an elevated White Blood Cell Count as "alarm reaction" to physical restraint.

Kaplan JR, Adam MR, Bumsted P 1983. Heart rate changes associated with tethering of cynomolgus monkeys. Laboratory Animal Science 38, 493 (Abstract)
"The results suggest that some amount of cardiovascular (and perhaps hormonal) disturbance may persist in tethered animals, even if several weeks are allowed for 'habituation'."

Landi MS, Kissinger JT, Campbell SA, Kenney CA, Jenkins EL 1990. The effects of four types of restraint on serum alanine aminotransferase and asparate aminotransferase in the *Macaca fascicularis*. Journal of the American College of Toxicology 9, 517-523
"All methods of restraint resulted in elevation in AST and ALT over time."

Line SW, Markowitz H, Morgan KN, Strong S 1991. Effect of cage size and environmental enrichment on behavioral and physiological responses of rhesus macaques to the stress of daily events. In Through the Looking Glass Novak MA, Petto AJ (eds), 160-179. American Psychological Association, Washington, DC
"Restraint with the cage-squeeze mechanism and confinement in a transfer box were both associated with significant increases in plasma cortisol. ... Repeated exposure to brief restraint did not lead to habituation of the heart-rate response."

Loomis MR, Henrickson RV, Anderson JH 1980. Effects of ketamine hydrochloride on the hemogram of rhesus monkeys (*Macaca mulatta*). Laboratory Animal Science 30, 851-853
"Restraining a monkey in its cage represents a stressful situation which may result in a physiological leukocytosis and hemoconcentration in the sample collected."

Manning PJ, Lehner NDM, Feldner MA, Bullock BC 1969. Selected hematologic, serum chemical, and arterial blood gas characteristics of squirrel monkeys *(Saimiri sciureus)*. Laboratory Animal Care 19, 831-837
Catching and restraint procedures resulted in respiratory alkalosis and metabolic acidosis. Sedation reduced, but did not eliminate this stress response.

Mason JW 1972. Corticosteroid response to chair restraint in the monkey. American Journal of Physiology 222, 1291-1294
"These experiments indicate clearly that placement in the restraining chair represents a potent stimulus to the pituitary-adrenal cortical system."

Mason JW, Mougey EH 1972. Thyroid (plasma BEI) response to chair restraint in the monkey. Psychosomatic Medicine 34, 441-448
"Study of 14 of these monkeys throughout a longer period of 8 weeks of chair restraint indicated that ... mean BEI levels remained significantly elevated through the third week. ... Acute emotional arousal [enforced restraint] elicits stimulation of the pituitary-thyroid system in the rhesus monkey."

Mason JW, Wool MS, Wherry FE, Pennington LL, Brady JV, Beer B 1968. Plasma growth hormone response to avoidance in the monkey. Psychosomatic Medicine 30, 760-773
The "psychological response to the venipuncture procedure ['forcibly restrained on rubber mattress in order to perform venipuncture'] may be a major determinant of 'baseline' variability in growth hormone levels. The liability of this system appears to be such that venipuncture effects may occur within the period of a few minutes required for a single venipuncture."

McNamee GA, Wannemacher RW, Dinterman RE, Rozmiarek H, Montrey RD 1984. A surgical procedure and tethering system for chronic blood sampling, infusion, and temperature monitoring in caged nonhuman primates. Laboratory Animal Science 34, 303-307
"The stress of chairing the monkeys may result in a significant decrease in hemoglobin, hematocrit, and lymphocyte concentration with an accompanying neutrophilia. In addition, chair-restrained monkeys tend to develop lower leg edema and decubital ulcers on long-term studies."

Morrow-Tesch JL, McGlone JJ, Norman RL 1993. Consequences of restraint stress on natural killer cell activity, behavior, and hormone levels in rhesus macaques (*Macaca mulatta*). Psychoendocrinology 18, 383-395
Animals were chair restrained and samples taken after 1, 2 and 3 hours. "WBC and the percentage of neutrophils increased during the restraint period, while the percent lymphocytes and monocytes decreased. NK [natural killer cell] activity also decreased over time after restraint whereas plasma cortisol and ß-endorphin levels increased significantly."

Morton WR, Knitter GH, Smith PM, Susor TG, Schmit K 1987. Alternatives to chronic restraint of nonhuman primates. Journal of the American Veterinary Medical Association 191, 1282-1286
"Despite attention to details of conditioning and daily assessments of the animals' health status, chronic chair restraint is accompanied by inherent problems such as skin abrasions, necrosis of the ischial callosities, position-dependent edema, inguinal hernia, rectal prolapse, and laryngeal air sacculitis."

Myers BA, Mendoza SP, Cornelius CE 1988. Elevation of plasma glucagon levels in response to stress in squirrel monkeys: Comparison of two subspecies (*Saimiri sciureus boliviensis* and *Saimiri sciureus sciureus*). Journal of Medical Primatology 17, 205-214
Enforced restraint leads to an elevation of plasma glucagon levels.

Nakamura RK, Coates R, Crawford H, Friedman D 1982. A flexible restraint chair for the cynomolgus monkey *(Macaca fascicularis)*. Journal of Medical Primatology 11, 178-185
"There is a general consensus that restraint chairs should be used only where necessary, since they inherently cause monkeys physical and emotional stress." Authors found "that the animals showed restless sleeping patterns which persisted despite our attempts to adapt the animals to the chairs slowly. It was soon evident that the restlessness resulted from the rapid development of chafing ta the neck, a breakdown of tissue in the ischial pads, and lesions at the base of the tail."

Norman RL, McGlone J, Smith CJ 1994. Restraint inhibits luteinizing hormone secretion in the follicular phase of the menstrual cycle in rhesus macaques. Biology of Reproduction 50, 16-26
Chair restraint affects LH and ACTH in rhesus macaques.

Norman RL, Smith CJ 1992. Restraint inhibits luteinizing hormone and testosterone secretion in intact male rhesus macaques: Effects of concurrent naloxone administration. Neuroendocrinology 55, 405-415
Enforced restraint inhibits luteinizing hormone and testosterone secretion.

Puri CP, Puri V, Anand-Kumar TC 1981. Serum levels of testosterone, cortisol, prolactin and bioactive luteinizing hormone in adult male rhesus monkeys following cage-restraint or anaesthetizing with ketamine hydrochloride. Acta Endocrinologica 97, 118-124
Single-housed, adult male rhesus macaques were restrained in their home cages for blood collection at 20 minute intervals. While testosterone levels significantly declined, serum cortisol concentrations significantly increased over a one-hour sampling period.

Quadri SK, Pierson C, Spies HP 1978. Effects of centrally acting drugs on serum levels in rhesus monkeys. Neuroendocrinology 27, 136-147
Immobilization on restraint cross induced progressive increase in prolactin concentration.

Rabot S, Fisco M, Martin F, Blanquie JP, Popot F, Bensaada M, Vaissade P, Searby N, Szylit O 1997. Effects of chair-restraint on gastrointestinal transit time and colonic fermentation in male rhesus monkey (*Macaca mulatta*). Journal of Medical Primatology 26, 190-195
"Chair-restraint induced a 2.5-fold acceleration of the gastrointestinal transit time, which persisted throughout the 7 day postrestraint period, and an increase of the fecal dry matter content. "

Reinhardt V, Liss C, Stevens C 1995. Restraint methods of laboratory nonhuman primates: A critical review. Animal Welfare 4, 221-238
http://www.awionline.org/Lab_animals/biblio/aw6metho.htm
"Published information provides scientific evidence that traditional, involuntary restraint techniques of research non-human primates are intrinsically a source of distress resulting from fear."

Schnell CR, Wood JM 1993. Measurement of blood pressure, heart rate, body temperature, ECG and activity by telemetry in conscious unrestrained marmosets. Proceedings of the 5th Federation of European Laboratory Animal Science Association Symposium, 107-111
Restraining well habituated marmosets by hand significantly increased heart rate and blood pressure even after the animals were returned to their home cages.

Todd HE, Shideler SE, Laughlin LS, Overstreet JW, Pohl CR, Byrd W, Lasley BL 1999. Application of an enzyme immunoassay for urinary follicle-stimulating hormone to describe the effects of an acute stressor at different stages of the menstrual cycle in female laboratory macaques. American Journal of Primatology 48, 135-151
Capture and restraint "occurring during the luteal-follicular transition not only resulted in acute perturbations of FSH but also led to abnormalities in the subsequent menstrual cycle in 50% of the cases."

Torii R, Kitagawa N, Nigi H, Ohsawa N 1993. Effects of repeated restraint stress at 30-minute intervals during 24-hours on serum testosterone, LH and glucocorticoids levels in male Japanese monkeys (*Macaca fuscata*). Experimental Animal 42, 67-73
"30-min intervals sampling [using "compulsory restraint"] serum testosterone levels decreased and glucocorticoid levels increased, respectively, immediately after the start of blood sampling."

Verlangieri AJ, De Priest JC, Kapeghian JC 1985. Normal serum biochemical, hematological, and EKG parameters in anesthetized adult male *Macaca fascicularis* and *Macaca arctoides*. Laboratory Animal Science 35, 63-66
Author underscores undesirable variations in serum biochemical and hematological parameters in macaques and suggests that incongruities between values presented in different reports may be due to a variety of factors including the method of restraint during handling procedures.

Wheeler MD, Schutzengel RE, Barry S, Styne DM 1990. Changes in basal and stimulated growth hormone secretion in the aging rhesus monkeys: A comparison of chair restraint and tether and vest sampling. Journal of Clinical Endocrinology and Metabolism 71, 1501-1507
Animals who "were adapted to chair restraint" appeared calm, but they showed consistently higher cortisol levels than "free moving" tethered animals.

Yasuda M, Wolff J, Howard CF 1988. Effects of physical and chemical restraint on intravenous glucose tolerance test in crested black macaques (*Macaca nigra*). American Journal of Primatology 15, 171-180
Restrained monkeys "appeared relaxed, but glucose clearance and insulin secretion were impaired" and cortisol values increased.

(8) Queue Effect, Sequential Treatment

Fox MW 1986. Laboratory Animal Husbandry: Ethology, Welfare and Experimental Variables. State University of New York Press, Albany, NY
"The 'queue' effect of treating animals sequentially is an often overlooked experimental variable."

Flow BL, Jaques JT 1997. Effect of room arrangement and blood sample collection sequence on serum thyroid hormone and cortisol concentrations in cynomolgus macaques (*Macaca fascicularis*). Contemporary Topics in Laboratory Animal Science 36(1), 65-68
Sequence of blood collection [as determined by room arrangement] affected serum cortisol and thyroxine levels.

(9) Unfamiliar Environment

Crockett CM, Bowers CL, Shimoji M, Leu M, Bellanca RU, Bowden DM 1993. Appetite and urinary cortisol responses to different cage sizes in female pigtailed macaques. American Journal of Primatology 31, 305
"Appetite during the first three days in the new room was moderately suppressed."

Crockett CM, Bowers CL, Shimoji M, Leu M, Bowden DM, Sackett GP 1995. Behavioral responses of longtailed macaques to different cage sizes and common laboratory experiences. Journal of Comparative Psychology 109, 368-383
Monkeys who were moved to a new room and to a lesser extent to a new, clean cage showed "disrupted sleep the 1st night and suppressed activity, especially self-grooming, the next day."

Davenport MD, Lutz CK, Tiefenbacher S, Novak MA, Meyer JS 2007. A rhesus monkey model of self-injury: Effects of relocation stress on behavior and neuroendocrine function. Biological Psychiatry, in press
"Twenty adult male rhesus macaques were exposed to the stress of relocation to a new housing arrangement in a newly constructed facility. .. Our results indicate that relocation is a significant stressor for rhesus macaques and that this stressor triggers an increase in self-biting behavior as well as sleep disturbance in monkeys previously identified as suffering from SIB."

Herndon JG, Turner JJ, Perachio AA, Blank MS, Collins DC 1984. Endocrine changes induced by venipuncture in rhesus monkeys. Physiology and Behavior 32, 673-676
Blood collection in a transport box resulted in elevated GH and cortisol values. "The present data suggest that such responses may complicate interpretation of GH and cortisol measurements derived from samples collected by venipuncture."

Lindburg DG, Coe J 1995. Ark design update: Primate needs and requirements. In Conservation of Endangered Species in Captivity Gibbons E, Durrant B, Demarest A (eds), 553-570. SUNY Press, Albany
"Wherever possible, every effort should be made to design in ways that bring the treatment to the animal, instead of the reverse. Removal for any purpose exposes the animal to overly novel, frequently noxious, and always stressful, stimuli."

Line SW, Clarke AS, Markowitz H 1987. Plasma cortisol of female rhesus monkeys in response to acute restraint. Laboratory Primate Newsletter 26(4), 1-3
http://www.brown.edu/Research/Primate/lpn26-4.html#line
"Confinement in a transfer box was a significant event, as measured by cortisol response, even though this condition was presumably intrinsically less stressful than manual restraint. .. Novelty alone can be a significant source of stress for laboratory primates."

Line SW, Morgan KN, Markowitz H, Strong S 1989. Heart rate and activity of rhesus monkeys in response to routine events. Laboratory Primate Newsletter 28(2), 9-12
http://www.brown.edu/Research/Primate/lpn28-2.html#line
Adult female rhesus macaques responded with a significant, protracted increase in heart rate to being placed in transfer boxes while their dirty cages were replaced with clean ones. "The mean heart rate remained elevated for two hours after completion of the procedure.... These observations are important to note if one is to avoid confounding the physiological and behavioral effects of experimental manipulations with those induced by routine husbandry."

Line SW, Markowitz H, Morgan KN, Strong S 1991. Effect of cage size and environmental enrichment on behavioral and physiological responses of rhesus macaques to the stress of daily events. In Through the Looking Glass Novak MA, Petto AJ (eds), 160-179. American Psychological Association, Washington, DC

Adult, single-housed female rhesus macaques responded with a significant rise in heart rate to being removed from their home cage and replaced after the cage had been cleaned. "Once the cage change was completed and the technicians left the room, it was several hours before heart rates returned to the expected level."

Mason JW 1972. Corticosteroid response to chair restraint in the monkey. American Journal of Physiology 222, 1291-1294
Animals who were restrained in an unfamiliar environment showed significantly higher urinary cortisol levels than animals who were familiar with the environment in which they were restrained.

Mason JW, Mougey EH, Kenion CC 1973. Urinary epinephrine and norepinephrine responses to chair restraint in the monkey. Physiology and Behaviour 10, 801-803
Animals who were restrained in an unfamiliar environment showed significantly higher urinary catecholamine levels than animals who were familiar with the environment in which they were restrained.

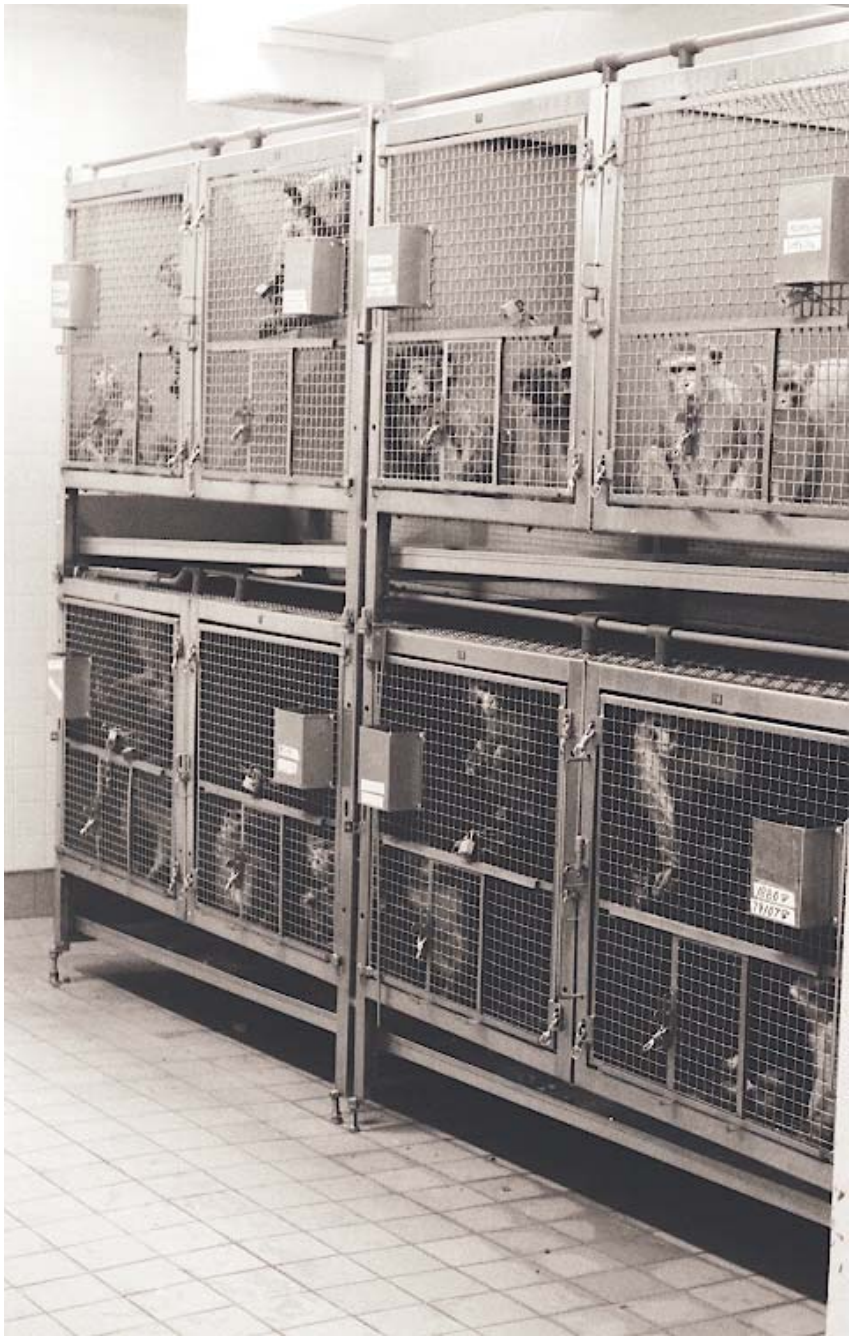
Mitchell G, Gomber J 1976. Moving laboratory rhesus monkeys *(Macaca mulatta)* to unfamiliar home cages. Primates 17, 543-547
"The results of this study should serve as a warning to those who wish to observe behavior or take physiological measurements on monkeys. Removing an animal from its home cage prior to monitoring anything biological will probably affect the event being monitored. Behavioral and almost certainly physiological distress occur following removal from the home cage."

Phoenix CH, Chambers KC 1984. Sexual behavior and serum hormone levels in aging rhesus males: Effects of environmental change. Hormones and Behavior 18, 206-215
"Cortisol levels [of single-housed subjects] were significantly higher immediately [one hour] after the move [to another cage in a nearby building] than they were on the first day of bleeding before the move."

Reinhardt V, Cowley D, Eisele S, Scheffler J 1991. Avoiding undue cortisol responses to venipuncture in adult male rhesus macaques. Animal Technology 42, 83-86
http://www.awionline.org/Lab_animals/biblio/at83.htm
Six adult rhesus males were: a) habituated to actively cooperate during venipuncture away from the homecage in a treatment squeeze cage, and b) trained to actively cooperate during venipuncture in the homecage. The magnitude of cortisol increase was significant when the males were venipunctured in the hallways but not when they were venipunctured in the homecage. "It was concluded that venipuncture per se was not a physiologically distressing event. It became distressing only when it was associated with a temporary removal from the homecage."

Schapiro SJ, Nehete PN, Perlman JE, Sastry KJ 1997. A change in housing condition leads to relatively long-term changes in cell-mediated immune responses in adult rhesus macaques. American Journal of Primatology 42, 146
"A change in housing condition results in changes in immune responses, even after subjects had spent up to eight months in the new housing and regardless of whether the change was to solitary or pair housing."

(10) Double-tier Cage Arrangement



Baskerville M 1999. Old World Monkeys. In The UFAW [Universities Federation for Animal Welfare] Handbook on the Care and Management of Laboratory Animals Seventh Edition Poole T, English P (eds), 611-635. Blackwell Science, Oxford, UK
"Captive primates like to move upwards and look down on unfamiliar humans, and ideally the cage height should allow this. Two tier caging should be avoided."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 9.5. Multi-Tier Caging. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/variables.html#multi-tier

"In a quantitative study I did on 20 pair-housed cynos, the animals spent 94 percent of their waking time in the upper part of the vertically arranged double cage. All food was given in the bottom section, yet the animals would bring the food to the upper part and consume it there. The monkeys preference along the gradient of height was unequivocal!

I observed squirrel monkeys in vertically arranged double cages and also found that the animals clearly preferred the upper half of their cages. The only time they went to the bottom half was when they retrieved a toy or picked through the bedding for treats.

When visiting facilities that have their pair-housed macaques kept in vertically arranged double-cages, I repeatedly got the impression that subordinate partners are disadvantaged in this caging system, with dominant animals preventing subordinates from spending as much time in the upper section as they would like to."

Box HO, Rohrhuber B 1993. Differences in behaviour among adult male, female pairs of cotton-top tamarins in different conditions of housing. Animal Technology 44, 19-30
http://www.awionline.org/Lab_animals/biblio/at-box.htm
Animals living in upper-row cages were more active and engaged in more close contact amicable behavior than animals living in lower-row cages.

Clough G 1982. Environmental effects on animals used in biomedical research. Biological Reviews 57, 487-523
"The intensity of light in animal cages is likely to be the most variable environmental factor in the average animal room."

European Commission 2002. The Welfare of Non-human Primates - Report of the Scientific Committe on Animal Health and Animal Welfare. European Commission, Strasbourg, France
http://europa.eu.int/comm/food/fs/sc/scah/out83_en.pdf
"Primates should not be placed in double-tiered caging unless the arrangement permits adequate vertical movement for the animal."

Heger W, Merker H-J, Neubert D 1986. Low light intensity decreases the fertility of *Callithrix jacchus*. Primate Report 14, 260
http://www.awionline.org/Lab_animals/biblio/pr14-2.htm
"Improvement of the light fixtures in both rooms doubled the lighting force and increased the breeding rate during the following 12 months approximately 20% in the upper and 130% in the lower cages."

European Commission 2002. The Welfare of Non-human Primates - Report of the Scientific Committee on Animal Health and Animal Welfare. European Commission, Strasbourg, France
"Primates should not be placed in double-tiered caging unless the arrangement permits adequate vertical movement for the animal."

Mahoney CJ 1992. Some thoughts on psychological enrichment. Lab Animal 21(5), 27,29,32-37
"The sanitation tray, which runs the length of the room beneath the upper tier of cages, reduces significantly the amount of light from ceiling-mounted fixtures that can penetrate to the lower cage tier; animals in the lower tier are thus relegated to a permanent state of semi-gloom."

Mulder JB 1976. Behavior patterns of laboratory animals. Lab Animal 5(5), 22-28
"Placing of the cage on a rack even further reduces the available light. During experimentation, care must be exercised to use cages of the ... same placement to avoid variations in lighting. If this is not done, the investigator may be measuring behavioral rather than experimental results."

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://books.nap.edu/books/0309052335/html/index.html
“Wild marmosets and tamarins only occasionally descent to the ground and in captivity prefer to be above caregiving personnel. Therefore, it is advisable not to house these primates in two-tier cages. ... Under natural conditions, many primates spend much of their lives aboveground and escape upward to avoid terrestrial threats. Therefore, these animals might perceive the presence of humans above them as particularly threatening. ... Even macaques, which some describe as semiterrestrial, spend most of the day in elevated locations and seek the refuge of trees at night.”

Reinhardt V 1989. Evaluation of the long-term effectiveness of two environmental enrichment objects for singly caged rhesus macaques. Lab Animal 18(6), 31-33
http://www.awionline.org/Lab_animals/biblio/la-eval.htm
"The proportion of time spent with the pipes was three times greater for animals living in lower-row cages than for animals living in upper-row cages. ... In the elevated position, the light exposure was increased, a fact that made the pipes of particular value for the lower-row cages animals."

Reinhardt V, Reinhardt A 1999. The monkey cave: The dark lower-row cage. Laboratory Primate Newsletter 38(3), 8-9
http://www.brown.edu/Research/Primate/lpn38-3.html#cave
"The typical lower-row cage provides a cave-like housing environment which may impair well-being, invalidate research data, and undermine good housekeeping."

Reinhardt V, Reinhardt A 2000. The lower row monkey cage: An overlooked variable in biomedical research. Journal of Applied Animal Welfare Science 3, 141-149
http://www.awionline.org/Lab_animals/biblio/jaaws1.htm
"A survey of 96 primatological articles revealed that cage location of research monkeys is usually not mentioned (98%), in spite of the fact that the environment of upper- and lower-row housed animals markedly differs in terms of light quality, light intensity and living dimension. Not accounting for these uncontrolled variables may increase variability of data and, consequently, the number of experimental animals needed to obtain statistically acceptable results."

Ross PW, Everitt JI 1988. A nylon ball device for primate environmental enrichment. Laboratory Animal Science 38(4), 481-483
"We feel that macaques fare better when they are housed in cages on the upper tier or racks. This may relate to better interactions with the animal care technicians when they are housed in this position."

Schapiro SJ, Stavisky R, Hook M 2000. The lower-row cage may be dark, but behaviour does not appear to be affected. Laboratory Primate Newsletter 39(1), 4-6
http://www.brown.edu/Research/Primate/lpn39-1.html#dark
The situation of 3 upper-row single-caged females was compared with that of 6 lower-row single-caged females under undisturbed conditions... Mean light levels at nine different positions within the cage were significantly lower in bottom-row cages than in upper-row cages. "Less than 8% of light readings in lower-row cages were higher than the lowest light level readings at the same position in the upper-row cages. .... There were no statistically significant differences

in behavior." The mean percent time spent in abnormal behavior was 0.7 for upper-row caged subjects versus 1.6 for lower-row caged subjects.

Schapiro SJ, Bloomsmith M 2001. Lower-row caging in a two-tiered housing system does not affect the behaviour of young, singly housed rhesus macaques. Animal Welfare 10, 387-394
"Although lower-row cages are significantly darker than upper-row cages at our facility, the data from the present study demonstrate that the diminished lighting and other supposed disadvantages experienced by lower-row-housed monkeys have few behavioural consequences" [under undisturbed conditions].

Seier JV, Loza J, Benjamin L 2004. Housing and stereotyped behaviour: Some observations from an indoor colony of vervet monkeys (*Chlorocebus aethiops*). Folia Primatologica 75(Supplement 1), 332 (Abstract)
"Both sexes housed in the upper rows spent less time engaging in stereotyped behaviour."

Shimoji M, Bowers CL, Crockett CM 1993. Initial response to introduction of a PVC perch by singly caged *Macaca fascicularis*. Laboratory Primate Newsletter 32(4), 8-11
http://www.brown.edu/Research/Primate/lpn32-4.html#pvc
Single-housed "monkeys spent significantly more time clinging to the cage wall ("suspended") in the absence of the perch. ... Monkeys in lower level cages averaged somewhat more time on the perch than those in upper cages."

Shively CA 2001. Psychological well-being of laboratory primates at Oregon Regional Primate Research Center. Web site link in Willamette Week, March 21, 2001
http://www.wweek.com/html2/shivreport.html
"We have observed lower body weights in animals housed in lower tier cages."

Woodbeck T, Reinhardt V 1991. Perch use by *Macaca mulatta* in relation to cage location. Laboratory Primate Newsletter 30(4), 11-12
http://www.brown.edu/Research/Primate/lpn30-4.html#perch
Single-housed "animals living in lower-row cages spent an average of 31.6% of the time perching on their pipes while animals living in upper-row cages perched only 6.9% of the time. Access to the vertical dimension of the cage was more important for the lower-row caged monkeys who continuously live close to the ground, in the horizontal dimension of the room."

(11) Neighbor Effect

Aureli F, Seres M, Whitten PL, de Waal FB 2001. Living conditions affect stress levels of captive chimpanzees. American Journal of Primatology 54(Supplement), 67-68 (Abstract)
"Stress levels in captive chimpanzees are not affected by population density per se (chimpanzees use behavioural coping strategies), but when coupled with high Neighbor Effect stress levels increase. If many groups need to live in close proximity, it is better to house chimpanzees in large compounds."

Baker KC, Aureli F 1996. The neighbor effect: Other groups influence intragroup agonistic behavior in captive chimpanzees. American Journal of Primatology 40, 283-291
Hearing the vocalizations of neighboring groups increased the likelihood of intragroup fighting. "It may be indicated to construct corrals at a distance from each other to avoid this undesirable neighbor effect."

Coe CL 1991. Is social housing of primates always the optimal choice? In Through the Looking Glass Novak MA, Petto AJ (eds), 78-92. American Psychological Association, Washington, DC
"Introduction of female subjects into the housing area had a significant effect on other physiological systems, including the immune systems, of these male pairs. For example, both dominant and subordinate males showed a month-long decline in the natural killer-cell activity following the psychological stimulation evoked by housing two females in cages adjacent to the cages of the male pairs."

Kurth B, Bryant D 1998. Pairing female *Macaca fascicularis*. Laboratory Primate Newsletter 37(4), 3
http://www.brown.edu/Research/Primate/lpn37-4.html#kurth
Twenty-nine previously single-caged adult female long-tailed macaques were paired with each other in vertical, double-cage configuration. "Neighboring pairs were often charging each other across the grid panel. ... To avoid this, pairs were transferred to a horizontal configuration after the first month."

Lipman NS 1992. Large colonies vs. small colonies. In Implementation Strategies for Research Animal Well-Being: Institutional Compliance with Regulations Krulisch L (ed), 145-150. Scientist Center for Animal Welfare and WARDS, Bethesda, MD
"It is important to recognize that visual contact between incompatible conspecifics can lead to problems such as anorexia and stereotypic behavior. Therefore our caregivers and veterinary staff pay close attention to the cage arrangement [of the single-caged animals] within each room".

Wallis J, King BJ 1986. The effect of female proximity and social interaction on the menstrual cycle of crab-eating monkeys (*Macaca fascicularis*). Primates 27(1), 83-94
"Close physical contact and social interaction between female crab-eating monkeys affects the reproductive cycle: females with a history of irregular and/or unusually long cycles began exhibiting more normal cycling patterns when placed in proximity to a regularly cycling female. Irregular controls continued to show cycles that were abnormally long."

(12) Observer Effect, Presence of Personnel

Boinski S, Gross TS, Davis JK 1999. Terrestrial predator alarm vocalizations are a valid monitor of stress in captive brown capuchins *(Cebus apella)*. Zoo Biology 18, 295-312
"We have most commonly ... documented TPAs [terrestrial predator alarms] being produced in association with the entrance into or presence of humans in colony rooms. Most predictably those humans are research technicians associated with manipulative research projects involving the capuchins. ... Mean TPA production was correlated to fecal cortisol and behavioral disorders."

Bowers CL, Crockett CM, Bowden DM 1998. Differences in stress reactivity of laboratory macaques measured by heart period and respiratory sinus arrhythmia. American Journal of Primatology 45, 245-261
"Exposure to an unfamiliar technician with capture gloves stimulated cardiac reactivity more strongly than an intense sound. ... Behavior responses to the glove indicated that all subjects consistently perceived this 'ecologically relevant' stimulus as threatening."

Line SW, Morgan KN, Markowitz H, Strong S 1989. Heart rate and activity of rhesus monkeys in response to routine events. Laboratory Primate Newsletter 28(2), 9-12
http://www.brown.edu/Research/Primate/lpn28-2.html#line
“Variations in heart rate and activity are closely associated with human activity in the room."

Line SW 1995. Effects of observation technique on the behavior of adult rhesus macaques. Contemporary Topics in Laboratory Animal Science 34, 61-65
"During videotaped sessions, movement was higher in frequency and duration, while aggressive behavior was lower" and stereotyped locomotion higher in frequency than during direct live observations.

Malinow MR, Hill JD, Ochsner AJ 1974. Heart rate in caged rhesus monkeys *(Macaca mulatta)*. Laboratory Animal Science 24, 537-540
“The rapid increase of 80 beats/min recorded when someone entered the room and tapped the cages is most probably related to the action of the autonomic nervous system and may explain the high heart rates reported in most studies of restrained or anesthetized monkeys. Thus, when the results of cardiovascular studies in rhesus monkeys are interpreted, the variables introduced by the sympathetic or parasympathetic nerves should be considered."

Manuck SB, Kaplan JR, Clarkson TB 1983. Behavioral induced heart rate reactivity and atherosclerosis in cynomolgus monkeys. Psychosomatic Medicine 45, 95-108
The presence of the experimenter [without glove!] dramatically increased heart rate in about 50% of animals studied.

Reinhardt V 1997. Refining the traditional housing and handling of laboratory rhesus macaques improves scientific methodology. Primate Report 49, 93-112
http://www.awionline.org/Lab_animals/biblio/pr-refi.htm
“The macho-type person is out of place in the animal room because s/he triggers stress or even distress reactions. Typically, the animal will freak out and hide in a back corner of the cage when such a person comes into their room."

Reinhardt V 1999. Pair-housing overcomes self-biting behavior in macaques. Laboratory Primate Newsletter 38(1), 4
http://www.brown.edu/Research/Primate/lpn38-1.html#pair
Seven single-caged subjects exhibited self-biting behavior predictably in the presence of personnel.

Schnell CR, Wood JM 1993. Measurement of blood pressure, heart rate, body temperature, ECG and activity by telemetry in conscious unrestrained marmosets. Proceedings of the 5th Federation of European Laboratory Animal Science Association Symposium, 107-111
"After event A [presence of a person], we observed a twofold increase in activity and a marked increase in CT [temperature], MAP [blood pressure] and HR [heart rate]."

Schnell CR, Wood JM 1993. Measurement of blood pressure and heart rate by telemetry in conscious, unrestrained marmosets. American Journal of Physiology 264, H1509-1516
During the weekend, daytime values of heart rate and blood pressure were significantly lower, and motor activity was higher. "The higher motor activity suggests greater social interactions when the marmosets are undisturbed. The lower MAP [blood pressure] and HR [heart rate] suggest that the animals may be less anxious and feel better in this situation."

Tatoyan SK, Cherkovich GM 1972. The heart rate in monkeys (Baboons and Macaques) in different physiological states recorded by radiotelemetry. Folia Primatologica 17, 255-266
"In the presence of man the heart rate is always increased, in spite of the fact that the monkeys appear to be calm."

Tinklepaugh OL 1928. The self-mutilation of a male *Macacus rhesus* monkey. Journal of Mammalogy 9, 293-300
A drastic case of observer-induced self-biting of a male rhesus macaques is described.

(13) Noise

Baldwin AL, Schwartz GE, Hopp DH 2007. Are investigators aware of environmental noise in animal facilities and that this noise may affect experimental data? Journal of the American Association for Laboratory Animal Science [Contemporary Topics in Laboratory Animal Science] 46(1), 45-51
"Because faculty are the least aware of noise as a potential problem but are primarily responsible for designing experiments, research involving animals may be confounded by noise as an unknown variable. This effect may lead to unnecessary numbers of animals being required to achieve statistical significance and possibly to erroneous interpretation of results. On the basis of the findings of this survey, we present recommendations for improving the environment, particularly for decreasing the noise level, in animal facilities."

Patterson-Kane EG, Farnworth MJ 2006. Noise exposure, music, and animals in the laboratory: A commentary based on Laboratory Animal Refinement and Enrichment Forum (LAREF) discussions. Journal of Applied Animal Welfare Science 9, 327-332
"Evidence supports the use of quiet music during nonhuman animals' activity periods, if this practice is introduced with an awareness of the risks to welfare and research."

Pines MK, Kaplan G, Rogers LJ 2004. Stressors of common marmosets (*Callithrix jacchus*) in the captive environment: Effects on behaviour and cortisol levels. Folia Primatologica 75(Supplement), 317-318 (Abstract)
Salivary cortisol samples, collected using a cotton bud with banana on the tip, doubled following 30 minutes of exposure to playing radio (70-80 dB) or loud construction work (70-80 dB). Despite being sheltered from rain while outdoors, the marmosets moved indoors voluntarily when it was raining. "There was no change in cortisol levels following the non-traumatic death of a cage/room mate, however, cortisol levels doubled (and remained elevated for at least five days) following the accidental injury and death of a cage/room mate in the absence of any other disturbing event. Involvement of room-mates in non-invasive experiments was also stressful, with cortisol levels doubling. Activity levels and time spent on the floor of the cage decreases, but there was no change in other stress-indicative behaviours. It would seem that the marmosets might be using a passive coping technique to deal with stressors over which they have no control. The results suggest that marmosets are negatively affected by noise and any kind of event adversely affecting a room-mate."

Refinement

(1) Definition

Refinement is the attempt to enhance animal welfare and control extraneous variables that may increase research data variability.

Russell WMS, Burch RL 1959. The Principles of Humane Experimental Technique. Methuen, London
http://altweb.jhsph.edu/publications/humane_exp/het-toc.htm
"Refinement means any decrease in the incidence or severity of inhumane procedures applied to those animals which still have to be used."

(2,a) Unstructured Space

Bayne K, McCully C 1989. The effect of cage size on the behavior of individually housed rhesus monkeys. Lab Animal 18(1), 25-28
A moderate increase of unstructured cage space does not affect stereotypical behaviors in individually caged rhesus macaques.

Boot R, Leussink AB, Vlug RF 1985. Influence of housing conditions on pregnancy outcome in cynomolgus monkeys (*Macaca fascicularis*). Laboratory Animal Science 19, 42-47
More successful pregnancies were recorded for females housed individually in large cages than for females housed in small cages.

Brent L 1992. The effects of cage size and pair housing on the behavior of captive chimpanzees. American Journal of Primatology 27, 20
"Environmental manipulation was higher and inactivity lower in the [furnished] large single cage than in the [furnished] small single cage. The mean abnormal behaviors decreased in the larger cages but the difference was not significant."

Crockett CM, Shimoji M, Bowden DM 2000. Behavior, appetite, and urinary cortisol responses by adult female pigtailed macaques to cage size, cage level, room change, and ketamine sedation. American Journal of Primatology 52, 63-80
A moderate increase of unstructured cage space does not affect abnormal behaviors in individually caged pig-tailed macaques.

Daschbach NJ, Schein MW, Haines DE 1983. Cage-size effect on locomotor, grooming and agonistic behaviors of the slow loris (*Nycticebus coucang*). Applied Animal Ethology 9, 317-330
"Results of the experiments in this study indicate that slow lorises kept in larger [furnished] cages will be more active than those housed in [furnished] cages approaching recommendations for size proposed by the U.S. National Research Council."

Kitchen AM, Martin AA 1996. The effects of cage size and complexity on the behaviour of captive common marmosets, *Callithrix jacchus jacchus*. Laboratory Animals 30, 317-326
"Stereotyped behaviours, which occurred in the small [furnished] cages, were never exhibited in the large [furnished] cages. We conclude that the welfare of captive marmosets is enhanced by the provision of larger and more complex cages."

Line SW, Morgan KN, Markowitz H, Strong S 1990. Increased cage size does not alter heart rate or behavior in female rhesus monkeys. American Journal of Primatology 20, 107-113
A moderate increase of the dimensions of standard cages that lack any structures for climbing, perching, swinging or other activities does not affect the behavior of individually caged rhesus macaques.

Mallapur A, Waran N, Sinha A 2005. Use of enclosure space by captive lion-tailed macaques (*Macaca silenus*) housed in Indian zoos. Journal of Applied Animal Welfare Science 8, 175-185
"Captive lion-tailed macaques used the edge zone — the space closest to the visitor areas — when their ... environments were deficient in appropriate environmental stimuli."

Paulk HH, Dienske H, Ribbens LG 1977. Abnormal behavior in relation to cage size in rhesus monkeys. Journal of Abnormal Psychology 86, 87-92
"Observations were made of 24 monkeys that were introduced singly into a [barren] small and a [barren] large test cage. In a large cage .. less stereotyped locomotion was shown than in a small cage."

Williams LE, Steadman A, Kyser B 2000. Increased cage size affects *Aotus* time budgets and partner distances. American Journal of Primatology 51(Supplement), 98 (Abstract)
"Aotes spp. housed in typical, small, laboratory cages appear to be sedentary animals that spend large amounts of time sitting alone or in physical contact with social partners. ... The Aotus, housed as pairs or family groups, were moved from cages measuring 0.63m x 1.5m x 0.76m to larger housing measuring 1.5m x 3m x 2m. Perches and nest boxes were provided in both housing conditions. ... Results indicate that Aotus will disperse and use the cage area provided. Changes in time budgeting are indicative of more relaxed animals, spending less time huddled with family members or in their nest box [alone], and spending more time eating and drinking."

(2,b) Structured Space

Photo by Moshe Bushmitz

Erwin J 1977. Factors influencing aggressive behavior and risk of trauma in the pigtail macaque *(Macaca nemestrina)*. Laboratory Animal Science 27, 541-547
"Provision of cover ... reduced aggression among members of stable groups."

Günther MM 1998. Influence of habitat structure on jumping behaviour in *Galago moholi*. Folia Primatologica 69(Supplement), 410 (Abstract)
"These results suggest that support material [perches], as well as height, influences the behaviour of G. maholi and these should be taken into consideration in behavioural and biomedical studies as well as in the construction of cage facilities. Studies which do not take these factors into account are to some extent vitiated."

Maninger N, Kim JH, Ruppenthal GC 1998. The presence of visual barriers decreases agonism in group housed pigtail macaques *(Macaca nemestrina)*. American Journal of Primatology 45, 193-194
"Bite, grab and chase were found to be significantly greater [among members of harem groups of 23 pig-tailed macaques] when visual barriers were absent compared to when they were present."

McCormack K, Megna NL 2001. The effects of privacy walls on aggression in a captive group of rhesus macaques *(Macaca mulatta)*. American Journal of Primatology 54(Supplement), 50-51
"Preliminary results suggest that non-contact aggression (vocalizations, fear grimaces, chases, and threats) is significantly reduced after the introduction of the privacy walls ($p<.05$)."

Miller-Schroeder P, Paterson JD 1989. Environmental influences on reproduction and maternal behavior in captive gorillas: Results of a survey. In Housing, Care and Psychological Wellbeing of Captive and Laboratory Primates Segal EF (ed), 389-415. Noyes Publications, Park Ridge, NJ
Females reproduced more successfully if their enclosures contained various structures, especially privacy refuges like sight barriers and cages.

Nakamichi M, Asanuma K 1998. Behavioral effects of perches on group-housed adult female Japanese monkeys. Perceptual and Motor Skills 87, 707-714
"When [4 adult female] monkeys were housed in a cage which contained eight wooden perches to increase usable space, the rate of agonistic interactions ... decreased in comparison with those evident when they were housed in a cage [identical dimension] without such perches."

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://books.nap.edu/books/0309052335/html/index.html
"Optimal use of available cage space might well depend more on the placement of perches, platforms, moving and stationary supports, and refuges than on cage size itself."

Neveu H, Deputte BL 1996. Influence of availability of perches on the behavioral well-being of captive, group-living mangabeys. American Journal of Primatology 38, 175-185
"A total deprivation of perches yielded an increase in aggressive behaviors and locomotion, and a decrease in cohesiveness. Placing perches progressively in the experimental cage restored the level of all the variables to levels found in the control cage [with five perches]."

Reinhardt V 1989. Evaluation of the long-term effectiveness of two environmental enrichment objects for singly caged rhesus macaques. Lab Animal 18(6), 31-33
http://www.awionline.org/Lab_animals/biblio/la-eval.htm
"While perching, the monkeys sat in front of the cage for 95% of the time, in the middle or rear of the cage for 5% of the time. The proportion of time spent with the pipes was three times greater for animals living in lower-row cages than for animals living in upper-row cages. In the elevated position, the light exposure was increased, a fact that made the pipes of particular value for the lower-row cages animals."

Reinhardt V 1990. A perch for caged macaques. Humane Innovations and Alternatives in Animal Experimentation 4, 134-135
http://www.awionline.org/Lab_animals/biblio/h134.htm
Perches are "particularly attractive for animals during the daily cleaning of their cages because they offer a dry, comfortable place to sit while the floors of their cages are sprayed with water."

Ricker RB, Williams LE, Brady AG, Gibson SV, Abee CR 1995. Environmental enhancement for laboratory-housed squirrel monkeys: Fifteen-year retrospective analysis of procedures. Contemporary Topics in Laboratory Animal Science 34(4), 55 (Abstract)
"Cut pieces of PVC pipe (12 in diameter) were hung in each run as a hide box, allowing eye contact to be broken between disputing animals. This decreased fight wounds by 60%."

Shimoji M, Bowers CL, Crockett CM 1993. Initial response to introduction of a PVC perch by singly caged *Macaca fascicularis*. Laboratory Primate Newsletter 32(4), 8-11
http://www.brown.edu/Research/Primate/lpn32-4.html#pvc
Single-housed "monkeys spent significantly more time clinging to the cage wall ("suspended") in the absence of the perch. ... There was less stereotypy when the perch was present."

Spencer H 2005. A tale of two cynos. Tech Talk 10(3), 4 & 6
"After implementing the vertical tunnels, both [pair-housed male cynos] primates stopped exhibiting stereotypical and self-injurious behaviors." The two animals "were free of stereotypical behavior for a little over two years."

Westergaard GC, Izard MK, Drake JD, Suomi SJ, Higley JD 1999. Rhesus macaque *(Macaca mulatta)* group formation and housing: Wounding and reproduction in a specific pathogen free (SPF) colony. American Journal of Primatology 49, 339-347
"When forming new rhesus macaque breeding groups, divided corrals that provide for social and visual separation of individuals lead to lower rates of traumatic wounding than do undivided corrals."

Wolff A 1989. Polyvinyl chloride piping as perch material for squirrel monkeys. Laboratory Primate Newsletter 28(1), 7
http://www.brown.edu/Research/Primate/lpn28-1.html#pvc
"An additional unexpected benefit of the PVC piping has been a decrease in dorsal tail-head abrasions, frequently seen in squirrel monkeys that sit on the stainless steel flooring of standard primate cages."

(2,c) Playpen, Outdoor Housing, Exercise Cage

Baker KC, Ross SK 1998. Outdoor access: The behavioral benefits to chimpanzees. American Journal of Primatology 45, 166 (Abstract)
"When compared to the results of ameliorative environmental enrichment techniques furnished to the indoor-housed subjects, the small outdoor groups of [two or three] chimpanzees showed broader and more dramatic improvements in well-being." Animals with outdoor access showed significantly less abnormal behavior (e.g., coprophagy, regurgitation/reingestion), less yawning, and more self-grooming.

Bayne K, Dexter S, Suomi S 1992. A preliminary survey of the incidence of abnormal behavior in rhesus monkeys *(Macaca mulatta)* relative to housing condition. Lab Animal 21(5), 38-46
"The greatest frequency of overall abnormal behavior and stereotypic exploratory behavior was in the SC [single cage] condition, and the lowest frequency of occurrence in the CC [corn crib] condition ... in IO [indoor/outdoor] runs, the animals showed no self-directed behavior."

Brent L, Lee DR, Eichberg JW 1991. Evaluation of a chimpanzee enrichment enclosure. Journal of Medical Primatology 20, 29-34
http://www.awionline.org/Lab_animals/biblio/jmp20-2.htm
Chimpanzees were given access to a complex new outdoor playground. "Activity and environmental manipulation increased while abnormal and self directed behaviors decreased."

Bryant CE, Rupniak NMJ, Iversen SD 1988. Effects of different environmental enrichment devices on cage stereotypies and autoaggression in captive cynomolgus monkeys. Journal of Medical Primatology 17, 257-269
http://www.awionline.org/Lab_animals/biblio/jmp17-2.htm
"Stereotypy and autoaggression were markedly reduced in the playpen, but reappeared on return to the home cage."

Clarke AS, Juno CJ, Maple TL 1982. Behavioral effects of a change in the physical environment: a pilot study of captive chimpanzees. Zoo Biology 1, 371-380
A group of chimpanzees was translocated from a laboratory environment to a naturalistic man-made island. Stereotyped and self-directed behaviors were dramatically reduced on the island.

Fontenot MB, Wilkes MN, Lynch CS 2006. Effects of outdoor housing on self-injurious and stereotypic behavior in adult male rhesus macaques *(Macaca mulatta)*. Journal of the American Association for Laboratory Animal Science [Contemporary Topics in Laboratory Animal Science] 45(5), 35-43
"Our findings suggest that self-biting and self-directed stereotypic behavior in rhesus macaques with a history of self-injurious behavior is significantly reduced by outdoor housing" in corncribs equipped with perches and toys. The outdoor housing provided a 114% increase in floor area for single-housed animals and a 364% to 837% increase in floor area for group-housed animals.

Fried J, Whitehouse M 1992. A pre-post occupancy comparison of activity budgets and habitat utilization in a group of captive mandrills *(Mandrillus sphinx)*. American Journal of Primatology 27, 28 (Abstract)
"For the group as a whole, feeding, traveling and object oriented behaviors increased, and stereotypic behaviors decreased" in the naturalistic environment.

Goerke B, Fleming L, Creel M 1987. Behavioral changes of a juvenile gorilla after a transfer to a more naturalistic environment. Zoo Biology 6, 283-295
"Coprophagy and regurgitation/reingestion were reduced in the juvenile [group-housed] gorilla in the larger and more natural environment."

Honess PE, Marin C, Brown AP, Wolfensohn SE 2005. Assessment of stress in non-human primates: application of the neutrophil activation test. Animal Welfare 14, 291-295
"All macaques were group-housed indoors in either a traditional caging system of three linked modules of typical reinforced stainless steel two-tier laboratory cages, or in open-rooms containing either these cages with the fronts removed or no caging at all. ... Animals housed in a traditional caging system produced a significantly lower leukocyte response than animals housed in open-rooms, indicating that there was a higher level of stress associated with caged housing than open-room housing."

Jensvold MLJ, Fouts RS, Fouts DH 1999. Behavioral changes in captive chimpanzees. ChimpanZoo Conference Proceedings, 66 (Abstract)
"Overall, after the move to the larger [structurally enriched] facility, there was an increase in activity, a decrease in stereotypical behaviour, and an increase in threat behavior."

Kessel AL, Brent L 1995. An activity cage for baboons, Part I. Contemporary Topics in Laboratory Animal Science 34(6), 74-79
Single-housed "baboons provided with a large enriched activity cage [during two days each month] display dramatic changes in behavior typically considered to represent positive psychological well-being. ... The home cages and the activity cage were located in the same room, and provided visual, olfactory, and auditory access to other baboons."

Kessel AL, Brent L 1997. Behavioural effects of transferring singly housed baboons to outdoor social groups. In Proceedings on the 2nd International Conference on Environmental Enrichment Holst B (ed), 142-147. Copenhagen Zoo, Frederiksberg

"Moving singly housed baboons to an enriched outdoor enclosure had significant effects on all behaviors analyzed. Abnormal behavior, cage directed activities, and self-directed activities all decreased in the corn cribs. Inactivity, locomotion, and normal behavior, as well as enrichment directed activities and social behavior all increased in the corn cribs."

Leu M, Crockett CM, Bowers CL, Bowden DM 1993. Changes in activity levels of singly housed longtailed macaques when given the opportunity to exercise in a larger cage. American Journal of Primatology 30, 327 (Abstract)
"Over a period of 36 days, each [single-housed] animal had 15 min per day access to a multicompartmental [large] exercise cage." Locomotion increased while stereotypical behavior decreased when the animals were in the exercise cage.

Maple TL, Finlay TW 1987. Post-occupancy evaluation in the zoo. Applied Animal Behaviour Science 18, 5-18
"We investigated the effects of translocating great apes from barren cages to innovative naturalistic habitats. ... For both gorillas and orangutans, the new environment had the effect of reducing the variety and frequency of aggressive interactions. ... Some behaviors, such a play-biting, were recorded for the first time in the new enclosure. Both gorillas were prone to regurgitation and re-ingestion in their former cages. However, in the naturalistic environments these abnormal behaviors were never observed."

Marriott BM, Marriott RW, Norris J, Lee D 1993. A semi-natural habitat for housing small, nonhuman primates. Journal of Medical Primatology 22, 348-354
http://www.awionline.org/Lab_animals/biblio/jmp22-3.htm
A semi-natural habitat was designed to house a group of squirrel monkeys. Animals maintained in this environment were "healthy, and none of the animals exhibited locomotor stereotypies."

McGuffey LH, McCully CL, Bernacky BJ, Blaney SM 2002. Incorporation of an enrichment program into a study protocol involving long-term restraint in macaques. Lab Animal 31(10), 37-39
"In our experience, the provision of periodic intervals of unrestricted activity directly correlated with an increased tolerance during relatively more extended periods of [chair] restraint."

O'Neill PL 1989. Short-term and long-term benefits of environmental enrichment on laboratory rhesus monkeys (*Macaca mulatta*). American Zoo and Aquarium Association Regional Conference Proceedings, 616-625
The animals were transferred from their barren group cage to a more spacious playroom equipped with climbing /perching structures and swings for one hour per day, five days a week: The animals showed a decline in the frequency of three [out of four] behavioral disorders in the playpen. This therapeutic effect was nullified back in the barren homecage."

Pines MK, Kaplan G, Rogers LJ 2007. A note on indoor and outdoor housing preferences of common marmosets (*Callithrix jacchus*). Applied Animal Behaviour Science 108(3-4), 348-353
"When given free access to move between their home cage and outdoors, the marmosets spent 70% of their day in the outdoor cage."

Seier JV, Loza J, Benjamin L 2004. Housing and stereotyped behaviour: Some observations from an indoor colony of vervet monkeys (*Chlorocebus aethiops*). Folia Primatologica 75(Supplement), 332 (Abstract)

The animals "spent most time in stereotypies when in unenriched single cages. This was significantly reduced by the provision of either an exercise cage or a foraging log. No stereotyped behaviour was observed in the largest most enriched cages."

Storey PL, Turner PV, Tremblay JL 2000. Environmental enrichment for rhesus macaques: A cost-effective exercise cage. Contemporary Topics in Laboratory Animal Science 39(1), 14-16
"Increased visual attentiveness by other animals, decreased self-directed biting and hair picking, and improved food consumption was observed when rhesus macaques were permitted access to an exercise cage for several hours daily."

Tustin GW, Williams LE, Brady AG 1996. Rotational use of a recreational cage for the environmental enrichment of Japanese macaques (*Macaca fuscata*). Laboratory Primate Newsletter 35(1), 5-7
http://www.brown.edu/Research/Primate/lpn35-1.html#tustin
The rotational use of a "recreation cage" resulted in increased use of enrichment devices and a decrease in stereotypical behaviors.

Wilkes MN, Lynch CS, Fontenot MB 2006. Outdoor housing decreases self-injurious and stereotypic behavior in adult male rhesus macaques (*Macaca mulatta*). American Journal of Primatology 68(Supplement), 106 (Abstract)
Access to an outdoor area decreased self-injurious and stereotypical behaviors in adult male rhesus who had been single-caged or group-housed indoors.

(3) Inanimate and Feeding Enrichment

Baker KC 1997. Straw and forage material ameliorate abnormal behaviors in adult chimpanzees. Zoo Biology 16, 225-236
"In an [successful] effort to reduce abnormal behaviors, especially regurgitation and reingestion, and promote higher activity levels [locomoting and playing], straw and scattered forage material were added to the enclosures of 13 indoor-housed chimpanzees living in pairs and trios."

Baker KC, Springer DA 2006. Frequency of feeding enrichment and response of laboratory nonhuman primates to unfamiliar people. Journal of the American Association for Laboratory Animal Science [Contemporary Topics in Laboratory Animal Science] 45(1), 69-73
"The data presented support the hypothesis that levels of treat feeding influence monkeys' receptivity to unfamiliar people."

Bayne K, Dexter SL, Mainzer H, McCully C, Campbell G, Yamada F 1992. The use of artificial turf as a foraging substrate for individually housed rhesus monkeys *(Macaca mulatta).* Animal Welfare 1, 39-53
http://www.awionline.org/Lab_animals/biblio/aw1-39.htm
"An increasing trend in time spent foraging with a concomitant decline in aberrant behaviour over a time period of six months was particularly noteworthy [in the single-housed subjects]."

Bayne K, Dexter S, Suomi S 1992. A preliminary survey of the incidence of abnormal behavior in rhesus monkeys *(Macaca mulatta)* relative to housing condition. Lab Animal 21(5), 38-46
"The greatest frequency of overall abnormal behavior and stereotypic exploratory behavior was in the SC [single cage] condition, and the lowest frequency of occurrence in the CC [corn crib] condition ... in IO [indoor/outdoor] runs, the animals showed no self-directed behavior."

Bayne K, Mainzer H, Dexter SL, Campbell G, Yamada F, Suomi SJ 1991. The reduction of abnormal behaviors in individually housed rhesus monkeys *(Macaca mulatta)* with a foraging/grooming board. American Journal of Primatology 23, 23-35
All of the single-housed "animals foraged from the board to the point that a significant reduction in the level of abnormal behavior was noted."

Bennett BT, Spector MR 1989. The use of naturally occurring manipulanda to improve the psychological well-being of singly housed baboons. Journal of the American Veterinary Medical Association 194, 1782 (Abstract)
Single-housed animals demonstrated a marked reduction of stereotypy when they had corn-on-the-cob.

Bloomsmith MA, Alford PL, Maple TL 1988. Successful feeding enrichment for captive chimpanzees. American Journal of Primatology 16, 155-164
Four feeding techniques were simultaneously implemented. "Agonistic, abnormal, and grooming behaviors were significantly reduced."

Boccia ML 1989. Long-term effects of a natural foraging task on aggression and stereotypies in socially housed pigtail macaques. Laboratory Primate Newsletter 28(2), 18-19
http://www.brown.edu/Research/Primate/lpn28-2.html#maria
"Two months following the introduction of the foraging task stereotypies remained depressed, and hairpulling remained rare. In addition, bedding exploration and other types of exploration remained elevated, and agonistic behaviors remained low."

Boccia ML, Hijazi AS 1998. A foraging task reduces agonistic and stereotypic behaviors in pigtail macaque social groups. Laboratory Primate Newsletter 37(3), 1-5
http://www.brown.edu/Research/Primate/lpn37-3.html#boccia
Time spent foraging increased, while agonistic and abnormal behavior (e.g., hairpulling) and stereotypies (e.g., pacing) decreased.

Boinski S, Gross TS, Davis JK 1999. Terrestrial predator alarm vocalizations are a valid monitor of stress in captive brown capuchins *(Cebus apella)*. Zoo Biology 18, 295-312
"Our results are consistent with the interpretation that in conditions of low environmental enrichment the study subjects were more stressed, and therefore more reactive to the presence of a threatening terrestrial stimulus (human observer), than when in more enriched conditions."

Brent L, Eichberg JW 1991. Woodchip bedding as enrichment for captive chimpanzees. American Journal of Primatology 24, 91-92
"Abnormal behavior and environmental manipulation were significantly lower during the woodchip [not mixed with food] condition."

Brent L, Long KE 1995. The behavioral response of individually caged baboons to feeding enrichment and the standard diet: A preliminary report. Contemporary Topics in Laboratory Animal Science 34(2), 65-69
"Increasing foraging opportunities in this study reduced abnormal behaviors from 16.4% of the data points in the baseline condition to 4.9% and 5.7% in the chow [normal feeding condition] and feeder condition, respectively."

Brent L, Belik M 1997. The response of group-housed baboons to three enrichment toys. Laboratory Animals 31, 81-85
"Abnormal, cage-directed, inactive and self-directed behaviours all significantly decreased after the [simultaneous] provision of the toys."

Brown DL, Gold KC 1997. Effects of straw bedding on non-social and abnormal behavior of captive lowland gorillas *(Gorilla gorilla gorilla)*. In Proceedings on the 2nd International Conference on Environmental Enrichment Holst B (ed), 27-35. Copenhagen Zoo, Frederiksberg
"Two individuals were frequently observed to hold their ears or head while the exhibit was in an unbedded condition. This behavior virtually disappeared in the enriched condition. ... Of the eight individuals found to engage in coprophagy, five individuals were observed to exhibit this behavior in solely the unbedded condition." Individuals who engaged in regurgitation-reingestion demonstrated lower levels of this behavior in the bedded condition.

Chamove AS, Anderson JR, Nash VJ 1984. Social and environmental influences on self-aggression in monkeys. Primates 25, 319-325
"It is clear that enriched environmental conditions reduced SA [self-aggression]. Allowing monkeys to forage through clean woodchips, even when there is no obvious incentive, substantially reduced the level of this abnormal behavior."

Crockett CM, Bellanca RU, Heffernan KS, Ronan DA, Bonn WF 2001. Puzzle Ball foraging device for laboratory monkeys. Laboratory Primate Newsletter 40(1), 4-7
http://www.brown.edu/Research/Primate/lpn40-1.html#ball
"The empty Puzzle Balls were associated with a reduction [approximately 60%] in abnormal behavior."

Eaton GG, Kelley ST, Iliff-Sizemore SA 1993. Rawhide 'chew-bones' reduce abnormal behavior in individually housed adult rhesus macaques. American Journal of Primatology 30, 308 (Abstract)
"Self-clasp showed a significant decline when the rawhide bones were present. We conclude that rawhide chew-bones are an effective, and relatively inexpensive method of enriching the environment of individually housed rhesus macaques."

Honess PE, Marin CM 2006. Enrichment and aggression in primates. Neuroscience and Biobehavioral Reviews 30, 413-346
"There is considerable evidence that primates housed under impoverished conditions develop behavioural abnormalities, including, in the most extreme example, self-harming behaviour. This has implications for all contexts in which primates are maintained in captivity from laboratories to zoos since by compromising the animals' psychological well-being and allowing them to develop behavioural abnormalities their value as appropriate educational and research models is diminished. This review examines the extensive body of literature documenting attempts to improve living conditions with a view to correcting behavioural abnormalities and housing primates in such a way that they are encouraged to exhibit a more natural range and proportion of behaviours, including less self-directed and social aggression. The results of housing, feeding, physical, sensory and social enrichment efforts are examined with specific focus on their effect on aggressive behaviour and variation in their use and efficacy. It is concluded that while inappropriate or poorly distributed enrichment may encourage aggressive competition, enrichment that is species, sex, age and background appropriate can dramatically reduce aggression, can eliminate abnormal behaviour and substantially improve the welfare of primates maintained in captivity."

Kessel AL, Brent L 1998. Cage toys reduce abnormal behavior in individually housed pigtail macaques. Journal of Applied Animal Welfare Science 1, 227-234
"Providing multiple manipulable toys as enrichment for [single-caged] pigtail macaques was effective in reducing abnormal behavior" during 30- min observation session.

Lam K, Rupniak NMJ, Iversen SD 1991. Use of a grooming and foraging substrate to reduce cage stereotypies in macaques. Journal of Medical Primatology 20, 104-109
http://www.awionline.org/Lab_animals/biblio/jmp20-1.htm
"Stereotyped behaviours were reduced by up to 73%."

Maki S, Alford PL, Bloomsmith MA, Franklin J 1989. Food puzzle device simulating termite fishing for captive chimpanzees (*Pan troglodytes)*. American Journal of Primatology 19(Supplement), 71-78
"Significant reductions of abnormal behavior and significant increases in activity occurred with the pipe feeder's availability."

Meunier LD, Dukting JT, Landi MS 1989. Modification of stereotypic behavior in rhesus monkeys using videotapes, puzzlefeeders, and foraging boxes. Laboratory Animal Science 39, 479 (Abstract)
"Results of this study demonstrate that foraging boxes and puzzle feeders can reduce stereotypic behavior significantly [in single-housed subjects]."

Murphy DE 1976. Enrichment and occupational devices for orang utans and chimpanzees. International Zoo News 137(23.5), 24-26
http://www.awionline.org/Lab_animals/biblio/izn-mur.htm
Subjects were provided with an artificial termite mount. "The most encouraging result was a reduction in the female's stereotyped pacing. The environmental enrichment of the chimp exhibit has resulted in a decrease in observable coprophagy, a diversification of the activities, and a probable improvement in the physical and psychological condition of the animals."

Nadler RD, Herndon JG, Metz B, Ferrer AC, Erwin J 1992. Environmental enrichment by varied feeding strategies for individually caged young chimpanzees. In Chimpanzee Conservation and Public Health: Environments for the Future Erwin J, Landon JC (eds), 137-145. Diagnon/Bioqual, Rockville
"Providing an ear of unhusked corn on alternate days, in addition to laboratory chow, resulted in more time spent contacting food [primarily the corn] an hour after feeding than feeding laboratory chow alone. Seven of eight [single-housed] animals exhibited less stereotypy on the days they received the ear of corn. Stereotypical behavior, which occurs at relatively low frequencies under natural conditions, was reduced somewhat when the animals were fed three [rather than one] meals."

Neu K, Lambeth S, Toback E, Schapiro S 2001. Hay can be used to decrease feces smearing in groups of captive chimpanzees. American Journal of Primatology 54(Supplement), 78 (Abstract)
Feces smearing on the walls decreased significantly when hay was present compared to when no hay was available.

Poffe A, Melotto S, Gerrard PA 1995. Comparison of four environmental enrichment strategies in captive common marmosets *(Callithrix jacchus)*. Primate Report 42, 24-25

"Access to the puzzles was accompanied by increase in social interaction and activity and decrease in stereotypic behaviour. This behavioural profile was also observed, to a lesser extent, in animals exposed to the 'gum tree'. ... Novel objects alone [toys] failed to significantly alter behaviour."

Preilowski B, Reger M, Engele H 1988. Combining scientific experimentation with conventional housing: A pilot study with rhesus monkeys. American Journal of Primatology 14, 223-234
Manipulatory activity required by the apparatus reduced motor stereotypies but not self-biting.

Pyle DA, Bennett AL, Zarcone TJ, Turkkan. J. S., Adams RJ, Hienz RD 1996. Use of two food foraging devices by singly housed baboons. Laboratory Primate Newsletter 35(2), 10-15
http://www.brown.edu/Research/Primate/lpn35-2.html#pyle
"Stereotypical behaviors are reduced [in single-housed subjects] when the devices are present. In addition, the foraging devices elicited species-typical behaviors such as foraging and grooming, even after food appeared to be absent from the devices."

Roberts RL, Roytburd LA, Newman JD 1999. Puzzle feeders and gum feeders as environmental enrichment for common marmosets. Contemporary Topics in Laboratory Animal Science 38(5), 27-31
"Gum feeders and Puzzle-Feeders™ loaded with waxmoth larvae are useful for reducing the rates of pacing and inactivity" in single-housed and in pair-housed marmosets.

Steen Z 1995. Effects of enriched food acquisition on activity budgets of two tamarin species at Adelaide Zoo. International Zoo News 42, 284-298
http://www.awionline.org/Lab_animals/biblio/izn-ste.htm
Simple bamboo pipe feeder is described and tested in group-housed animals. "The aim of the study was to [successfully] increase foraging time with an increasing number of feeding devices [brawn bowl, bamboo pipe]. ... Prior to the study large amounts of fur were found in the nesting box of the golden tamarins. The zoo vet suspected that this was a result of overgrooming. During and after the study the overgrooming apparently ceased because the animals had something else to do."

Taylor TD 2002. Feeding enrichment for red-handed tamarins. The Shape of Enrichment 11(2), 1-3
http://www.enrichment.org/articles/112Tamarin.pdf
Access to a 'feeding basket' [stuffed with straw mixed with their normal feed and hung from a perch] and suspended sticks smeared with acacia gum increased feeding activities while reducing the incidence of stereotypy [primarily somersaulting], hyperactivity, coprophagy and excessive grooming and scent marking in a 3-adult-member group.

Watson L 1992. Effect of an enrichment device on stereotypic and self-aggressive behaviors in singly-caged macaques: A pilot study. Laboratory Primate Newsletter 31(3), 8-10
http://www.brown.edu/Research/Primate/lpn31-3.html#watson
"A [temporary] reduction in some behavior pathology was noted, possibly due to replacing the stereotypic behaviors with activities directed toward the feeder."

Weld K, Erwin J 1990. Provision of manipulable objects to cynomolgus macaques promotes species-typical behavior. American Journal of Primatology 20, 243 (Abstract)

"A different pet toy was provided to each [single-caged] monkey" during six weeks. "Self-directed abnormal behavior was reduced or eliminated in all subjects ... but increased after removal of the toys."

Wiard J 1992. Reduction of regurgitation and reingestion (R&R) in lowland gorillas at the Oklahoma City Zoo. Gorilla Gazette 6(3), 6-7
"The addition of browse or hay to the diet of captive gorilla reduces the occurrence of R&R [regurgitation-reingestion]. Novelty items tend to reduce R&R [only] for short periods of time."

(4) Acoustical Enrichment

Brent L, Weaver D 1996. The physiological and behavioral effects of radio music on singly housed baboons. Journal of Medical Primatology 25, 370-374
http://www.awionline.org/Lab_animals/biblio/jmp25-3.htm
Vocalization [of the single-housed subjects] was twice as high when the radio was off. Blood pressure did not vary with radio condition, but the heart rate was significantly lower when the radio was playing.

Howell S, Roeder E, Nelson C, Fritz J, Schwandt M 2002. The effect of music on the behavior of captive chimpanzees (*Pan troglodytes*). American Journal of Primatology 57(Supplement), 83-84 (Abstract)
"Results suggest music has a significant effect on behavior of captive chimpanzees. It resulted in decreased aggression and active exploratory behavior and increased inactive resting and social behavior (principally social grooming). .. We suggest music may have a calming effect on behavior and good potential as therapeutic environmental enrichment."

McDermott J, Hauser MD 2007. Nonhuman primates prefer slow tempos but dislike music overall. Cognition 104, 654-668
Both tamarins and marmosets preferred slow tempo to fast temp music, and when allowed to choose between slow tempo musical stimuli and silence they preferred silence.

Rukstalis M, French JA 2005. Vocal buffering of the stress response: exposure to conspecific vocalizations moderates urinary cortisol excretion in isolated marmosets. Hormones and Behavior 47, 1-7
"For many species, the presence of a significant social partner can lessen the behavioral and physiological responses to stressful stimuli. This study examined whether a single, individually specific, signature vocalization (phee call) could attenuate the physiological stress response that is induced in marmosets by housing them in short-term social isolation. .. Isolated marmosets exposed to a familiar pair mate's vocalization showed significantly lower levels of urinary cortisol than when exposed to unfamiliar marmoset vocalizations ($P < 0.04$) or to no auditory stimuli ($P < 0.03$). .. The results presented here provide the first evidence that a single, individually specific communication signal can decrease the magnitude of a physiological stress response in a manner analogous to the physical presence of a social partner, a process we term vocal buffering."

Videan EN, Fritz F, Howell H, Murphy J 2007. Effects of two types and two genre of music on social behavior in captive chimpanzees (Pan troglodytes). Journal of the American Association for Laboratory Animal Science [Contemporary Topics in Laboratory Animal Science] 46(1), 66-70

"The purpose of this study was to test the effects of 2 different types (vocal versus instrumental) and 2 genres (classical vocal versus 'easy-listening' vocal) of music on social behavior in 31 female and 26 male chimpanzees (Pan troglodytes). Results indicated that instrumental music was more effective at increasing affiliative behavior in both male and female chimpanzees, whereas vocal music was more effective at decreasing agonistic behavior. A comparison of 2 genre of vocal music indicated that easy-listening (slower tempo) vocal music was more effective at decreasing agonistic behavior in male chimpanzees than classical (faster tempo) vocal music. Agonistic behavior in females remained low (<0.5%) throughout the study and was unaffected by music. These results indicate that, like humans, captive chimpanzees react differently to various types and genres of music. The reactions varied depending on both the sex of the subject and the type of social behavior examined. "

Wells DL, Coleman D, Challis MG 2006. A note on the effect of auditory stimulation on the behaviour and welfare of zoo-housed gorillas. Applied Animal Behaviour Science 100(3-4), 327-332
Six gorillas housed in Belfast Zoo "were exposed to three conditions of auditory stimulation: a control (no auditory stimulation), an ecologically relevant condition (rainforest sounds) and an ecologically non-relevant condition (classical music). The gorillas' behaviour was recorded in each condition using a scan-sampling technique. There was no significant effect of the auditory environment on the gorillas' behaviour, although animals tended to show more behaviours suggestive of relaxation (i.e. resting, sitting) and fewer behaviours typically associated with stress (i.e. aggression, abnormal behaviour) during the ecologically relevant, and, in particular, the non-relevant, conditions than the control. Overall, findings suggest that certain types of auditory stimulation may hold some merit as a method of enrichment for zoo-housed gorillas."

(5) Animate Enrichment

Alexander S, Fontenot MB 2003. Isosexual social group formation for environmental enrichment in adult male *Macaca mulatta*. AALAS 54th National Meeting Official Program, 141 (Abstract)
Isosexual groups [average group size: 4.2 animals] of 80, previously single-caged 4-10 years old male rhesus macaques were formed [group formation protocol is not outlined]. "Thirty-one [38.8%] of these animal had at least one prior incidence of SIB [self-injurious biting]. .. During the year prior to group formation, the clinical history of the subjects included a 20% of diarrhea, 1.0% incidence of wound infection and 12.5% incidence of severe SIB requiring pharmacological intervention and wound care. Animals with severe SIB were treated pharmacologically for 2-11 months prior to group formation. All of these cases were removed from treatment prior to group formation. Over the 4-month period post formations <5.0% of the animals were removed for treatment of minor fight wounds. Less than 2.0% of the animals were removed for clinical purposed (e.g., diarrhea, dehydration). No occurrence of sever SIB was noted. We concluded that the formation of isosexual social groups is a suitable alternative to individual housing of adult male rhesus monkeys and may decrease the occurrence of SIB in a susceptible population."

Baker KC 1996. Chimpanzees in single cages and small social groups: Effects of housing on behavior. Contemporary Topics in Laboratory Animal Science 35(3), 71-74
Chimpanzees housed in pairs or trios showed fewer signs of tension, anxiety and aggressiveness than those housed singly.

Baker KC 1997. Human interaction as enrichment for captive chimpanzees: A preliminary report. American Journal of Primatology 42, 92 (Abstract)

"These results suggest that simple, unstructured affiliation between humans and chimpanzees has a powerful impact on well-being, promoting activity and relaxed conspecific interactions and ameliorating undesirable behaviors [e.g., abnormal behaviors]."

Bayne K, Dexter SL, Suomi SJ 1991. Social housing ameliorates behavioral pathology in *Cebus apella*. Laboratory Primate Newsletter 30(2), 9-12
http://www.brown.edu/Research/Primate/lpn30-2.html#bayne
Change from single- to group-housing "effectively reduced stereotypic behaviors; however, it also was associated with more passive behaviors... The concurrent shifts in these components of the behavioral repertoire suggests that the animals were in a calmer state when housed socially."

Bayne K, Dexter SL, Strange GM 1993. The effects of food treat provisioning and human interaction on the behavioral well-being of rhesus monkeys *(Macaca mulatta)*. Contemporary Topics in Laboratory Animal Science 32(2), 6-9
"*The effects of human interaction and food supplementation appear to be protracted, resulting in a reduction of pathology [behavioral disorders] even after the enrichment is removed."*

Bloomsmith MA, Baker KC, Ross SK, Lambeth SP 1998. Enlarging chimpanzee social groups: The behavioral course of introductions. American Journal of Primatology 45, 171 (Abstract)
Stereotyped rocking declined in newly integrated individuals.

Boccia ML, Reite M, Laudenslager ML 1989. On the physiology of grooming in a pigtail macaque. Physiology and Behavior 45, 667-670
When the subject received grooming from others, heart rate was significantly lower than during self grooming, as well as during other behaviors.

Bourgeois SR, Brent L 2005. Modifying the behaviour of singly caged baboons: evaluating the effectiveness of four enrichment techniques. Animal Welfare 14, 71-81
Seven singly caged adolescent [mean age: 4.2 years] male baboons were studied. "Analysis of baseline behaviour verified substantial durations of abnormal behaviour [9.8/30- min observations (33% of time)]. We tested the effectiveness of ... positive reinforcement training (PRT), food enrichment [fruits, frozen fruit/juice, foraging devices], non-food enrichment [toys], and social enrichment (pair/trio). .. The social enrichment condition resulted in the most positive behavioural changes, including ... near elimination of abnormal behaviours [0.7/30-min observation (2% of time)]. Significant reduction in total abnormal behaviour levels were also found for other types of enrichment, but only social enrichment and PRT were effective in reducing whole-body stereotypies. ... Animal enrichment (human or conspecific stimulation), as opposed to inanimate enrichment, provides optimal means of behaviour modification for singly caged baboons."

Bushong D, Schapiro SJ, Bloomsmith MA 1992. Self-aggression in nonhuman primates: A review of its development/possible causes, methods of therapeutic treatment, and its relevance to the zoo situation. American Zoo and Aquarium Association Regional Conference Proceedings, 723-728
"Social enrichment appears to be the most effective method of reducing the development or frequency of abnormal behaviors." After the animals "were moved from single- to pair-housing, preliminary analyses of individual behavior indicated that there was a decrease in time spent in self-aggressive behaviors."

Choi GC 1993. Humans enrich the lives of lab baboons. WARDS Newsletter 4, 3-7 & 13
"The reduction in cage painting and banging was dramatic and remarkable" after the single-housed animals received more attention from the attending personnel.

Coe CL, Franklin D, Smith ER, Levine S 1982. Hormonal responses accompanying fear and agitation in the squirrel monkey. Physiology and Behavior 29, 1051-1057
"The presence of a social partner reduced signs of behavioral disturbance."

Coelho AM, Carey KD, Shade RE 1991. Assessing the effects of social environment on blood pressure and heart rates of baboon. American Journal of Primatology 23, 257-267
In the social companion condition, a subject was able to have visual, tactile, and auditory interactions with his companion through the wire mesh walls of the specially designed cages. "When animals were housed with social companions their blood pressures were consistently lower than when they were either housed individually or with social strangers. ... Measurements of cardiovascular physiology obtained under social housing may more closely model normal physiology than ... individual housing."

Eaton GG, Kelley ST, Axthelm MK, Iliff-Sizemore SA, Shiigi SM 1994. Psychological well-being in paired adult female rhesus (*Macaca mulatta).* American Journal of Primatology 33, 89-99
Paired females show strong preference to spend time in close proximity; agonistic behaviors are very infrequent. Health measures, body weight gains, reproduction and immune responses do not differ between dominant, subordinate, and single-housed females. Paired females spend less time engaged in abnormal behavior than single-housed females."

Fritz P, Fritz J 1979. Resocialization of chimpanzees. Journal of Medical Primatology 8, 202-221
"With the exception of Tim, stereotyped behaviors in other individuals decreased almost immediately upon introduction of a compatible cage mate and continued to decrease as socialization proceeded."

Gonzalez CA, Coe CL, Levine S 1982. Cortisol responses under different housing conditions in female squirrel monkeys. Psychoneuroendocrinology 7, 209-216
Plasma levels of cortisol "were significantly lower in pair-housed females than in those living in a social group or individually. The increment in cortisol levels after stress (handling and ether anesthesia) also was smaller in females housed in pairs." Dominant and subordinate partners of female pairs did not differ in their plasma cortisol levels.

Goodwin J 1997. The application, use, and effects of training and enrichment variables with Japanese snow macaques (*Macaca fuscata*) at the Central Park Wildlife Center. American Zoo and Aquarium Association Regional Conference Proceedings, 510-515
A training protocol is briefly described which allows the keepers through vocal and visual cues to herd the animals to a holding area. Training sessions were "deterring stereotypic and abnormal behaviour - such as excessive grooming and fur-pulling."

Goosen C 1988. Studies of disturbed behaviour in macaques. In Biomedical Research in Primates. Proceedings of the TNO Symposium Jonker M (ed), 67-74
Stereotyped locomotion amounted to about 20% of the time when subjects were housed solitary. The amount of time was reduced to about 4% when the subjects had one or more social partners.

Gunnar MR, Gonzalez CA, Levine S 1980. The role of peers in modifying behavioral distress and pituitary-adrenal response to a novel environment in year-old rhesus monkeys. Physiology and Behavior 25, 795-798
Infant rhesus macaques were captured from their social group and placed in an unfamiliar environment for 24 hours either (a) alone or (b) with another infant from the same group. When tested alone, the animals exhibited significantly more signs of distress - agitation, distress vocalization - than when they were tested with a companion, indicating that the companion had a stress-buffering effect.

Gust DA, Gordon TP, Brodie AR, McClure HM 1994. Effect of a preferred companion in modulating stress in adult female rhesus monkeys. Physiology and Behavior 55, 681-684
"Adult female rhesus monkeys exhibited a profound stress response when removed from their social group to a novel environment. Recovery time [of T cell subsets] was significantly enhanced by the presence of a preferred companion."

Gwinn LA 1996. A method for using a pole housing apparatus to establish compatible pairs among squirrel monkeys. Contemporary Topics in Laboratory Animal Science 35(4), 61 (Abstract)
Pair formation protocol in a pole-and-collar housing system is described. "Pair housing the animals has not interfered with research. During nine treatments with an identical test compound, singly housed animals lost significantly more weight on average than did pair housed animals."

Hartner MK, Hall J, Penderghest J, White E, Watson S, Clark L 2000. A novel approach to group-housing male cynomolgus macaques in a pharmaceutical environment. Contemporary Topics in Laboratory Animal Science 39(4), 67 (Abstract)
"Twenty percent of our primates are maintained in a single-housed environment. Of those .. animals, 40% exhibited moderate to marked degrees of self-directed activity; i. e., hairpulling. By contrast, none of the pair or group-housed animals exhibited these behaviors. ... These primates are now more receptive to handling and training, and will therefore be better animal models, as noted by a marked decrease in vocalization and self-directed behavior during pole/collar capture and chair restraint procedures."

Hennessy MB 1984. Presence of companion moderates arousal of monkeys with restricted social experience. Physiology and Behavior 33, 393-398
When placed in a novel environment for 30 minutes, juvenile squirrel monkeys emitted significantly more high-pitched vocalizations when tested alone than when tested in the presence of the companion. A significant elevation of plasma cortisol was observed only when animals were exposed to the novel environment alone.

Kessel AL, Brent L 1997. Rehabilitating a rheboon (*Macaca mulatta* x *Papio hamadryas cynocephalus*), from single housing to social housing: A case study. American Journal of Primatology 42, 121 (Abstract)
Abnormal behavior was reduced from 46% of observation time in the single-housed condition to 4% after introduction to an enclosure with ten other rhesus females.

Kessel A, Brent L 2001. The rehabilitation of captive baboons. Journal of Medical Primatology 30, 71-80

"*Eleven baboons who had been singly housed indoors for an average of 5 years were moved to outdoor social groups in an attempt to provide a more species-typical environment and reduce high levels of abnormal behavior. ... Abnormal behavior decreased significantly from an average of 14% of the observation time in the single cages to 3% in the sixth month of social housing. Cage manipulation and self-directed behaviors also significantly decreased."*

Line SW, Morgan KN, Markowitz H, Roberts J, Riddell M 1990. Behavioral responses of female long-tailed macaques (*Macaca fascicularis*) to pair formation. Laboratory Primate Newsletter 29(4), 1-5
http://www.brown.edu/Research/Primate/lpn29-4.html#line
"Self-abusive behaviors were recorded for five of the ten subjects when singly housed, but were completely absent after pair formation."

Lutz CK, Novak M 2005. Environmental enrichment for nonhuman primates: Theory and application. ILAR [Institute for Laboratory Animal Research] Journal 46(2), 178-191
http://dels.nas.edu/ilar_n/ilarjournal/46_2/html/v4602lutz.shtml
"Only social contact satisfies the goal of promoting a wide variety of species-typical activities while at the same time reducing or preventing the development of abnormal behavior. .. A number of toys should be provided initially and rotated on a regular basis to maintain interest. .. At present, the most effective form of enrichment for captive primates is social housing."

Mahoney CJ 1992. Some thoughts on psychological enrichment. Lab Animal 21(5), 27,29,32-37
"Isolation 'wards' for ill animals and infectious study chambers can have windows or transparent plastic panels between cages, providing visual communication without interfering with ... air-flow."

Mason WA 1960. Socially mediated reduction in emotional responses of young rhesus monkeys. Journal of Abnormal and Social Psychology 60, 100-110
"Previous observations that social stimuli may function as a source of security and a means of mitigating emotional distress in young primates are fully supported by the present results."

Miller LC, Bard KA, Juno CJ, Nadler RD 1986. Behavioral responsiveness of young chimpanzees (*Pan troglodytes*) to a novel environment. Folia Primatologica 47, 128-142
"Extreme distress reported previously for chimpanzees and human children when tested alone in a novel situation was rarely observed in these tests when an attachment figure [human caretaker] was present."

Minkel R 2007. Pair-housing eliminates compulsive hair pulling: a case report. Laboratory Animal Refinement and Enrichment Forum (electronic discussion group), September 27, 2007
http://groups.yahoo.com/group/LAREF/members
"At a previous institution we had a cyno — 'Grandpa' — who suffered from severe hair pulling. He had removed practically all hair from his body; all that was left was a patch in the middle of his back that he could not reach! He was not shy about hiding his idiosyncratic behavior at all and would contort into strange positions to do it. The veterinarians tried various treatments to alleviate the problem to no avail. We tried all the various enrichment devices we could find; they would only keep him occupied for a day or so. We pulled all the dividers from his cage to give him more space; no luck. We were reluctant to pair him as he was an older male who had been singly housed for so long, but there was no other treatment option left.

We tried two unsuccessful pairings and finally settled on a newly acquired juvenile male who was very rowdy and active (Grandpa was quite the opposite: relaxed and sedate). The little

guy, himself was on his second pair attempt. During his first attempt — all he did was try to start a fight. To our great relief the new pair worked out just fine. This truly "odd couple" got along great from the start. Grandpa responded correctly, brought the little guy in line, and actually perked up. The most surprising part, however, was that Grandpa stopped hair pulling. He stopped completely, and all his hair had grown back in the course of several months.

Three years later Grandpa had not resumed his old habit, even though his buddy had been removed for research-related reasons one year after the original pair formation."

Missakian EA 1972. Effects of adult social experience on patterns of reproductive activity of socially deprived male rhesus monkeys (*Macaca mulatta*). Journal of Personality and Social Psychology 21(1), 131-134
Two of three males showed a decrease in both stereotyped locomotion and self-aggression after being introduced into a group of rhesus macaques.

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://fermat.nap.edu/books/0309052335/html/index.html
"Social interactions are considered to be one of the most important factors influencing the psychological well-being of most nonhuman primates. ... The common practice of housing rhesus monkeys singly calls for special attention."

Reimers M, Schwarzenberger F, Preuschoft S 2007. Rehabilitation of research chimpanzees: Stress and coping after long-term isolation. Hormones and Behavior, in print
"Permanent retirement from biomedical research in combination with therapeutic resocialization maximizing chimpanzees' situation control resulted in reduced fecal cortisol metabolite levels. Our results indicate that chimpanzees can recover from severe social deprivation, and may experience resocialization as less stressful than solitary housing."

Roberts SJ, Platt ML 2004. Pair-housing macaques with biomedical implants: a safe and practical alternative to single-housing. American Journal of Primatology 62(Supplement), 96-97
http://www.asp.org/asp2004/abstractDisplay.cfm?abstractID=734&confEventID=828
"Recognition of the importance of social interaction for primate well-being has led to new USDA guidelines recommending that animal facilities provide social enrichment for captive primates, as long as doing so does not endanger the animals or interfere with research goals. Group- or pair-housing is the best way to provide social enrichment, but many primates used in medical research are housed singly because they have implants which may make them more vulnerable to inflicted injury. In addition, pairing adult male monkeys is often considered too difficult and too impractical to attempt. The goal of this study was to evaluate these assumptions. Eight adult male rhesus macaques (Macaca mulatta) and two adult male crab-eating macaques (Macaca fascicularis) were evaluated for pairing and then housed with a compatible partner for up to three years. During the period of study, 9 of the 10 monkeys received cranial and scleral search coil implants. On average, each monkey was compatible with 69% of partners, and this high degree of compatibility allowed monkeys to be paired continuously within three weeks of initial evaluation. Moreover, the rate of implant failure during pair-housing (0.07 failures per month) was not significantly different from the rate of implant failure when monkeys were singly-housed (0.098). These data demonstrate that pair-housing provides a safe and practical social alternative to single-housing for adult male macaques with biomedical implants."

Reinhardt V, Houser WD, Eisele S, Champoux M 1987. Social enrichment with infants of the environment for singly caged adult rhesus monkeys. Zoo Biology 6, 365-371
http://www.awionline.org/Lab_animals/biblio/zb6-365.htm
"Three adults exhibiting stereotypical behavior abandoned their peculiar habits after they had lived with their young companions for four months."

Reinhardt V, Houser W, Eisele S, Cowley D, Vertein R 1988. Behavior responses of unrelated rhesus monkey females paired for the purpose of environmental enrichment. American Journal of Primatology 14, 135-140
http://www.brown.edu/Research/Primate/lpn26-2.html#vik
6 of 7 animals abandoned behavioral disorders within the first 4 ws of living together with a companion.

Reinhardt V, Houser WD, Cowley D, Eisele S, Vertein R 1989. Alternatives to single caging of rhesus monkeys (*Macaca mulatta*) used in research. Zeitschrift für Versuchstierkunde 32, 275-279
http://www.awionline.org/Lab_animals/biblio/es32-2~1.htm
"Pairing caged rhesus monkeys with compatible conspecifics does not interfere with a number of common research protocols [e.g., headcap implantation, experimental surgery, blood collection]."

Reinhardt V 1990. Social enrichment for laboratory primates: A critical review. Laboratory Primate Newsletter 29(3), 7-11
http://www.brown.edu/Research/Primate/lpn29-3.html#rev
"23% (54/237) of individually caged, but only 10% (38/382) of pair-housed rhesus monkeys required medical treatment."

Reinhardt V 1999. Pair-housing overcomes self-biting behavior in macaques. Laboratory Primate Newsletter 38(1), 4
http://www.brown.edu/Research/Primate/lpn38-1.html#pair
Subjects exhibited self-biting behavior predictably in the presence of personnel. "The transfer to a compatible social-housing arrangement [isosexual pair-housing] effectively cured the [seven] rhesus subjects from the behavioral pathology of habitual self-biting."

Rukstalis M, French JA 2005. Vocal buffering of the stress response: exposure to conspecific. Hormones and Behavior 47, 1-7
"*For many species, the presence of a significant social partner can lessen the behavioral and physiological responses to stressful stimuli. This study examined whether a single, individually specific, signature vocalization (phee call) could attenuate the physiological stress response that is induced in marmosets by housing them in short-term social isolation. .. Isolated marmosets exposed to a familiar pair mate's vocalization showed significantly lower levels of urinary cortisol than when exposed to unfamiliar marmoset vocalizations ($P < 0.04$) or to no auditory stimuli ($P < 0.03$). .. The results presented here provide the first evidence that a single, individually specific communication signal can decrease the magnitude of a physiological stress response in a manner analogous to the physical presence of a social partner, a process we term vocal buffering." Vocalizations moderate urinary cortisol excretion in isolated marmosets.*

Ruppenthal GC, Walker CG, Sackett GP 1991. Rearing infant monkeys (*Macaca nemestrina*) in pairs produces deficient social development compared with rearing in single cages. American Journal of Primatology 25, 103-113
In contrast to singly caged infants, pair-reared infants failed to show "rock/huddle/self clasp and stereotypy categories.“

Schapiro SJ, Bushong D 1994. Effects of enrichment on veterinary treatment of laboratory rhesus macaques (*Macaca mulatta*). Animal Welfare 3, 25-36
http://www.awionline.org/Lab_animals/biblio/aw3-25.htm
"Diarrhea-related problems typical for singly-housed animals and trauma-related problems typical of group-housed animals were not as prominent in the pairs."

Schapiro SJ, Nehete PN, Perlman JE, Sastry KJ 2000. A comparison of cell-mediated immune responses in rhesus macaques housed singly, in pairs, or in groups . Applied Animal Behaviour Science 68, 67-84
“Social housing condition affects immune responses. While not unidirectional, these effects generally suggest enhanced immune responses for socially housed animals. .. It is our contention that strong social relationships, particularly the affiliative interactions that characterize our pair housed monkeys, may diminish the likelihood of severe infection with potentially diarrhea-inducing agents. ... Since rhesus monkeys live socially in nature, and the immune responses of singly housed animals differed from those housed socially, there is considerable motivation and justification for suggesting that the use of singly housed rhesus macaques may complicate interpretations of normal immunological responses."

Schapiro SJ 2002. Effects of social manipulations and environmental enrichment on behavior and cell-mediated immune responses in rhesus macaques. Pharmacology, Biochemistry and Behavior 73, 271-278
"In general, enrichment of the inanimate environment with toys, structures, foraging devices, and/or videotapes increased the amount of species-typical behavior expressed by the monkeys, but did not affect their immune responses. Housing monkeys socially, on the other hand, not only resulted in increased time spent in species-typical activities, but also resulted in (1) decreases in time spent in abnormal behavior and (2) changes in a number of immune parameters."

Schnell CR, Gerber P 1997. Training and remote monitoring of cardiovascular parameters in non-human primates. Primate Report 49, 61-70
“Training of non-human primates to handling and experimental procedure will reduce the variance and increase the significant level of observed changes, allows the measurement of normal physiological parameters and finally reduces the number of animals used in an experiment.”

Steinbacher EA, Setser JJ, Morris TD, Gumpf D 2006. Development and implementation of a program for the social housing of nonhuman primates on toxicology studies. AALAS 57th National Meeting Official Program, 157 (Abstract)
"We developed a step-wise procedure for social housing animals (cynomolgus and rhesus) into pairs, triads or quads based on the study design. Nonhuman primates that were socially housed showed signs of better physical and psychological health, thereby greatly reducing abnormal behaviors and stereotypies, such as self-biting, that could potentially compromise study data. Based on the success of our social housing program, all nonhuman primate studies longer than 28 d will be socially housed unless otherwise approved by our institutional ACUC.”

Thompson MA, Bloomsmith MA, Taylor LL 1991. A canine companion for a nursery-reared infant chimpanzee. Laboratory Primate Newsletter 30(2), 1-4
http://www.brown.edu/Research/Primate/lpn30-2.html#dog
"Reduction in rocking and other stress-related behaviors in the dog's presence is a strong argument for providing nursery-reared chimpanzees with dog companions. We have safely housed dogs with single infants as well as with small groups of infants, until infants reach about three years of age."

Van Loo P, Skoumbourdis E, Reinhardt V 2006. Postsurgical pairing: a discussion by the Refinement & Enrichment Forum. Animal Technology and Welfare 5, 17-19
http://www.awionline.org/Lab_animals/biblio/atw9.html
"It is my experience with rhesus macaques that it is advisable to pair an animal after surgery as soon as possible with his or her compatible companion. We did this especially with animals after one of them had head cap implant surgery. The animals recover better from the surgery stress when their familiar companion is with them than when they are alone."

Wait C, Buchanan-Smith H, Morris K 2002. The effects of caretaker-primate relationships on primates in the laboratory. Journal of Applied Animal Welfare Science 5, 309-319
Group-housed "animals who had friendly relationships with caretakers were less disturbed by routine husbandry procedures. .. Caretakers are much more likely to sustain scratches or bites from animals who are fearful and aggressive toward them."

Weed JL, Wagner PO, Byrum R, Parrish S, Knezevich M, Powell DA 2003. Treatment of persistent self-injurious behavior in rhesus monkeys through socialization: A preliminary report. Contemporary Topics in Laboratory Animal Science 42(5), 21-23
Six individually caged males who engaged in persistent self-injurious behavior (SIB) were vasectomized and subsequently paired with females. The incidence of SIB was "markedly reduced for all male monkeys after social pairing." One male engaged in severe SIB after 32 months of pair-housing when he was temporarily removed from his partner for a procedure.

Wolfle TL 1987. Control of stress using non-drug approaches. Journal of the American Veterinary Medical Association 191, 1219-1221
"Human interaction with monkeys and apes is essential for the well-being of the animal, data validity, and ease of handling." The 'social bond' with the animal "conveys to the animal a quiet sense of assurance on which coping strategies can be developed for dealing with other stressful aspects of the laboratory."

(6) Natural Weaning

Cary M, Valentine B, Hill W 2000. The effect of mother-infant separation in captive baboons on time intervals to first postpartum estrus, confirmed pregnancy and subsequent parturition. AALAS 51st National Meeting Official Program, 126-127
"It is generally thought that early forced-weaning of infants would reduce the time from parturition to the first fertile postpartum estrus thus maximizing reproductive efficiency. ... From a survey of 23 animal records we determined the following values for mothers of both forced and naturally weaned infants: days to first postpartum cycle and days from first postpartum cycle to confirmed pregnancy. Mothers of naturally-weaned animals (those with infants) first cycled at 174 ± 31 days and were confirmed pregnant 26 ± 13 days after this. Conversely, mothers of force-weaned infants (weaning at 180 ± 16 days) first cycled at 187 ± 8 days and were confirmed pregnant 55 ± 26 days later. From these observations we suggest that both groups (mothers of

force-weaned versus naturally-weaned infants) require similar times to exhibit their first postpartum estrus, but mothers of naturally-weaned infants appear to breed back more quickly (approximately one cycle) than those of force-weaned infants."

International Primatological Society 1993. IPS International guidelines for the acquisition, care and breeding of nonhuman primates, Codes of Practice 1-3. Primate Report 35, 3-29
http://pin.primate.wisc.edu/ips/codes.txt
"A young monkey should not normally be separated from its mother at an early age (i.e., at 3-6 months) but should remain in contact for one year to 18 months, in most species. There is unlikely to be any greater productivity through early weaning, in seasonally breeding species, such as rhesus monkeys. Even in non-seasonal breeders, any slight increase in productivity must be offset against the resulting behavioural abnormalities of the offspring."

Mason WA 1991. Effects of social interaction on well-being: Development aspects. Laboratory Animal Science 41, 323-328
"Captive animals will be served best if developing individuals are raised at least through weaning by their biological mothers and have the experience of living in a social group that approximates the size and age-sex composition of the group in which they would develop in nature. ... It seems unlikely, however, that peer experience alone can provide a practical alternative to mother-rearing."

Valentine B, Cary M, Stanley J, White G, Wallis J 1999. The timing of mother-infant separation and its effect on postpartum estrus and subsequent conception in captive baboons. American Journal of Primatology 49, 110 (Abstract)
"There was no correlation between infant removal age and duration until next conception. ... Postpartum cyclicity usually resumed before infant removal. Subsequent conception, however, was not significantly influenced by infant removal. This study indicates that early forced weaning did not accomplish the goal of increased reproductive output. These findings - in addition to the concern for proper psychological development - suggest the better strategy is to allow infants to be naturally weaned by mothers."

Wallis J, Valentine B 2001. Early vs. natural weaning in captive baboons: The effect on timing of postpartum estrus and next conception. Laboratory Primate Newsletter 40(1), 10-13
http://www.brown.edu/Research/Primate/lpn40-1.html#wean
"We examined the details of 73 recorded pregnancies of 45 adult females. ... The results of this study indicate that forced infant weaning did not improve reproductive productivity in our colony of baboons. In fact, the data indicate that most females resumed their reproductive cycles well before infant removal and, when given the opportunity for natural weaning, the females conceived while their previous infants were still dependent upon them. .. The potential benefits of allowing infants to remain with their mothers throughout childhood are obvious."

(7) Working with Cooperative Animals

Bentson KL, Capitanio JP, Mendoza SP 2003. Cortisol responses to immobilization with Telazol or ketamine in baboons (*Papio cynocephalus/anubis*) and rhesus macaques (*Macaca mulatta*). Journal of Medical Primalogy 32, 148-160
"The injection and blood sampling process increased cortisol levels in monkeys not trained to extend an arm but exerted no effect on cortisol in trained macaques."

Bloomsmith MA, Marr MJ, Maple TL 2007. Addressing nonhuman primate behavioral problems through the application of operant conditioning: Is the human treatment approach a useful model? Applied Animal Welfare Science 102(3-4), 205-222
"Training by the systematic application of operant conditioning has been widely applied in the care, management, exhibition, and study of nonhuman primates and many other species, but is less often used to control problematic animal behavior such as stereotyped behavior or self-injurious behavior... Virtually all the techniques found to be effective treatments of stereotypy and self-injurious behavior in humans are directly applicable to similar behaviors in captive nonhuman primates. Thus the human work can serve as a model for how we can enhance our attempts to address behavioral problems in captive nonhuman primates."

Cross N, Pines MK, Rogers LJ 2004. Saliva sampling to assess cortisol levels in unrestrained common marmosets and the effect of behavioral stress. American Journal of Primatology 62, 107-114
"We report a method for taking saliva samples from unrestrained, captive marmosets (Callithrix jacchus) to assess levels of free cortisol. Saliva samples can be obtained reliably, without any habituation, by encouraging the marmosets to lick and chew a cotton-wool bud coated in banana. Saliva is thus left on the bud. We also tested sweetened fruit-drink crystals and a number of other substances, but none of these attracted all of the marmosets, and even flavors that were effective once soon lost their attraction. .. A first experiment showed that the marmosets exhibited a rise in salivary cortisol levels in response to social isolation. A second experiment showed elevation of cortisol during a period when the marmosets were disturbed by increased human activity and noise levels in the building in which they were housed. Hence, this method of saliva sampling is a convenient, noninvasive means of assessing cortisol levels in marmosets."

Elvidge H, Challis JRG, Robinson JS, Roper C, Thorburn GD 1976. Influence of handling and sedation on plasma cortisol in rhesus monkeys *(Macaca mulatta).* Journal of Endocrinology 70, 325-326
"The present study shows that it is possible by long-term regular training to achieve mean cortisol values which are significantly lower than in untrained or anaesthetized animals."

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK http://scienceandresearch.homeoffice.gov.uk/animal-research/legislation/
"The least distressing method of handling is to train the animal to co-operate in routine procedures. Advantage should be taken of the animal's ability to learn."

Iliff SA, Friscino BH, Anderson LC 2004. Refinement of study design using positive reinforcement training in macaques. Folia Primatologica 75(Supplement), 282-283 (Abstract)
"Implementation of Positive Reinforcement Training (PRT) to refine and modify study procedures conducted with rhesus macaques results in enhanced welfare for both animals and caregivers. Capitalizing on the macaques intelligence and their capability to learn and perform tasks with appropriate motivation, PRT can reduce or eliminate the need for sedatives or restraint. PRT is useful for standard husbandry procedures such as feeding and transferring animals between cages. It can also be used to facilitate sample collection from animals. Standard pharmacokinetic or metabolism study paradigms for evaluation of pharmaceutical test compounds require frequent collection of blood, bile and/or other body fluids from animals instrumented with catheters and subcutaneous access ports. Collection of these samples can be technically challenging, time consuming and potentially stressful for both personnel and the animals. However, when PRT is used to conduct sampling procedures in the animals home enclosure, stress is minimized as evidenced by lower cortisol levels."

Klein HJ, Murray KA 1995. Part C. Restraint. In Nonhuman Primates in Biomedical Research - Biology and Management Bennett BT, Abee CR, Henrickson R (eds), 286-297. Academic Press, New York, NY
"The importance of training and adaptation cannot be overemphasized. This not only reduces stress to the animal but promotes safety and quality data collection."

Lambeth SP, Hau J, Perlman JE, Martino M, Schapiro SJ 2006. Positive reinforcement training affects hematologic and serum chemistry values in captive chimpanzees (*Pan troglodytes*). American Journal of Primatology 68, 245-256

"Positive reinforcement training (PRT) techniques have received considerable attention for their stress reduction potential in the behavioral management of captive nonhuman primates. However, few published empirical studies have provided physiological data to support this position. To address this issue, PRT techniques were used to train chimpanzees (Pan troglodytes) to voluntarily present a leg for an intramuscular (IM) injection of anesthetic. Hematology and serum chemistry profiles were collected from healthy chimpanzees (n=128) of both sexes and various ages during their routine annual physical examinations over a 7-year period. Specific variables potentially indicative of acute stress (i.e., total white blood cell (WBC) counts, absolute segmented neutrophils (SEG), glucose (GLU) levels, and hematocrit (HCT) levels) were analyzed to determine whether the method used to administer the anesthetic (voluntary present for injection vs. involuntary injection) affected the physiological parameters. Subjects that voluntarily presented for an anesthetic injection had significantly lower mean total WBC counts, SEG, and GLU levels than subjects that were involuntarily anesthetized by more traditional means."

Lambeth SP, Hau J, Perlman JE, Schapiro SJ 2006. Positive reinforcement training and physiological responses in chimpanzees. AALAS [American Association for Laboratory Animal Science] 57th National Meeting Official Program, 160 (Abstract)

"A subset of variables potentially indicative of acute stress were analyzed to determine if the method of adminstration of anesthetic (voluntary present for injection compared with nonvoluntary injection) and/or the method of obtaining the blood sample (voluntary compared with anesthesized) affected these physiogical parameters. Those subjects that voluntarily presented for an anesthetic injection and/or venipuncture differed significantly on many of these parameters from those subjects that were nonvonluntarily anesthetized by more traditional means or whose blood was obtained following anesthesia. This data set objectively demonstrates that positive reinforcement training for behaviors relevant to the blood sampling process significantly affects some of the physiological measures correlated with stress responses in captive chimpanzees."

McKinley J, Buchanan-Smith HM, Morris K 2002. Training common marmosets (*Callithrix jacchus*) to co-operate during routine laboratory procedures: Reliability and time investment. XIXth Congress of the International Primatological Society, Abstracts, 183-184.

"Nine pairs of ... marmosets were target trained to allow in-homecage weighing" and six pairs were trained to provide urine samples on request. Behavioural data showed that "increased positive interactions with humans as a consequence of training reduced stress as indicated by significantly less scent-marking, self-scratching and tsk and phee vocalisation. ... Data collection with trained animals was significantly faster than using standard techniques."

Michael RP, Setchell KDR, Plant TM 1974. Diurnal changes in plasma testosterone and studies on plasma corticosteroids in non-anaesthetized male rhesus monkeys (*Macaca mulatta*). Journal of Endocrinology 63, 325-335

Authors evaluated plasma corticosteroid concentrations in male rhesus macaques who "were trained to enter voluntarily a restraining apparatus" and permitted venipuncture without showing signs of stress. Basal cortisol values were 30% lower than previously reported for different, untrained animals.

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://fermat.nap.edu/books/0309052335/html/index.html
"Procedures that reduce reliance on forced restraint and that reduce invasiveness are less stressful for animals and staff, safer for both, and generally more efficient."

Prentice ED, Zucker IH, Jameton A 1986. Ethics of animal welfare in research: The institution's attempt to achieve appropriate social balance. The Physiologist 29, 1&19-21
"Physical restraint procedures should be used on awake animals only after alternative procedures have been considered and found to be inadequate. If a restraint will be utilized the animal should be trained or conditioned to the restraining device, using positive reinforcement."

Prescott MJ, Buchanan-Smith HM 2007. Training laboratory-housed non-human primates, part I: a UK survey. Animal Welfare 16(1), 21-36
Training using positive reinforcement is increasingly recognised as a valuable tool for the humane and effective management and use of laboratory-housed non-human primates. A survey was carried out on the use of training and other learning processes (socialisation, habituation and desensitisation) in over half of UK establishments using and breeding primates. There is widespread awareness of training as a refinement technique but it not used as widely or as fully as it might be. We conclude that there is opportunity for refinement of common scientific, veterinary and husbandry procedures (such as blood and urine collection, injection, capture from the group and weighing) through use of positive reinforcement training, especially when combined with appropriate socialisation, habituation and desensitation. Recommendations on best practice, training techniques and staff education are given.

Reinhardt V 1992. Improved handling of experimental rhesus monkeys. In The Inevitable Bond Davis H, Balfour AD (eds), 171-177. Cambridge University Press, Cambridge, UK
http://www.awionline.org/Lab_animals/biblio/bond.htm
The significant increase of serum cortisol concentration associated with involuntary manual or mechanical restraint during venipuncture was absent in females who were trained to voluntarily cooperate during the procedure.

Schnell CR, Gerber P 1997. Training and remote monitoring of cardiovascular parameters in non-human primates. Primate Report 49, 61-70
http://www.awionline.org/Lab_animals/biblio/pr49-6~1.htm
"We could prove that marmosets can be trained to participate willingly in cage restraint and to urine sampling by the use of appropriate (banana milk-shake) rewards. Under this prospect, they showed no behavioral and cardiovascular signs of distress." The "training of non-human primates to handling and experimental procedure will reduce the variance and increase the significant level of observed changes, allows the measurement of normal physiological parameters and finally reduces the number of animals used in an experiment."

Smith CC, Ansevin A 1957. Blood pressure of the normal rhesus monkey. Proceedings of the Society for Experimental Biology and Medicine 96, 428-432
"Most [single-housed] monkeys could be trained to sit quietly" during blood pressure measurements. "The procedure used in handling the monkeys was an important factor in securing reproducible blood pressure measurement."

Smith M, Barley J, Down N, Francis R, Feurtado M, Kerwin A, Patterson-Kane E, Sherwin C, Reinhardt V 2005. Catching animals who have escaped from their primary enclosure: A discussion by the Laboratory Animal Refinement & Enrichment Forum. Animal Technology and Welfare 4(1), 41-44
http://www.awionline.org/Lab_animals/biblio/atw4.html
"Capturing rodents, nonhuman primates and birds who have escaped from their primary enclosure does not need to be a chaotic event and does not necessitate the use of stress-inducing, possibly injurious methods in most cases. The application of basic ethological principles plus compassion can make a big difference, turning the recapture procedure into a harmless event both for the escapee and for the personnel."

Tiefenbacher S, Lee B, Meyer JS, Spealman RD 2003. Noninvasive technique for the repeated sampling of salivary free cortisol in awake, unrestrained squirrel monkeys. American Journal of Primatology 60, 69-75
"Individually housed adult male squirrel monkeys were trained to chew on dental rope attached to a pole, from which saliva was extracted by centrifugation and analyzed for cortisol. .. Eight of nine monkeys readily acquired the task, reliably providing adequate saliva samples for the assay. .. The described sampling technique provides a reliable and sensitive means for repeated measurement of HPA activity in unrestrained, awake squirrel monkeys."

Schwindaman D 1991. The 1985 animal welfare act amendments. In Through the Looking Glass Novak MA, Petto AJ (eds), 26-32. American Psychological Association, Washington, DC
"To reduce the stress and pain of laboratory animals, nontraumatic restraining techniques must be taught. ... We believe that teaching of procedural skills is crucial for maintaining high research standards within the laboratory."

Wall HS, Worthman C, Else JG 1985. Effects of ketamine anaesthesia, stress and repeated bleeding on the haematology of vervet monkeys. Laboratory Animals 19, 138-144
"10 adult [single-housed] non-pregnant females were trained to present a limb for unstressed sampling."

(8) Treatment of Animals in their Home Enclosure

Nelms R, Davis BK, Tansey G, Raber JM 2001. Utilization of training techniques to minimize distress and facilitate the treatment of a chronically ill macaque. AALAS 52nd National Meeting Official Program, 97-98 (Abstract)
"In order to permit the more frequent measurement of blood glucose, at times up to eight measurements a day, with minimal or no distress to the animal, we trained the monkey [long-tailed macaque with unspecified gender] to voluntarily present the hand and accept a finger stick for the collection of blood."

Reinhardt V, Cowley D, Scheffler J, Vertein R, Wegner F 1990. Cortisol response of female rhesus monkeys to venipuncture in homecage versus venipuncture in restraint apparatus. Journal of Medical Primatology 19, 601-606
http://www.awionline.org/Lab_animals/biblio/jmp19.htm
In monkeys venipunctured in the restraint apparatus, cortisol concentrations were on average 50% higher 15 minutes after venipuncture ($p<0.001$). The magnitude of cortisol elevation was only 18% in monkeys venipunctured in the homecage ($p>0.1$).

Reinhardt V, Cowley D, Eisele S, Scheffler J 1991. Avoiding undue cortisol responses to venipuncture in adult male rhesus macaques. Animal Technology 42, 83-86
http://www.awionline.org/Lab_animals/biblio/at83.htm
Six adult males were: a) habituated to actively cooperate during venipuncture in a treatment cage, and b) trained to actively cooperate during venipuncture in the homecage. The magnitude of cortisol increase was significant when the males were venipunctured in the hallways but not when they were venipunctured in the homecage. "It was concluded that venipuncture per se was not a physiologically distressing event. It became distressing only when it was associated with a temporary removal from the homecage."

Reinhardt V, Cowley D 1992. In-homecage blood collection from conscious stumptailed macaques. Animal Welfare 1, 249-255
http://www.awionline.org/Lab_animals/biblio/aw1blood.htm
Blood collection of trained animals was not accompanied by an increase in serum cortisol concentration.

Thomsen R, Voigt CC 2006. Non-invasive blood sampling from primates using laboratory-bred blood-sucking bugs (*Dipetalogaster maximus*; Reduviidae, Heteroptera). Primates, 397-400
"Primates are easily stressed by the conventional veterinary blood sampling routine and consequently, measured blood parameters may be biased. In this study, we tested blood-sucking bugs (Dipetalogaster maximus) on one lemur and two ape species (Microcebus murinus, Pongo abelii, Pan paniscus) as an alternative, non-invasive technique for bleeding primates. Within time periods of between 6 and 62 min we obtained blood volumes of 0.01-2.4 ml in 11 out of 12 trials from all three species. Therefore, we conclude that these bugs represent a new, gentle and effective tool for bleeding captive primates without stress."

(9) Cage Arrangement

Reinhardt V 1997. Lighting conditions for laboratory monkeys: Are they adequate? Animal Welfare Information Center Newsletter 8(2), 3-6
http://www.nal.usda.gov/awic/newsletters/v8n2/8n2reinh.htm
"The prevailing monkey cage arrangement makes adequate, that is uniform, illumination impossible, because the cages of upper-rows block the light from entering the cages of lower-rows. Caging all animals at the same level of the room is the only solution to the problem of uneven lighting conditions."

United States Department of Agriculture 1991. Title 9, CFR (Code of Federal Register), Part 3. Animal Welfare; Standards; Final Rule. Federal Register 56(32), 6426-6505
http://www.nal.usda.gov/awic/legislat/awadog.htm
"Lighting must be uniformly diffused throughout animal facilities and provide sufficient illumination to aid in maintaining good housekeeping practices, adequate cleaning, adequate inspection of animals, and for the well-being of animals."

Environmental Enrichment

(1) Definition

Environmental enrichment is the provision of stimuli that promote the expression of species-appropriate behavioral and mental activities.

Bayne K 2000. Laboratory animal enrichment. In The IACUC (Institutional Animal Care and Use Committee) Handbook Silverman J, Suckow MA, Murthy S (eds), 465-480. CRC Press, New York, NY
"Environmental enrichment is an environment in which complex stimuli are provided to alleviate the occurrence of abnormal behaviors."

United States Department of Agriculture 1991. Title 9, CFR (Code of Federal Register), Part 3. Animal Welfare; Standards; Final Rule. Federal Register 56(32), 6426-6505
http://www.nal.usda.gov/awic/legislat/awadog.htm
"The physical environment in the primary enclosures must be enriched by providing means of expressing noninjurious species-typical activities. .. Examples of environmental enrichment include providing perches, swings, mirrors, and other increased cage complexities; providing objects to manipulate; varied food items; using foraging or task-oriented feeding methods; and providing interaction with the care giver or other familiar and knowledgeable person consistent with personnel safety precautions."

(2) Promoting Social Behavior

Canadian Council on Animal Care, Olfert ED, Cross BM, McWilliam AA 1993. Guide to the Care and Use of Experimental Animals, Volume 1, 2nd Edition. Canadian Council on Animal Care, Ottawa, ON
http://www.ccac.ca/en/CCAC_Programs/Guidelines_Policies/GUIDES/ENGLISH/toc_v1.htm
"The social needs of animals used in research, teaching, or testing, should be given equal consideration with environmental factors such as lighting, heating, ventilations and containment.. Particularly in the case of singly housed animals, daily observation provides an alternative from of social contact .. and commonly facilitates handling .. Most animals should not be housed singly unless required by medical condition, aggression, or dictates of the study. Singly housed animals should have some degree of social contact with others of their own kind. ... In the interest of well-being, a social environment is desired for each animal which will allow basic social contacts and positive social relationships. Social behaviour assists animals to cope with circumstances of confinement."

European Commission 2002. The Welfare of Non-human Primates - Report of the Scientific Committe on Animal Health and Animal Welfare. European Commission, Strasbourg, France
http://europa.eu.int/comm/food/fs/sc/scah/out83_en.pdf
"Primates should not be housed singly unless fully justified by health considerations (for the animal and human handler) or research procedures, as advised following an ethical review process. If primates have to be singly housed, the animals should have visual, olfactory and autitory contact with conspecifics."

European Economic Community 1986. Council Directive 86/609, Annex II Guidelines for Accommodation and Care of Animals. Official Journal of the European Communities L358, 7-28
http://www.uku.fi/laitokset/vkek/Sopimus/convention.html
"The performance of an animal during an experiment depends very much on its confidence in man, something which has to be developed. ... It is therefore recommended that frequent contact should be maintained so that the animals become familiar with human presence and activity. Where appropriate, time should be set aside for talking, handling and grooming."

International Primatological Society 1993. IPS International guidelines for the acquisition, care and breeding of nonhuman primates, Codes of Practice 1-3. Primate Report 35, 3-29
http://pin.primate.wisc.edu/ips/codes.txt
"A compatible conspecific probably provides more appropriate stimulation ...than any other potential environmental enrichment factor."

National Research Council 1996. Guide for the Care and Use of Laboratory Animals National Academy Press, Washington, DC
http://www.nap.edu/books/0309053773/html/
"Animals should be housed with the goal of maximizing species-specific behaviors and minimizing stress-induced behaviors. For social species, this normally requires housing in compatible pairs or groups."

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://fermat.nap.edu/books/0309052335/html/index.html
"Social interactions are considered to be one of the most important factors influencing the psychological well-being of most nonhuman primates. ... The common practice of housing rhesus monkeys singly calls for special attention [p. 99] ... Every effort should be made to house these [singly caged] animals socially (in groups or pairs), but when this is not possible, the need for single housing should be documented by investigators and approved by the IACUC. ... The animal technician's and caregiver's roles are pivotal to the social support of primates, particularly animals that are singly caged."

United States Department of Agriculture 1991. Title 9, CFR (Code of Federal Register), Part 3. Animal Welfare; Standards; Final Rule. Federal Register 56(32), 6426-6505
http://www.nal.usda.gov/awic/legislat/awadog.htm
The environmental enhancement plan "must include specific provisions to address the social needs of nonhuman primates of species known to exist in social groups in nature. ... Examples of environmental enrichment include ... providing interaction with the care giver or other familiar and knowledgeable person consistent with personnel safety precautions."

(2,1,a) Group-housing: Practical Issues

Alford PL, Bloomsmith MA, Keeling ME, Beck TF 1995. Wounding aggression during the formation and maintenance of captive, multimale chimpanzee groups. Zoo Biology 14, 347-359
"There is more wounding and more severe wounding in groups composed of older, socially experienced males than in groups composed of younger socially inexperienced males, many of whom also had extensive visual exposure to one another before grouping."

Baker KC, Seres M, Aureli F, de Waal FBM 2000. Injury risks among chimpanzees in three housing conditions. American Journal of Primatology 51, 161-175
"Over a two-year period all visible injuries to 46 adult males, 64 adult females, and 25 immature chimpanzees were recorded. ... Housing included ... groups of up to 12 individuals, and smaller indoor-outdoor runs for pairs and trios. ... Compound-housed chimpanzees incurred the highest level of minor wounding, but serious wounding levels were not affected by housing condition. ... Overall, this study indicates that maintaining chimpanzees in pairs and trios would not be an effective means for reducing injuries. The management of wounding in chimpanzee colonies is influenced more by the sex and rearing composition of a colony."

Bellinger LL, Hill EG, Wiggs RB 1992. Inexpensive modifications to nonhuman primate cages that allow social grouping. Contemporary Topics in Laboratory Animal Science 31(3), 10-12
"These two design modifications [PVC tunnels and stainless steel tunnels connecting two adjacent cages] allow us to inexpensively modify existing caging to meet the USDA regulations of social grouping."

Bernstein IS 1989. Breeding colonies and psychological well-being. American Journal of Primatology 19 (Supplement), 31-36
Valuable discussion of relatively safe group-housing management practices.

Bloomsmith MA 1989. Interaction between adult male and immature captive chimpanzees: Implications for housing chimpanzees. American Journal of Primatology 19(Supplement), 93-99
"These observations suggest that captive adult male chimpanzees have the potential to develop affiliative relationships with immature conspecifics. Housing adult males in groups along with infants may be an important way of increasing the social complexity of the males' environments."

Boyce WT, O'Neill-Wagner PL, Price CS, Haines MC, Suomi SJ 1998. Crowding stress and violent injuries among behaviorally inhibited rhesus macaques. Health Psychology 17, 285-289
A rhesus group of 36 animals was kept during 6 'warm' months in a large outdoor enclosure, during 6 'cold' months confined in a building. "During the 6-month period of confinement stress, a fivefold acceleration in [medically-attended] injury incidence was found."

Catlow G, Ryan PM, Young RJ 1998. Please don't touch, we're being enriched! In Proceedings of the 3rd International Conference on Environmental Enrichment Hare VJ, Worley E (eds), 209-217. Shape of Enrichment, San Diego, CA
"Non-interference in their social lives is an important form of environmental enrichment." Rather than locking the chimpanzees into their indoor cages every evening, an average of 17 hours a day the animals were given continuous access to their whole area and to each other. "The males became more tolerant towards one another, and started to socialise as a unit. ... Far more normal behaviours are present and the afternoon tension for both animal and keeper has ceased."

Caws C, Aureli F 2001. Coping with short-tem space restriction in chimpanzees. Primate Eye 74, 9
http://www.psgb.org/Meetings/Spring2001.html
"During the indoor period the chimpanzees showed no increase in aggression, grooming, and submissive greeting, nor changed their proximity to adult males. However, the percentage of aggressive events that involved more than 2 individuals was significantly lower during the indoor period. In addition, 36 dyads were identified as "highly aggressive" during the control period; aggression was reduced in these dyads during the indoor period. These results confirm

previous evidence that chimpanzees do not increase aggression during space restriction. Furthermore, they seem to inhibit aggression by not joining ongoing conflicts and by selectively decreasing the targeting of common 'victims'."

Dazey J, Kuyk K, Oswald M, Marenson J, Erwin J 1977. Effects of group composition on agonistic behavior of captive pigtailed macaques *(Macaca nemestrina)*. American Journal of Physical Anthropology 46, 73-76
Females showed significantly less aggression in the presence of adult males [one male per group] than they did in female-only groups.

Elton RH 1979. Baboon behavior under crowded conditions. In Captivity and Behavior Erwin J, Maple T, Mitchell G (ed), 125-139. Van Nostrand Reinhold, New York, NY
Crowding produced sharp increases in aggression, noticeable increase in tension and general activity. "Social disintegration [e.g., vicious aggression, social withdrawal accompanied by self-directed behaviors], as well as individual pathology [e.g., "pulling of hair out of other animals (by the handful) and eating it"; chewing fingers], was the end result of the crowding in this group of baboons."

Erwin J 1977. Factors influencing aggressive behavior and risk of trauma in the pigtail macaque *(Macaca nemestrina)*. Laboratory Animal Science 27, 541-547
"Provision of cover reduced aggression among members of stable groups."

Erwin J 1979. Aggression in captive macaques: Interaction of social and spacial factors. In Captivity and Behavior Erwin J, Maple T, Mitchell G (eds), 139-171. Van Nostrand, New York, NY
Providing a male-dominated group access to two rooms rather than one allowed some animals to be out of the dominant male's sight. Loss of the male's control over his group resulted in a dramatic increase in aggression among the females.

Ha JC, Robinette RL, Sackett GP 1999. Social housing and pregnancy outcome in captive pigtailed macaques. American Journal of Primatology 47, 153-163
"A greater number of moves decreased the probability of a viable birth and increased gestation length and the need for clinical treatment of the dam, while increased group size decreased gestation length. Increased moves and group size may increase stress by continuously shuffling social relationships, keeping females from establishing social hierarchies, and reducing group stability. Low group stability may increase aggression by making females more likely to attack other females without knowing the opponent's social position or physical abilities."

Hartner MK, Hall J, Penderhest J, Clark LP 2001. Group-housing subadult male cynomolgus macaques in a pharmaceutical environment. Lab Animal 30(8), 53-57
A carefully designed, successful group-formation and group-housing protocol of five 3.5+ years old previously single-caged cynos is described in detail. "Not only can the social complexity of the animals' interactions be increased, but also routine tasks can be accomplished with ease. The animals are easy to handle, restrain, and chair train, and they readily accept biomedical research project requirements. ... Through the maintenance of touch gates and constant visual contact during the study [requiring single-housing for over a month], we were able to regroup the animals [without accidents] within 24 hours. .. Since we began the program, the animals have transitioned through puberty and subadult stages .. and are now cohabitating as adults."

Judge PG, de Waal BM, Paul KS, Gordon TP 1994. Removal of a trauma-inflicting alpha matriline from a group of rhesus macaques to control severe wounding. Laboratory Animal Science 44, 344-350
"Results identify an unusual outbreak of serious wounding by the alpha matriline of a large captive group [of rhesus macaques] and indicate that identification and removal of the animals responsible can be an effective management procedure for controlling such injuries."

Judge P, Griffaton N, Fincke A 2001. No effect of acute crowding on the behavior of hamadryas baboons *(Papio hamadryas)*. American Journal of Primatology 54(Supplement), 68-69 (Abstract)
Aggressive, submissive, affiliative and self-directed responses of the six adults - two males and four females - were recorded in their small indoor quarters versus large outdoor section of their enclosure. Agonistic behavior, and "scratching, an indicator of anxiety in primates, did not increase during crowding. .. Perhaps male hamadryas baboons exert such a controlling influence that conflict management among the other group members is unnecessary during crowding."

Kaplan JR, Manning P, Zucker E 1980. Reduction of mortality due to fighting in a colony of rhesus monkeys (*Macaca mulatta*). Laboratory Animal Science 30, 565-570
"Mortality resulting from fighting [17 deaths per 100 females per year] in a breeding colony of rhesus monkeys living in groups was an important management problem. It was found that the cause of the fighting was the social disruption resulting from a breeding protocol which required the regular removal of pregnant animals from groups and introduction of nonpregnant females."

Maninger N, Kim JH, Ruppenthal GC 1998. The presence of visual barriers decreases agonism in group housed pigtail macaques *(Macaca nemestrina)*. American Journal of Primatology 45, 193-194
"Instances of bite, grab and chase were found to be significantly greater [among members of harem groups] when visual barriers were absent compared to when they were present."

O'Neill-Wagner PL 1996. Facilitating social harmony in a primate group. American Zoo and Aquarium Association Regional Conference Proceedings, 323-325
"Installing an inexpensive electric net fencing system offered safe and innovative separation to two groups of monkeys in the field enclosure. Animals with incentive to transfer between areas successfully penetrated the electric net fence by leaping over it, or darting through the mesh openings at the risk of being zapped by a pulsating (high voltage, low amperage) electric shock. This challenging, yet penetrable fence was functional to monkeys in the following ways. The socially evicted males were able to leave their natal group when the time was approaching. When responses by animals on the other side of the fence indicated that it was safe to return, they would do so. This system functions in a positive way by providing evidence of tension between and within groups, offering escape routes during aggressive interactions, [and] reducing the potential for injuries."

Porton I, White M 1996. Managing an all-male group of gorillas: Eight years of experience at the St. Louis Zoological Park. American Zoo and Aquarium Association Regional Conference Proceedings, 720-728
"Our experience suggests that a gorilla bachelor group is a viable and indeed a desirable alternative to solitary housing of 'emigrated' captive males."

Reinhardt V, Reinhardt A, Houser WD 1986. Hair pulling-and-eating in captive rhesus monkeys. Folia Primatologica 47, 158-164
http://www.awionline.org/Lab_animals/biblio/pr14-1.htm
It was concluded that hair pulling and eating is an aggressive behavioral disorder reflecting adjustment problems to a stressful [group-housing] environment.

Reinhardt V, Reinhardt A, Eisele S, Houser WD, Wolf J 1987. Control of excessive aggressive disturbance in a heterogeneous troop of rhesus monkeys. Applied Animal Behaviour Science 18, 371-377
"Chronic harassment in a troop of rhesus monkeys was related to two animals. The carefully supervised removal of these individuals brought harmony back into the group."
Reinhardt V 1990. Catching Individual Rhesus Monkeys Living in Captive Groups (videotape). Wisconsin Regional Primate Research Center, Madison, WI
A simple capture-chute design is demonstrated. Using vocal commands, a single person swiftly catches all members of a trained rhesus breeding group one-by-one in a transport box without causing any disturbance.

Reinhardt V 1993. Nonspecific diarrhea in the alpha-male of a breeding troop: A case report. Laboratory Primate Newsletter 32(1), 4
http://www.brown.edu/Research/Primate/lpn32-1.html#poop
"Bob's prompt recovery from intractable diarrhea upon being removed from his troop suggests that asserting his role as alpha-animal constituted a chronic social challenge that may have altered his resistance to facultative pathogens and/or autonomic neural tone, to produce diarrhea."

Rolland RM 1991. A prescription for psychological well-being. In Through the Looking Glass Novak MA, Petto AJ (eds), 129-134. American Psychological Association, Washington, DC
"By far the most common physical problem that I treat as clinical veterinarian is trauma sustained by macaques in group-housing situations."

White G, Hill W, Speigel G, Valentine B, Weigant J, Wallis J 2000. Conversion of canine runs to group social housing for juvenile baboons. AALAS 51st National Meeting Official Program, 126 (Abstract)
"Our Division recently converted two rooms equipped with 10 stainless steel, elevated floor canine runs into rooms providing social housing for young baboons. The detachable walls were removed to create larger primary enclosures and tops were fitted with stainless steel panels to provide complete containment."

Wolfensohn S, Peters A 2005. Refinement of neuroscience procedures using non human primates. Animal Technology and Welfare 4, 49-50
It is demonstrated that long-tailed macaques with cranial implants can be group-housed without undue risk. "Contrary to initial expectations we have not found any increased incidence in infection due to the presence of other animals or foraging substrate."

(2,1,b) Group-housing: Group Formation/Introduction/Integration

Baboons *(Papio* spp.)

Else JG, Tarara R, Suleman MA, Eley RM 1986. Enclosure design and reproductive success of baboons used for reproductive research in Kenya. Laboratory Animal Science 36, 168-172
"The [75] females were introduced first to the cage and given an opportunity to stabilize. The [6] males, whose canine teeth had been cut, were paired for at least one week prior to placement with females. Eight animals were removed within the first month due to fight wounds and general incompatibility."

Wallis J, Hartley D 2001. Comparing two methods of forming large social groups of captive baboons *(Papio* spp.). American Journal of Primatology 54(Supplement), 54-55 (Abstract)
The formation of a large group of previously singly caged baboons [unspecified sex] was most successfully accomplished gradually, by first allowing individuals to live in small groups.

Capuchin monkeys *(Cebus apella)*

Bayne K, Dexter SL, Suomi SJ 1991. Social housing ameliorates behavioral pathology in *Cebus apella*. Laboratory Primate Newsletter 30(2), 9-12
http://www.brown.edu/Research/Primate/lpn30-2.html#bayne
No serious aggression was associated with group formation of two females and four males.

Cooper MA, Thompson RK, Bernstein IS, de Waal FBM 1997. The integration of stranger males into a group of tufted capuchin monkeys (*Cebus apella*). American Journal of Primatology 42, 10 (Abstract)
"The introductions were noteworthy for their early lack of both aggression and affiliation. Unlike the macaque model, in which aggression occurs immediately and relationships are settled quickly, the social integration of male capuchins was a gradual process."

Fragaszy D, Baer J, Adams-Curtis L 1994. Introduction and integration of strangers into captive groups of tufted capuchins *(Cebus apella)*. International Journal of Primatology 15, 399-420
"Two to four unfamiliar animals were housed together for 3-5 days in one room of each resident group's two-room cage, while the resident group remained in the other room. Following the acclimation period, we permitted the resident group to mix with the newcomers in the full cage. No morbidity from aggression occurred at the time of introductions or during several months following. Introductions of adult females can be carried out with acceptable risk to the newcomers provided that careful monitoring occurs, so that the onset of severe aggression instigated by resident females toward new females can be avoided [by temporarily dividing the group for a few days]; juveniles can be introduced with minimal risk, and adult males can be introduced into groups lacking resident adult males with minimal risk."

Wolff A, Ruppert G 1991. A practical assessment of a non-human primate exercise program. Lab Animal 20(2), 36-39
Five females and three males were transferred once a week to an exercise pen for several hours. Aggressive interactions were never observed throughout a 9-week study period.

Chimpanzees *(Pan* spp.)

Bloomsmith MA, Lambeth SP 1996. Managing aggression in multi-male, multi-female chimpanzee groups. American Zoo and Aquarium Association Regional Conference Proceedings, 449-452
"We found that wounding aggression was minimal during introductions of females to males or other females, and during male-male introductions of formerly single-caged adolescent and young adult males having long-term prior visual familiarity. Serious wounding occurred during male-male introductions, particularly when there were major discrepancies in their ages and social experience."

Bloomsmith MA, Baker KC, Ross SK, Lambeth SP 1998. Enlarging chimpanzee social groups: The behavioral course of introductions. American Journal of Primatology 45, 171 (Abstract)
New group members were introduced behind mesh. Subsequent full physical contact did not further increase agonism. All 42 introductions of chimpanzees in already established groups were successful.

Fritz J, Howell S 2001. Captive chimpanzee social group formation. In Special Topics in Primatology Volume 2 Brent L (ed.), 172-203. The American Society of Primatologists, San Antonio, TX
"Forming new social groups of captive chimpanzees requires appropriate facilities, a knowledgeable staff, planning, and careful observations." A well-tested socialization system is reviewed which "includes a gradual acclimation of unfamiliar chimpanzees and introductions in a controlled setting. The process has been used to form hundreds of different social groups without serious injuries.... Most of our 35 males live in one of seven all-male groups. While there is considerable potential for male-male aggression among adults, we have found males to be quite social and, in most cases, able to live compatibly with other males. We developed this social group strategy to provide males with increased opportunities to form strong social bonds with other males as is common among wild chimpanzees and as a management technique to prevent pregnancy." The authors share extremely valuable first-hand experiences and outline practical recommendations for the careful establishment of new social units without undue risk of stress, distress and injury.

Hartner MK, Hall J, Penderhest J, Clark LP 2001. Group-housing subadult male cynomolgus macaques in a pharmaceutical environment. Lab Animal 30(8), 53-57
A carefully designed, successful group-formation protocol of five 3.5+ years old previously single-caged male long-tailed macaques is described in detail.

McDonald S 1994. The Detroit Zoo Chimpanzees *Pan troglodytes:* exhibit design, group composition and the process of group formation. International Zoo Yearbook 33, 235-247
"All adults were introduced to each other first through mesh and then physically. Before all physical introductions, the chimpanzees involved were fed double their normal morning rations and then fed a single ration ten minutes prior to the start of the introduction. Play items were scattered throughout the day room. ... Following the dyadic/triadic introductions, an adult female group was formed and the [two] males were added later. All 11 Chimpanzees were successfully integrated into one social group."

McNary JK 1992. Integration of chimpanzees *(Pan troglodytes)* in captivity. In The Care and Management of Chimpanzees *(Pan troglodytes)* in Captive Environments Fulk R, Garland C (eds), 88-100. North Carolina Zool Society, Asheboro, NC
Clear recommendation of how to introduce new chimpanzees to a core group and how to form a new group.

Pazol K, McDonald S, Baker K, Smuts B 1998. Placing hand-reared chimpanzees *(Pan troglodytes)* into adult social groups: A technique for facilitating group integration. Laboratory Primate Newsletter 37(3), 11-13
http://www.brown.edu/Research/Primate/lpn37-3.html#smuts
"This study suggests that prior housing with socially experienced adult females can facilitate the integration of hand-reared infants into naturalistic social groups."

Gorillas *(Gorilla* spp.)

Catlow G 1990. Introducing Killa-Killa. Gorilla Gazette 4(1), 8-10
The successful introduction procedure of an adult female to a group of two adult females and one adult male gorilla is described in detail.

Chatfield JJ 1990. Notes on the introduction of an aggressive male gorilla at the Los Angeles Zoo. Proceedings of the Columbus Zoo Gorilla Workshop, 2-4
The integration of a conspicuously aggressive adult gorilla into an established group of young animals plus one adult female is described. "The introduction took close to two years and lots of patience and effort. The end result proved that is was all worthwhile and certainly the risks [bite wound inflicted on the adult female requiring surgery] were justified." The male was tolerant toward the young animals.

Downman M 1998. The formation of a bachelor group of gorillas at Loro Parque. International Zoo News 45, 208-211
http://www.awionline.org/Lab_animals/biblio/izn-dow.htm
Successful bachelor group formation protocol is described.

Enciso AE, Calcagno JM, Gold KC 1999. Social interactions between captive adult male and infant lowland gorillas: Implications regarding kin selection and zoo management. Zoo Biology 18, 53-62
"Infants may be introduced into non-natal groups without being attacked or physically harmed by dominant males, but their subsequent relationships with these males may lack the close, affiliative interactions that enhance infant social development."

Jendry C 1989. Gorilla introductions. Gorilla Gazette 3(3), 5-6
A well-tested introduction protocol is outlined step-by-step.

Johnstone-Scott R 1992. The integration of Julia. International Zoo News 39(6), 18-26
http://www.awionline.org/Lab_animals/biblio/izn-joh.htm
Successful integration of an adult female gorilla into an established breeding group is described.

McCann CM, Rothman JM 1999. Changes in nearest-neighbor association in a captive group of Western Lowland gorillas after the introduction of five hand-reared infants. Zoo Biology 18, 261-278

The integration of five hand-reared infants into a group of 5 females and 1 male was successful and without incident. "Findings lend strong support to the importance of peer groups and the presence of a silverback male for facilitating the integration of hand-reared infants into established groups."

Meder A 1985. Integration of hand-reared gorilla infants in a group. Zoo Biology 4, 1-12
Zoo-born gorilla infants "could best be introduced into a group when about 1.5 to 2 years old; when younger or older, social integration becomes more difficult. An introduction to adult females in a small cage until strong social relations are formed leads to a smoother social integration in the whole group afterward and takes less time than socializing the infants to juveniles. Allowing the infants to explore the group's main enclosure alone and before they join the group permanently leads to better spacial orientation for them and helps to lessen their uneasiness in the new social situation. Providing the infants with a shelter within the group's enclosure, which gives them access to the group but is inaccessible to the adults, reduces tension and thus aggression toward them."

Winslow S, Ogden J. J., Maple TL 1990. Socialization of an adult male lowland gorilla *(Gorilla gorilla gorilla)*. Proceedings of the Columbus Zoo Gorilla Workshop, 195-204
Successful group formation process of an adult male, an adult female, and a juvenile female is outlined.

Macaques *(Macaca* spp.)

Asvestas C, Reininger M 1999. Forming a bachelor group of long-tailed macaques *(Macaca fascicularis)*. Laboratory Primate Newsletter 38(3), 14
http://www.brown.edu/Research/Primate/lpn38-3.html#group
The careful establishment of a compatible group of 24 male long-tailed macaques is described. "The worst injuries were a split lip and a bite to the leg, both of which healed up quickly."

Bernstein IS, Gordon TP 1977. Behavioral research in breeding colonies of Old World monkeys. Laboratory Animal Science 27, 532-540
"The simultaneous release of all animals has proven to produce the fewest injuries and the most rapid social integration. The addition of individuals to such a colony results in the mobbing of adults, often with severe consequences. Once a group is established, one should avoid adding animals no matter how desirable this might appear. If new groups are to be established, it is far less damaging to the stability of the colony to divide a group along matrilineal lines than to remove any particular age class."

Clarke AS, Czekala NM, Lindburg DG 1995. Behavioral and adrenocortical responses of male cynomolgus and lion-tailed macaques to social stimulation and group formation. Primates 36, 41-46
"Males were exposed to a mirror, then visually exposed to conspecific neighbors in all pairwise combinations, and then formed into conspecific groups [of 3 animals each]. Following group formation [urinary] cortisol values showed a decreasing trend in the cynomolgus, but not in the lion-tails. The cynomolgus rapidly adapted to group living and relations between them were primarily affiliative. In contrast, no affiliative behavior was ever observed in the lion-tail group, which appeared to be highly stressed by group living and was eventually disbanded."

Clarke MR, Blanchard JL 1994. All-male social group formation: Does cutting canine teeth promote social integration? Laboratory Primate Newsletter 33(2), 5-8
http://www.brown.edu/Research/Primate/lpn33-2.html#clarke
Groups of rhesus males were formed by releasing future group members in same enclosure. Within the first five months one of 26 animals died and two were killed due to trauma resulting from fighting.

Good GP, Sassenrath EN 1980. Persistent adrenocortical activation in female rhesus monkeys after new breeding group formation. Journal of Medical Primatology 9, 325-334
"Persistent elevated adrenocortical responsiveness to ACTH has been demonstrated in female rhesus monkeys as long as 13 weeks after relocation into new single male breeding groups."

Gust DA, Gordon TP, Wilson ME, Brodie AR, Ahmed-Ansari A, McClure HM 1991. Formation of a new social group of unfamiliar female rhesus monkeys affects the immune and pituitary adrenocortical systems. Brain, Behavior, and Immunity 5, 296-307
Eight females were introduced. "Dominance rank was established within 48 h by noncontact threats and chases and was unchanged throughout the study. Only two minor wounds were recorded." The animals showed physiological stress responses during the first 9 weeks after group formation.

Jensen GD, Blanton FL, Gribble DH 1980. Older monkeys' *(Macaca radiata)* response to new group formation: Behavior, reproduction and mortality. Experimental Gerontology 15, 399-406
"A group of younger bonnets (5 males and 33 females under 10 yrs of age) suffered 11% mortality in the first three months after new group formation, the death all due to trauma."

Kessler MJ, London WT, Rawlins RG, Gonzales J, Martines HS, Sanches J 1985. Management of a harem breeding colony of rhesus monkeys to reduce trauma-related morbidity and mortality. Journal of Medical Primatology 13, 91-98
Mortality rates per year were reduced from 13.4% to 3.5% "when monkeys were maintained in permanent harems to which returning females were reintroduced compared to new social groups formed from aggregates of unfamiliar animals."

Line SW, Morgan KN, Roberts JA, Markowitz H 1990. Preliminary comments on resocialization of aged macaques. Laboratory Primate Newsletter 29(1), 8-12
http://www.brown.edu/Research/Primate/lpn29-1.html#line
Each rhesus monkey [6 males and 7 females] was introduced to group members in a series of brief pair tests. The incidence of serious injury was 62% including one fatality.

Meshik VA 1994. Group formation in adult Japanese macaques. International Zoo News 41(3), 5-9
http://www.awionline.org/Lab_animals/biblio/izn-mes.htm
"Starting with submissive animals, individuals from the first group [2 females and 1 male] were introduced step by step to the second [resident] group [3 females and 1 male]. A new group was successfully formed without severe fighting. There were practically no aggressive acts."

Reinhardt V 1991. Group formation of previously single-caged adult rhesus macaques for the purpose of environmental enrichment. Journal of Experimental Animal Science 34, 110-115
http://www.awionline.org/Lab_animals/biblio/es34-1.html

"Future group members [same sex, 6 females and 6 males] were given ample opportunity to physically interact with each other on a one-to-one basis and were considered ready for group formation only when they had demonstrated compatibility and clear-cut dominance-subordination relationships." Persistent aggressive interactions made it imperative to disband both groups shortly after group formation.

Rhine RJ, Cox RL 1989 How not to enlarge a stable group of stumptailed macaques (*Macaca arctoides*). In Housing, Care and Psychological Well-being of Captive and Laboratory Primates Segal EF (ed), 255-269. Noyes Publications, Park Ridge, NJ
"The best advice, based on our experience ... is to combine groups, or introduce adult animals, only as a very last resort, and then with great care and assiduous monitoring."

Schapiro SJ, Lee-Parritz DE, Taylor LL, Watson L, Bloomsmith MA, Petto AJ 1994. Behavioral management of specific pathogen-free rhesus macaques: Group formation, reproduction, and parental competence. Laboratory Animal Science 44, 229-234
Initial group formation was amicable. "During the first breeding season, there were outbreaks of severe aggression, leading to the permanent removal of three [of seven] males and 17 [of 50] females."

Stahl D, Herrmann F, Kaumanns W 2001. Group formation of a captive all-male group of lion-tailed macaques *(Macaca silenus)*. Primate Report 59, 93-108
http://www.dpz.gwdg.de/pr/pr59/stahl.pdf
6 adults were brought together simultaneously. They "showed no fights or other serious aggression during the first encounter on the first day. Aggression rates were high only during the first hour after introduction .... Afterwards, the aggression level remained within a similar low level ... The development of the social relationships within the first days suggests that there is a certain degree of social compatibility between male lion-tailed macaques.. .. After four days, the zoo decided to remove Heiner from the group. The animal did not show conspicious aggressive behaviour but it was thought that he was not compatible. .... Four weeks after the group establishment Nepomuk died because of a chronic, subacute gastritis. Two months later, another monkey, Smokie, died because of a bacterial infection. To prevent further risks the group was disbanded at the end of December 1995."

Westergaard GC, Izard MK, Drake JD, Suomi SJ, Higley JD 1999. Rhesus macaque *(Macaca mulatta)* group formation and housing: Wounding and reproduction in a specific pathogen free (SPF) colony. American Journal of Primatology 49, 339-347
Initially small groups were formed consisting of one male and up to eight females. Subsequently larger groups [about 3 males and 21 females] were formed by releasing group members simultaneously or incrementally" When forming rhesus macaque breeding groups from partial groups and strangers, a staged group formation method leads to lower traumatic wounding rates than does a rapid formation method in which all individuals are put together at once. When forming new rhesus macaque breeding groups, divided corrals that provide for social and visual separation of individuals lead to lower rates of traumatic wounding than do undivided corrals."

Orangutans *(Pongo pygmaeus)*

Hamburger L 1988. Introduction of two young orangutans, *Pongo pygmaeus*, into an established family group. International Zoo Yearbook 27, 273-278
Successful re-introduction of two hand reared young orangutans into a family group is described.

Watts E 1997. Introductions. In Orangutan Species Survival Plan Husbandry Manual Sodaro C (ed), 69-84. Atlanta Orangutan SSP (Species Survival Plan), Atlanta, GA
Group integration and re-introduction techniques are described and valuable recommendations made.

Squirrel monkeys *(Saimiri* spp.)

King JE, Norwood VR 1989. Free-environment rooms as alternative housing for squirrel monkeys. In Housing, Care and Psychological Well-being of Captive and Laboratory Primates Segal EF (ed), 102-114. Noyes Publications, Park Ridge
"Individual and gang cages were removed from two conventional colony rooms and the monkeys [11 females and 5 males] were simply released into the rooms. Immediately following the establishment of these two free-environment rooms, a few monkeys incurred sprains and broken teeth, probably resulting from falls. ... Two deaths resulted from attacks by other monkeys."

Mendoza SP 1991. Sociophysiology of well-being in nonhuman primates. Laboratory Animal Science 41, 344-349
The formation of same-sex groups "is rarely accompanied by injurious aggression. Once unisexual groups have stabilized, formation of larger heterosexual groups generally proceeds smoothly."

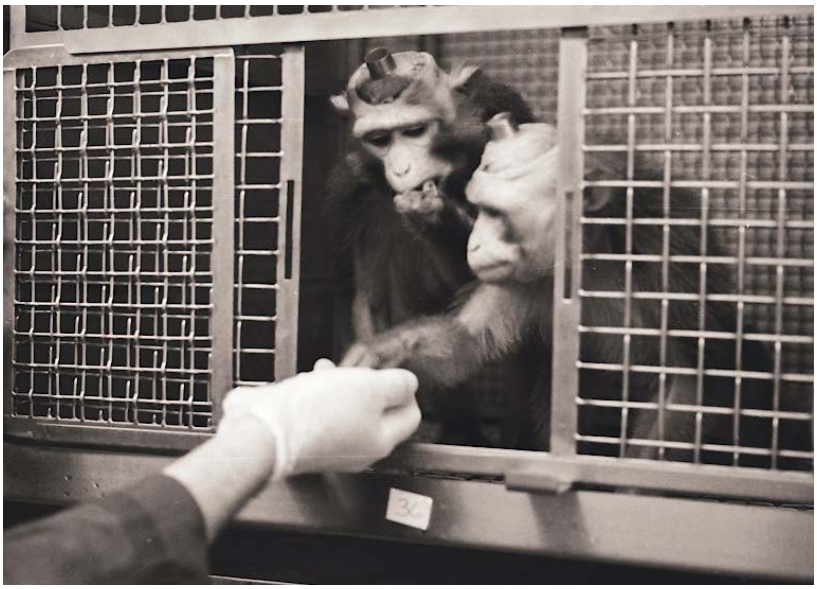
Vermeer J 1997. The formation of a captive squirrel monkey group. International Zoo News 44, 146-149
http://www.awionline.org/Lab_animals/biblio/izn-ver.htm
"It is important that all females of a new [heterosexual] group are related to each other, that is, that they come from the same natal group. The introduction of unfamiliar females to a small group with several females can result in much aggression with severe injury." The minimum number of breeding females in a group should be five to seven. A maximum of two adult males should be added to these females. Groups of up to ten males can be formed without many problems.

Williams LE, Abee CR 1988. Aggression with mixed age-sex groups of Bolivian squirrel monkeys following single animal introductions and new group formations. Zoo Biology 7, 139-145
"When introducing new animals to an established group, the new animals should be unfamiliar with one another so as not to form competing 'teams'. Additions to groups should include enough animals so that aggression from the resident group will be diffused, not concentrated on one or two animals." New groups should be followed for a number of hours, even after an initial decline in agonistic interactions.

Vervet monkeys *(Cercopithecus aethiops)*

Else JG 1985. Captive propagation of vervet monkeys *(Cercopithecus aethiops)* in harems. Laboratory Animal Science 35, 373-375
Animals were placed in ten single-male harem groups. This "resulted in considerable fighting among the females. Each group was gradually reduced over a one year period to 2-4 females with their young. Three adult females died during the [three year] study. All had been under fairly continual harassment."

(2,2,a) Pair-housing: Practical Issues, Time Budget



Baker K, Bloomsmith M, Schoof V, Neu K, Maloney M, Griffis C, Marinez M, Clay A 2005. Compairing pair-housing options for caged rhesus macaques (*Macaca mulatta)*. American Journal of Primatology 66(Supplement), 180 (Abstract)
"Baseline behavioral data were collected on 20 singly-housed adult rhesus macaques, 6 males and 14 females, all mother reared. Isosexual pairs were then formed, and pairs were housed in three form of pair caging balanced for order (6-8 weeks per phase): FC (full contact: sharing adjacent cages), PC (protected contact: access through perforated panels), and IC (intermittent contact: full pairings separated several days/week)." While all forms of pair housing increased affiliative behavior, levels were lower in the protected contact than full contact or intermittent contact housing condition. Levels of inactivity and anxiety-related behaviors were higher in the protected than in the full contact or intermittent contact condition, and full contact reduced anxiety-related behaviors from baseline. Full contact and intermittent contact decreased inactivity and increased aggression which occurred at higher level in the intermittent than in the partial contact housing condition. Abnormal behavior was affected only in females, with a decrease from baseline only in the intermittent, and higher levels in the partial than in the full contact condition. "Results suggest that periodic separation may not detract from the benefits of pair housing for rhesus macaques, but protected contact housing may, balanced only by decreased aggression."

Basile BM, Hampton RR, Chaudhry AM, Murray EA 2007. Presence of a privacy divider increases proximity in pair-housed rhesus monkeys. Animal Welfare 16(1), 37-39
"We observed twenty-five pairs of rhesus macaques (Macaca mulatta) both with and without the presence of a privacy divider. Monkeys spent significantly more time in the same half of the pair-cage when the divider was in place. Subjects were fifty adult rhesus macaque monkeys aged between 5 and 13 years, housed in socially compatible pairs consisting of 18 male/male pairs, 2 female/female pairs, and 5 male/female pairs. We conclude that the increase in proximity associated with the presence of the privacy dividers reflects an increase in social tolerance and/or attraction. A privacy divider may provide a safe haven and give monkeys the ability to diffuse hostile situations before they escalate."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 5.1. Pair Formation and Pair-Housing of Monkeys. Washington, DC: Animal Welfare Institute http://www.awionline.org/pubs/LAREF/soc-hous.html

"The PI who does research with our pair-housed rhesus insists that cage companions be separated during the night and on weekends, so that they cannot fight and injure each other while nobody is around. I would love to keep the animals together also during the night, but cannot argue with the PI because I really don't know if that would jeopardize the safety of the animals. In our facility, compatible companions are allowed to remain together also during the night, on weekends and holidays. This applies for both female and male pairs, as well as for all animals who have head cap implants. It has never happened that we found paired animals injured or bruised when entering their room in the early morning. I think there is no special risk when pairs spend the night together without being supervised.

We also keep our male and female rhesus pairs together 24/7 and encounter no problems related to aggression during the night.

At our facility, after pairs have been established, they are housed together uninterruptedly. This includes male and female isosexual pairs, and each species housed here, including rhesus, pigtails, sooty mangabeys, squirrel monkeys, chimps, and cynos. We have not noticed that paired companions fight during the night, on weekends and holidays when nobody is around."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 5.3.1. Post-Operative Care. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/buffer-post-op

"It is my experience with rhesus macaques that it is advisable to pair-house an animal after surgery as soon as possible with his or her compatible companion. We do this especially with pairs, after one of them had cranial implant surgery. It is the investigator's and my own impression that the animals recover better from the surgery stress when their familiar companion is with them than when they are alone.

Close to 95 percent of our cyno population is pair-housed. The animals are subjected to a lot of orthopedic procedures. There have never been problems with the re-pairing of the animals after surgery. We partition the pairs cage with a transparent panel, which we remove after the treated companion has fully recovered from anesthetic effects (usually 24 hours). It has never happened that animals who had no surgery showed any negative behavioral reactions toward their temporarily probably weaker cage mates."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 8.9. Pair-Housed Monkeys with Head Cap Implants. Washington, DC: Animal Welfare Institute http://www.awionline.org/pubs/LAREF/safety.html#head-caps

"Our university tries to pair all rhesus macaques regardless of cranial implants. Normally the pairs are established before they have undergone surgery for head caps, but we have successfully paired primates after surgery as well. Over a period of ten years, we have had no incidents of damage to the implants. We have more problems, with coils of head caps breaking, in single-housed than in pair-housed rhesus. The head caps of pair-housed animals are cleaner — as they groom each other — than those of individually caged animals.

We have ten pair-housed male rhesus and long-tailed macaques with head caps. The animals were 3 to 6 years old at the time of pair formation. They are presently approximately 10

years old. Some of them had head caps before they were paired, others got them afterwards. It didn't seem to matter. In my experience, pair-housing does not create a risk factor when the animals have head cap implants. In all the time I've been working with these monkeys, they've never damaged one another's head caps."

Brent L 1992. The effects of cage size and pair housing on the behavior of captive chimpanzees. American Journal of Primatology 27, 20 (Abstract)
Paired subjects spent approximately 11% of the observation time in socially directed behaviors.

Coe CL, Rosenblum LA 1984 Male dominance in the bonnet macaque. In Social Cohesion. Essays Toward a Sociophysiological Perspective Barchas PR, Mendoza SP (eds), 31-64. Greenwood Press, Westport
"During the first week [after formation of 5 male/male pairs], the males spent a mean 29 percent of the observation time within arm's reach, engaging in mutual grooming or passive body contact."

Coe CL, Franklin D, Smith ER, Levine S 1982. Hormonal responses accompanying fear and agitation in the squirrel monkey. Physiology and Behavior 29, 1051-1057
Dominant and subordinate partners of male pairs did not differ in their plasma cortisol levels.

Crockett CM 1998. Psychological well-being of captive nonhuman primates. In Second Nature Shepherdson DH, Mellen JD, Hutchins M (eds), 129-152. Smithsonian Institution Press, Washington, DC
"Adult female long-tailed macaques benefit from social enrichment through pairing with other females. Adult males also have social needs, although they are more likely to express them toward females. Many males ignore or behave aggressively toward other males, although some male pairs are highly compatible. Housing longtailed macaque males in paired caging with widely spaced grooming-contact bars prevents aggressive pursuits and increases the success rate of male pairing."

Eaton GG, Kelley ST, Axthelm MK, Iliff-Sizemore SA, Shiigi SM 1994. Psychological well-being in paired adult female rhesus (*Macaca mulatta*). American Journal of Primatology 33, 89-99
Paired females spend in close proximity approximately 80% of the time during the night, and 40% of the time during the day. They engage in social interactions approximately 17% of the time. "Health measures, body weight gains, reproduction and immune responses do not differ between dominant, subordinate, and single-housed females. Paired females spend less time engaged in abnormal behavior than single-housed females."

Gonzalez CA, Coe CL, Levine S 1982. Cortisol responses under different housing conditions in female squirrel monkeys. Psychoneuroendocrinology 7, 209-216
Dominant and subordinate partners of female pairs did not differ in their plasma cortisol levels.

Gwinn LA 1996. A method for using a pole housing apparatus to establish compatible pairs among squirrel monkeys. Contemporary Topics in Laboratory Animal Science 35(4), 61
Pair housing has not interfered with research. "During nine treatments with an identical test compound, singly housed animals lost significantly more weight on average than did pair housed animals."

Hotchkiss CE, Paule MG 2003. Effect of pair housing on operant behavior task performance by rhesus monkeys. Contemporary Topics in Laboratory Animal Science 42(4), 38-40
"In conclusion, pair-housing monkeys is feasible for studies involving operant behavior testing as a model for a variety of complex brain functions. However, housing condition may affect some test parameters, and this effect must be taken into consideration during experimental design."

Jackson MJ 2001. Environmental enrichment and husbandry of the MPTP-treated common marmoset. Animal Technology 52, 21-28
"One disadvantage of isosexual pairing that we have encountered is that temporary separation of the pair (e.g. for behavioural monitoring) can precipitate fighting on re-introduction. If this occurs we have found that a gradual re-association process, utilising adjacent cages to permit visual and audio contact, and supervised free running together, facilitates re-pairing."

McDonald KM, Ratajeski MA 2005. Pair-housing of monkeys on behavioral studies. AALAS 56th National Meeting Official Program, 133 (Abstract)
"After periods of separation, we did not observe the animals to act aggressively towards one other when re-paired, and injury to head holder implants was never observed."

Murray L, Hartner M, Clark LP 2002. Enhancing postsurgical recovery of pair-housed nonhuman primates (*M. fascicularis*). Contemporary Topics in Laboratory Animal Science 41(4), 112-113 (Abstract)
"In many facilities, postsurgical protocol in the nonhuman primate requires individual housing for a period of 2-10 days. ... Our goal was to allow [15 adult females] same-day return of the postoperative [placement of vascular access port] candidate to its paired environment. ... Change in hierarchy status, self-traumatic events, weight loss or diarrhea did not occur in any of these animals, and the incision sites healed unremarkably. The animals ate and drank normally, and received their postoperative treatments without problem (readily accepted oral medication). .. We conclude that this practice of quick return to group status postoperatively can be successfully employed, and it is a "best practice" when working with these laboratory animals."

Majolo B, Buchanan-Smith H 2001. Psychological wellbeing of common marmoset *(Callithrix jacchus)* females living in same-sex pairs. Primate Eye 74, 9-10
http://www.psgb.org/Meetings/Spring2001.html
The behaviour of female pairs of common marmosets resembles that of females living in family groups suggesting that this method of housing does not compromise their welfare."

Reinhardt V, Cowley D, Eisele S, Vertein R, Houser WD 1988. Pairing compatible female rhesus monkeys for the purpose of cage enrichment has no negative impact on body weight. Laboratory Primate Newsetter 27(1), 13-15
http://www.brown.edu/Research/Primate/lpn27-1.html#pair
“Keeping singly housed adult female rhesus monkeys in compatible pairs for the purpose of cage enrichment does not affect the animals' general health status as reflected in body weight."

Reinhardt V, Dodsworth R 1989. Facilitated Socialization of Previously Single Caged Adult Rhesus Macaques (videotape with accompanying text). Wisconsin Regional Primate Research Center, Madison, WI
Thirty scenes depict different adult rhesus monkeys [and one adult, male stump-tailed macaque], each paired with a compatible companion for up to two years. The following pair combinations and research situations are shown: adult male/male, adult female/female, adult male/juvenile male, adult female/juvenile female; experiments requiring headcap implants, tethering, or in-

home cage blood collection. Presenting for in-homecage injection. Paired companions interact with each other in various species-typical ways (e.g., grooming, huddling, mounting, playing, yielding, sharing food) and make use of perches and gnawing sticks. "Representing an every-changing, yet predictable stimulus, a compatible companion does not lose its boredom-reducing value over time."

Reinhardt V, Houser WD, Eisele S 1989. Pairing previously singly caged rhesus monkeys does not interfere with common research protocols. Laboratory Animal Science 39, 73-74
"Our experiences indicate that facilitated socialization of previously singly caged rhesus monkeys offers an inexpensive method of environmental enrichment that is practicable under common management situations and numerous research conditions."

Reinhardt V 1990. Time budget of caged rhesus monkeys exposed to a companion, a PVC perch and a piece of wood for an extended time. American Journal of Primatology 20, 51-56
After 1.5 years paired partners spent an average of 23.5% of the time interacting with the companion. Females were socially more active than males.

Reinhardt V, Cowley D, Scheffler J, Vertein R 1990. Living continuously with a compatible companion is not a distressing experience for rhesus monkeys. Laboratory Primate Newsletter 29(2), 16-17
http://www.brown.edu/Research/Primate/lpn29-2.html#rhesus
Paired females had serum cortisol concentrations that did not differ from single-housed females. "Dominant animals had cortisol concentrations that did not differ from those of their subordinate companions, indicating that neither dominant nor subordinate partners experienced social distress."

Reinhardt V 1991. Social enrichment for aged rhesus monkeys that have lived singly for many years. Animal Technology 43, 173-177
http://www.awionline.org/Lab_animals/biblio/at173.htm
"There is widespread concern that aged rhesus monkeys who have been housed singly for a long time would do better living alone than sharing a cage with a companion. Ten female and five male rhesus monkeys, 22 to 33 years old and deprived of physical contact with any other conspecific for more than 10 years, were socialized with weaned infants or with each other using two standard methods of pairing. Pairs were compatible in every case throughout a one year follow-up period."

Reinhardt V, Pape R, Zweifel D 1991. Multifunctional cage for macaques housed in pairs or in small groups. American Association for Laboratory Animal Science Bulletin 30(5), 14-15
Double-cage units were modified to provide optimal housing conditions for pair-housed macaques. Perch installation allows normal operation of the squeeze-back; a privacy panel offers visual seclusion.

Reinhardt V, Reinhardt A 1991. Impact of a privacy panel on the behavior of caged female rhesus monkeys living in pairs. Journal of Experimental Animal Science 34, 55-58
http://www.awionline.org/Lab_animals/biblio/es34-5~1.htm
"Paired partners spent significantly more time in close proximity when the privacy panel was provided. At the same time, they were more engaged in affiliative interactions while the incidence of agonistic interactions tended to decrease."

Reinhardt V, Hurwitz S 1993. Evaluation of social enrichment for aged rhesus macaques. Animal Technology 44, 53-57
http://www.awionline.org/Lab_animals/biblio/at44.htm
The 31-36 years old "subjects preferred to stay in close proximity with their companion even though this reduced their available cage space. They spent on average 21% of the time interacting with the companion. Sharing a cage with a compatible conspecific did not jeopardize the subjects' general health, as reflected in their body weight development."

Reinhardt V 1994. Social enrichment for previously single-caged stumptail macaques. Animal Technology 5, 37-41
http://www.awionline.org/Lab_animals/biblio/at37.htm
Female pairs and male pairs engaged in non-injurious species-typical activities 25% and 17% of the time.

Reinhardt V 1994. Continuous pair-housing of caged *Macaca mulatta*: Risk evaluation. Laboratory Primate Newsletter 33(1), 1-4
http://www.brown.edu/Research/Primate/lpn33-1.html#vic
"Pairs were compatible in 88% of cases during the follow-up period of 1 to 6.3 years. There were no indications that long-term compatibility of male pairs was less than that of female pairs."

Reinhardt V 1994. Pair-housing rather than single-housing for laboratory rhesus macaques. Journal of Medical Primatology 23, 426-431
http://www.awionline.org/Lab_animals/biblio/jmp23.htm
First-year compatibility was 88% in adult female-female pairs, 80% in adult male-male pairs. Adult-infant pairs were compatible in 92% of 15 male-infant pairs, and in 94% in 65 female-infant pairs. The incidence of serious injury was 0.7% (2/272) during the first year after pair formation.

Reinhardt V 1996. Frequently asked questions about safe pair-housing of macaques. Animal Welfare Information Center Newsetter 7(1), 11
http://www.nal.usda.gov/awic/newsletters/v7n1/7n1reinh.htm
Nine frequently asked questions regarding safe pair-housing protocols for macaques are addressed.

Reinhardt V, Reinhardt V 2000. Meeting the "social space" requirements of pair-housed primates. Laboratory Primate Newsletter 39(1), 7
http://www.brown.edu/Research/Primate/lpn39-1.html#vik
"Social space is the space required by a subordinate partner to buffer potential social tension, by increasing the distance to a dominant counterpart. At a minimum, pair-housed animals should be allocated at least twice the cage space that is legally required for single-housing."

Reinhardt V 2002. Addressing the social needs of macaques used for research. Laboratory Primate Newsletter 41(3), 7-10
http://www.brown.edu/Research/Primate/.lpn41-3.html#vik
"The present paper summarizes the author's experiences transferring a colony of rhesus macaques (Macaca mulatta) from individual- to pair-caging. ... The implementation of pair-housing as standard caging at Wisconsin RPRC was not excessively expensive in terms of work time and material. It was not a hindrance to active research; rather it improved the animals' behavioral health and made them more species-representative research models. A total of 726

pairs were formed involving 817 different animals, yet no indication was found that this rendered research data collected from them useless due to confounding variables such as stress or disease."

Roberts SJ, Platt ML 2005. Effects of isosexual pair-housing on biomedical implants and study participation in male macaques. Contemporary Topics in Laboratory Animal Science 44(5), 13-18

"Social housing has been shown to contribute to the psychological well-being and physical health of captive primates, and this factor has led to United States Department of Agriculture guidelines requiring facilities to address the social needs of primate species known to live socially in nature as long as doing so does not endanger the animals or interfere with research goals. Although pair-housing is the best way to provide social enrichment, many researchers and facilities are hesitant to implement it, particularly in biomedical research contexts where implanted devices or behavioral performance might be compromised. In order to study the effects of pair-housing on biomedical implants and study participation, we collected data from a group of isosexually pair-housed male macaques (adult and subadult) with 1) cranial and eye implants and 2) controlled access to water as means of motivating subjects to participate in psychophysical studies. Implants, study participation, and weight gain were not adversely affected by pair-housing. Our results support the use of pair-housing as social enrichment for macaques with biomedical implants and controlled access to water." Consistent directional dominance behavior served to assess potential partner compatibility. Of 15 rhesus diads, 12 [80%] were compatible. One cyno diad was also tested and was compatible. Compatibility was ascertained over a period of 0.8 - 3.3 years." One monkey, however, occasionally exhibited noninjurious self-biting when someone other than his usual handler took him out of his cage, and two other monkeys occasionally placed in their cages when agitated."

Schapiro SJ, Bloomsmith MA, Kessel AL, Shively CA 1993. Effects of enrichment and housing on cortisol response in juvenile rhesus monkeys. Applied Animal Behaviour Science 37, 251-263
"Social housing condition [single vs. pair] also did not affect cortisol."

Schapiro SJ, Bloomsmith MA, Porter LM, Suarez SA 1996. Enrichment effects on rhesus monkeys successively housed singly, in pairs, and in groups. Applied Animal Behaviour Science 48, 158-172
"Subjects were more socially oriented when pair-housed than when living in small groups. Subjects used enrichment less frequently when housed in groups. The data suggest that the presence of a social partner(s) led to more beneficial changes in behavior than did the provision of inanimate enhancements."

Sheehan J, Ziegelhofer T, Henn S, Miyamoto M, Vanterpool I 2005. A novel caging method for collecting telemetry data from pair-housed monkeys. AALAS [American Association for Laboratory Animal Science] 56th National Meeting Official Program, 117 (Abstract)
Caging method is described that allows telemetric measurements [ECG and blood pressure] of long-tailed macaques housed in pairs. "The first method consisted of modifying the current cages to add a wire mesh tunnel constructed above the two adjacent cages, with sliding doors on either end so the monkeys could be intermittently paired. The second method for improvement with these modified cages was to compare results if we permanently placed a telemetered and a non-telemetered pair of monkeys in the cages and collected data using the distributed receiver array which allows for two receivers to be configured to one animal." No differences were noted in the data collected nor were any artifacts created by application of the second uninterrupted pair-housing method.

Shively CA 2001. Psychological well-being of laboratory primates at Oregon Regional Primate Research Center. Web site link in Willamette Week March 21, 2001
http://www.wweek.com/html2/shivreport.html
"I was exposed to no protocols that required social isolation during my visit to the ORPRC. Rather, investigators were not giving priority to the social needs of the monkeys. For example, monkeys in virus studies at other institutions are housed socially with animals with similar virus load. Animals on timed mating protocol do not need to be housed alone. Animals in protocols requiring food restriction can be pair housed and separated from cagemates for 8 hrs during the day when food is accessible. They can be socially housed the other 16 hrs/day. ... The IACUC should use its authority to decline approval of protocols that do not demonstrate a detailed defense of single caging."

Yanagihara Y, Matsubayashi K, Matsuzawa T 1994. Environmental enrichment in Japanese monkeys: Feeding device [Japanese text with English summary]. Primate Research 10, 95-104
"The two monkeys spent the night in same living unit, while they spontaneously separated from each other in the different units during feeding time.

(2,2,b) Pair-housing: Pair formation

Baboons *(Papio* spp.)

Bourgeois SR, Brent L 2005. Modifying the behaviour of singly caged baboons: evaluating the effectiveness of four enrichment techniques. Animal Welfare 14, 71-81
Seven singly caged adolescent [mean age: 4.2 years] male baboons were studied. Pairs were formed by introducing sedated partners in the same cage. "Pairing was successful for all seven individuals, with no serious injuries or overt aggression observed."

Jerome CP, Szostak L 1987. Environmental enrichment for adult, female baboons (*Papio anubis*). Laboratory Animal Science 37, 508-509
"Each baboon was placed in a cage with another baboon for 3-4 hours, two or three times per week. The same pairs consistently visited each other in either animal's cage. No significant aggression occurred."

Gorillas *(Gorilla* spp.)

Gould JE 1990. Conspecific introduction, socialization, and attempts to breed a solitary-raised, silverback male gorilla. Proceedings of the Columbus Zoo Gorilla Workshop, 56-79
"His introduction to the adult female conspecific Muke was very successful." The careful pair formation procedure is described.

Macaques *(Macaca* spp.)

Abney DM, Weed JL 2006. Methods for successfully pair housing adult male rhesus macaques (*Macaca mulatta*). American Journal of Primatology 68(Supplement), 59 (Abstract)
The successful same-sex pairing of 34 male rhesus macaques is described. "Animals were socialized in different age combinations, consisting of adult/adult, adult/sub-adult, and adult/juvenile. .. The pairs started with a clear panel, allowing the animals to see one another, but not touch. Next, they were given a mesh panel, which allowed finger touch access. Grooming bars were the final panel used before the pair was given full, un-restricted access. Pairs were deemed successful if no serious fighting or injury occurred within one weeks time. Out of 56 rhesus socializations attempted which included at least one adult, 34 were successful (61%)."

Anonymous 2006. Pair formation and reintroduction of temporarily separated partners — A discussion on the Laboratory Animal Refinement & Enrichment Forum. Laboratory Primate Newsletter 45(1), 11-12
http://www.brown.edu/Research/Primate/lpn45-1.html#pair
"To sum up, it seems advisable to monitor the reintroduction of temporarily separated partners very carefully, and if possible, to allow the animals to first recognize each other before they are reunited as a pair. There is no good reason to believe that male cynos are less suitable for isosexual pair-housing than rhesus. If and how experimentally-induced pathophysiological processes affect the compatibility of pairs needs to be explored."

Byrum R, St. Claire M 1998. Pairing female *Macaca nemestrina*. Laboratory Primate Newslettere 37(4), 1
http://www.brown.edu/Research/Primate/lpn37-4.html#byrum
Twenty-four adult pig-tailed macaques were successfully transferred from single- to pair-housing arrangements following the establishment of rank relationships during a semi-contact familiarization period. "We have observed no serious fighting and wounding in our pairs, neither at the moment of introduction nor during follow-up observations of up to two years."

Coe CL, Rosenblum LA 1984 Male dominance in the bonnet macaque. In Social Cohesion. Essays Toward a Sociophysiological Perspective Barchas PR, Mendoza SP (eds), 31-64. Greenwood Press, Westport, CT

"The establishment of dominance relations occurred at pair formation. The aggressive incidents were limited, usually involving threats and pursuit behavior. .. More typically, one animal submitted and indicated his subordinate status through communicative gestures. In the first week following pair formation, the occurrence of aggressive behavior subsided almost entirely."

Crockett CM, Bowers CL, Bowden DM, Sackett GP 1994. Sex differences in compatibility of pair-housed adult longtailed macaques. American Journal of Primatology 32, 73-94
Newly formed pairs were separated for 17 hrs and subsequently reintroduced daily during a 23-day study. No female pair but seven [47%] male pairs were separated because of fighting and wounding.

Crockett CM, Lee GH, Thom JP, Bentson KL 2005. Does temperament similarity predict compatibility of same-sex and opposite-sex rhesus macaques paired in grooming/contact? American Journal of Primatology 66(Supplement), 58 (Abstract)
Partner compatibility was not significantly associated with temperament.

Doyle LA, Baker KC, Cox LD 2008. Physiological and behavioral effects of social introduction on adult male rhesus macaques. American Journal of Primatology 70, 1-9
Potential partners of four adult rhesus macaque pairs were first familiarized in cages in which partners were separated by a panel consisting of bars spaced 2 cm apart. The eight males were all implanted with biotelemetry devices for remote heart rate monitoring. After 24 hours, as neither persistent aggression nor wounding was observed, each pre-familiarized pair was introduced into full contact by removing the barred panel. All four introductions were successful and subjects showed no physiological (fecal cortisol concentration and heart rate) or behavioral signs (pathological behavior) of stress, or psychological indices of distress (depressive/anxiety-related behavior) not only during the introduction process but also over a follow-up period of 18 months. No overt aggression was displayed at all during the first two hours following pair formation. Aggressive interactions were minimal thereafter. Only one bite laceration was incurred 14 weeks after pair formation. The partners of this pair were maintained in the home cage with the barred panel to allow wound healing; they were subsequently placed again into full contact with no further complications. "The results of this study may be of practical use for designing and monitoring social introductions and suggest that managers should not dismiss the feasibility of successful pairing of adult male rhesus macaques."

Eaton GG, Kelley ST, Axthelm MK, Iliff-Sizemore SA, Shiigi SM 1994. Psychological well-being in paired adult female rhesus (*Macaca mulatta*). American Journal of Primatology 33, 89-99
Partners were paired after noncontact familiarization. Pairs were compatible in 86% of 21 cases.

Line SW, Morgan KN, Markowitz H, Roberts J, Riddell M 1990. Behavioral responses of female long-tailed macaques (*Macaca fascicularis*) to pair formation. Laboratory Primate Newsletter 29(4), 1-5
http://www.brown.edu/Research/Primate/lpn29-4.html#line
Potential partners were familiarized in a noncontact situation prior to pairing. Five of six pairs tested were compatible during a five to six months study period.

McLean M, Morris J, Watson E, Gavetti D, Marshall S 2006. Retrospective evaluation of pair-housing juvenile and adult cynomolgus macaques in a pharmaceutical environment. AALAS 57th National Meeting Official Program, 148 (Abstract)
"Our experience and data suggest that pair formation in juvenile and adult cynomolgus male and female macaques has been successful and as allowed us to provide social housing in a pharmaceutical environment."

McMillan J, Maier A, Tully L, Coleman K 2003. The effects of temperament on pairing success in female rhesus macaques. American Journal of Primatology 60(Supplement), 95 (Abstract)
"We assessed temperament in these monkeys, along with their two partners, by measuring their reaction to novel objects (e.g., a brightly colored novel toy) presented to them in their home cages. Every monkey received a score from 0-6 based on her reaction to the novelty. .. Temperament scores were more similar between the focal monkeys and their successful partner than their unsuccessful partner. These results suggest that assessing temperament with a simple testing paradigm may be useful in forming successful pairs."

Niemeyer C, Eaton, GG, Kelley ST1998. Practical aspects of the program to promote psychological well-being in nonhuman primates at the Oregon RPRC. In Proceedings of the Third International Conference on Environmental Enrichment Hare VJ, Worley E (eds), 345-354. The Shape of Enrichment, San Diego, CA
"New pairs are formed by moving both [pre-familiarized] individuals to a new location because monkeys housed in individual cages appear to become territorial about their cages."

Reaves ME, Cohen J 2005. Primate pairing under less than ideal circumstances. Tech Talk 10(5), 1-2
"Of the six male cynomolgus monkeys in our group, we were able to create three stable pairs. The animals share food, and although we have had some minor bumps and bruises, there have been no serious injuries. We later reproduced these results with our vervet colony and after the quarantine process with all new arrivals."

Reinhardt V, Houser WD, Eisele S, Champoux M 1987. Social enrichment with infants of the environment for singly caged adult rhesus monkeys. Zoo Biology 6, 365-371
http://www.awionline.org/Lab_animals/biblio/zb6-365.htm
"Twenty-nine weaned rhesus monkey infants were removed from breeding troops to avoid overcrowding and were placed with unfamiliar singly caged adults... Pairs were compatible in 90% of cases. Compatibility depended neither on the sex, age, and origin of the adult nor on the sex of the infant."

Reinhardt V 1989. Behavioral responses of unrelated adult male rhesus monkeys familiarized and paired for the purpose of environmental enrichment. American Journal of Primatology 17, 243-248
"Potential companions were first given the opportunity to establish clear-cut rank relationships during a 5-day period of noncontact familiarization. Only then were they paired in a different double cage. Rank relationships were confirmed within the first 6 minutes after pairing without the occurrence of any biting and fighting. It stands to reason that the risk of injury, intrinsically associated with pairing, can be minimized if only those dyads are selected whose partners show unequivocal signs of an established rank relationship during a period of noncontact familiarization."

Reinhardt V 1991. Agonistic behavior responses of socially experienced, unfamiliar adult male rhesus monkeys (*Macaca mulatta*) to pairing. Laboratory Primate Newsletter 30(1), 5-7
http://www.brown.edu/Research/Primate/lpn30-1.html#vik
"The present data demonstrate that unfamiliar adult male rhesus monkeys may generally be paired directly with each other without undue risk provided partners have previously lived with another male companion. This is congruent with the findings made with adult females."

Reinhardt V 1994. Social enrichment for previously single-caged stumptail macaques. Animal Technology 5, 37-41
http://www.awionline.org/Lab_animals/biblio/at37.htm
10 females and 6 males were isosexually introduced following the establishment of rank relationships during a three-day non-contact familiarization period. "Pair formations did not entail serious antagonism; instead companions engaged in conciliatory interactions."

Watson LM 2002. A successful program for same- and cross-age pair-housing adult and subadult male *Macaca fascicularis*. Laboratory Primate Newsletter 41(2), 6-9
http://www.brown.edu/Research/Primate/lpn36-2.html#watson
Isosexual pairs of adult males, adult male/juvenile male and adult females were established and pair compatibility ascertained throughout follow-up periods of 1 month to 3 years. Partners were introduced after a supervised noncontact familiarization period in a specific pair formation cage. Of 31 adult male pairs tested, 29 [94%] were compatible; two pairs had to be separated because "one animal in each pair sustained injuries during minor fighting."

Marmosets (*Callithrix* spp.)

Majolo B, Buchanan-Smith HM, Morris K 2001. Factors affecting the successful pairing of unfamiliar common marmoset *(Callithrix jacchus)* females. Primate Eye 73, 12-13 (Abstract)
http://www.psgb.org/Meetings/Winter2000.html
46 marmoset female pairs were formed. "The success rate was 83%. ... Aggression is lower if one member of the pair is not yet sexually mature... Pairing unfamiliar common marmoset females can be accomplished safely to avoid single housing when natural social grouping is not feasible."

Squirrel monkeys *(Saimiri* spp.)

Gwinn LA 1996. A method for using a pole housing apparatus to establish compatible pairs among squirrel monkeys. Contemporary Topics in Laboratory Animal Science 35(4), 61 (Abstract)
Successful pair formation protocol in a pole-and-collar housing system is described.

Vervet monkeys *(Cercopithecus* spp.)

Dansie C, Galvao AV, McKain J, Despain KE 2004. African Green nonhuman primate enrichment. AALAS 55th National Meeting Official Program, 129 (Abstract)
"Selected pairs are housed with plexi-panels between them for at least one week. At the end of this adaptive periods, pairs are allowed access to each other by removal of the grated panels separating them for a supervised period of one hour. The daily amount of time monkeys access each other is increased gradually until transition to pair-housing is complete."

Gerald MS, Weiss A, Ayala JE 2006. Artificial colour treatment mediates aggression among unfamiliar vervet monkeys (*Cercopithecus aethiops*): a model for introducing primates with colourful sexual skin. Animal Welfare 15(4), 363-369
"Painting the scrotum dark led to more aggression when these males were paired with dark coloured males and less aggression when these males were paired with pale coloured males. These findings suggest a practical and inexpensive means of reducing the likelihood of aggression when introducing new animals."

(2,3) Grooming-Contact Caging

Crockett CM, Bellanca RU, Bowers CL, Bowden DM 1997. Grooming-contact bars provide social contact for individually caged laboratory macaques. Contemporary Topics in Laboratory Animal Science, 53-60
Pair formation of adult long-tailed macaques was accomplished by using widely spaced, vertical grooming-contact bars that allow physical contact [but no copulation] but prevent pursuit by one animal into the other's cage. Pair compatibility was 100% in all cases except unfamiliar male pairs (86%).

Crockett CM, Koberstein D, Heffernan KS 2001. Compatibility of laboratory monkeys housed in grooming-contact cages varies by species and sex. American Journal of Primatology 54(Supplement), 51-52 (Abstract)
"Grooming contact is achieved through widely spaced vertical bars that permit grooming but not aggressive pursuit."
The following pair compatibility was found:
Macaca fascicularis: male-female 97%, female-female 89%, male-male 63%
Papio cynocephalus: male-female 88%, female-female 57%
M. nemestrina: male-female 78%, male-male 57%%, female-female 53%
M. mulatta: male-male 45%. "The majority of male-male pairs involved juveniles, so MM compatibility percentages may overestimate compatibility of adult male pairs."

Crockett CM, Lee GH, Thom JP 2006. Sex and age predictors of compatibility in grooming-contact caging vary by species of laboratory monkey. International Journal of Primatology 27(Supplement), 417 (Abstract)
Adult rhesus pairs were significantly less likely to be fully compatible (16%) than adult baboon pairs (64%), adult pig-tailed pairs (51%) and adult long-tailed pairs (67%).

(2,4) Positive Interaction with Humans

Abney D, Conlee K, Cunneen M, Down N, Lang T, Patterson-Kane E, Skoumbourdis E, Reinhardt V 2006. Human-animal relationship in the research lab: a discussion by the Refinement and Enrichment Forum. Animal Technology and Welfare 5(2), 95-98
http://www.awionline.org/Lab_animals/biblio/atw11.html
"I think an affectionate human-animal relationship makes a huge difference for the animals because it helps them overcome anxiety and fear in disturbing or distressing situations." "The stress resulting from a neutral or negative relationship between investigator/technician and animal is bound to affect the research data collected from the animal subject, but the research industry is not yet taking this methodological flaw seriously."

Anonymous 2006. Primate passion — An interview with Karen MacLeod, RVT, AALAS Northern California Branch Technologist of the Year 2006. Lab Animal 35(9), 6
When asked how she deals with attachment to animals in her care: "Its hard because I am passionate about what I do and because our animals are long-term. It is important to be attached and there are certainly days when I am in tears, but I think if I ever felt unaffected by euthanizing our animals, it would be time for me to leave. As hard as it is to be passionate about what I do, I think it is a serious job requirement."

Anonymous 2003. Personnel / Animal Relationships: Affectionate or Neutral: A Discussion. Laboratory Primate Newsletter 42(1), 14-15
http://www.brown.edu/Research/Primate/lpn42-1.html#relation
"Having a close relationship with your animals is necessary to regard them as living beings, rather than biological test tubes. As such, you are more careful and patient, and will think more about what the procedures mean to the animals. You will get more creative in finding animal friendly alternatives for the procedures you need to do on the animals. You will thus increase the well-being of your animals and, by doing so, make better research subjects and increase the validity of the test results. .. There was a consensus that the emotional attachment provides an assurance that the animals receive optimal care, both physically and behaviorally. .. Concern was expressed that establishing an affectionate relationship with experimental subjects and knowing them as individuals would hamper ones impartiality and capacity to be objective when observing and registering their behavior. A caregiver strongly objected: It seems to me that we get hung up on trying to divorce our emotions from what we hope to be our objectivity. I do not think that any normally functioning human being in the world does anything for any reason other than emotional. Sure, research is done to answer questions, but isn't the premise of all research to make human (or animal) lives better? If you want to make lives better, it's because of emotion, not because you are logically attached to life."

Baker KC 1997. Human interaction as enrichment for captive chimpanzees: A preliminary report. American Journal of Primatology 42, 92 (Abstract)
Simple, unstructured affiliation between humans and chimpanzees has a powerful impact on well-being, promoting activity and relaxed conspecific interactions and ameliorating behavioral disorders.

Bayne K 2002. Development of the human-research animal bond and its impact on animal well-being. ILAR [Institute for Laboratory Animal Research] Journal 43(1), 4-9
http://dels.nas.edu/ilar_n/ilarjournal/43_1/Development.shtml

The various roots of human-animal bonding in the research laboratory setting are reviewed. "The development of these relationships is enriching to both personnel and animals inasmuch as people who care about their animals are committed to promoting and ensuring the well-being of those animals."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 2.3.1. Affection for Animals. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/basic.html#rel
"Animal care personnel and researchers should be encouraged to develop affectionate relationships with their animals. Having such a relationship assures that you regard the animals as living beings, rather than biological test tubes. As such, you will be more careful and more patient. You will think more about what the experimental procedure implies to the animals. You will get more creative in refining procedures that are normally stressful or distressing to the animals. You will thus enhance their well-being and, by doing so, you will increase the scientific validity of the research results.

If you are not kind to your animals, make no attempt to enrich their boring, often depressing living quarters by addressing species-typical behavioral and social needs, and never show any kind of affection towards them (for example by offering them food treats from time to time), then I really don't think that you should work in an animal research laboratory."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 2.3.2. Giving Animals Names. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/basic.html#name
"Naming the animals helps me realize that I am working with sentient beings who deserve my consideration of their well-being. I guess, we can all relate much better to names than to numbers, and we tend to treat named versus numbered animals accordingly. The naming of animals in research labs could serve as a safeguard for optimal animal care.

We have an investigator who is against the naming of rabbits assigned to her research protocol. The PI is afraid that, when bonding with her research subjects, we add a variable that is detrimental to performing research. Our staff feels that this is an antiquated mentality and we are all standing strong in our position of naming all animals in our charge!"

Bayne K, Dexter SL, Strange GM 1993. The effects of food treat provisioning and human interaction on the behavioral well-being of rhesus monkeys *(Macaca mulatta)*. Contemporary Topics in Laboratory Animal Science 32(2), 6-9
"The effects of human interaction and food supplementation appear to be protracted, resulting in a reduction of pathology [behavioral disorders] even after the enrichment is removed."

Bennett BT 1990. Alternative methodologies. In Essentials for Animal Research: A Primer for Research Personnel Bennett BT, Brown MJ, Schofield JC (eds), 13-25. National Agricultural Library, Beltsville, MD
http://research.ucsb.edu/connect/acc/esalt.htm
"Almost every animal commonly used in the laboratory responds positively to a little tender loving care. It's inexpensive, readily portable, safe even at the highest doses and spreads rapidly through the staff."

Boccia ML, Broussard C, Scanlan J, Laudenslager ML 1992 Practice makes predictable. In The Inevitable Bond Davis H, Balfour AD (eds), 153-170. Cambridge University Press, Cambridge, UK
"In our laboratory, we have made it a point to minimize the human-animal interactions, assuming that by minimizing interactions, we optimize experimental conditions by eliminating confounding handling effects. The results presented here, however, suggest that it may be necessary to reverse this thinking."

Choi GC 1993. Humans enrich the lives of lab baboons. WARDS Newsletter Summer, 3-7 & 13
"The reduction in cage painting and banging was dramatic and remarkable" after the single-housed animals received more attention from the attending personnel.

European Economic Community 1986. Council Directive 86/609, Annex II Guidelines for Accommodation and Care of Animals. Official Journal of the European Communities L358, 7-28
http://www.uku.fi/laitokset/vkek/Sopimus/convention.html
"The performance of an animal during an experiment depends very much on its confidence in man, something which has to be developed. It is therefore recommended that frequent contact should be maintained so that the animals become familiar with human presence and activity."

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK
http://scienceandresearch.homeoffice.gov.uk/animal-research/legislation/
"Where appropriate, time should be set aside for handling and grooming. All staff, both scientific and technical, should be sympathetic, gentle and firm when dealing with the animals."

Jensvold ML 2007. Promoting positive interactions between chimpanzees (*Pan troglodytes*) and caregivers. Laboratory Primate Newsletter 46(1), 1-4
"We tested our contention that when caregivers use chimpanzee behavior, more positive interactions result.

Mahoney CJ 1992. Some thoughts on psychological enrichment. Lab Animal 21(5), 27,29,32-37
"A spark of compassion in any one person towards the animals can be fanned into flames of empathy with the right encouragement, without destroying the primary research goals. In my experience [as attending veterinarian] it is utterly impossible, however, to make an uncaring person caring. Such people are not suited for this line of work (p. 35). .. There should be no sharp demarcation between 'good guys' and 'bad guys.' All employees, to some extent must share the work. Nonhuman primates are quick to forget, or perhaps forgive, the momentary fear or resentment they feel towards a human being who has just subjected them to an unpleasant experience if a strong bond of trust already exists with that person."

Morton DB, Jennings M, Buckwell A, Ewbank R, Godfrey C, Holgate B, Inglis I, James R, Page C, Sharman I, Verschoyle R, Westall L, Wilson AB 2001. Refining procedures for the administration of substances. Laboratory Animals 35, 1-41
"Where substances are administered infrequently but on a long-term basis handling the animals during routine daily husbandry will help reduce stress when subsequently dosing them. In general, staff should be encouraged to handle animals as much as possible."

National Research Council 1996. Guide for the Care and Use of Laboratory Animals National Academy Press, Washington, DC
http://www.nap.edu/books/0309053773/html/

"The animal technician's and caregiver's roles are pivotal to the social support of primates, particularly animals that are singly caged. ... When they must be housed alone, other forms of enrichment should be provided to compensate for the absence of other animals, such as safe and positive interaction with the care staff."

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://fermat.nap.edu/books/0309052335/html/index.html
"Interactions between humans and nonhuman primates can be made less stressful by adherence to routine schedules and procedures, familiarity with handlers and researchers through positive interactions outside [sic] the handling context."

Reese EP 1991. The role of husbandry in promoting the welfare of laboratory animals. In Animals in Biomedical Research Hendriksen CFM, Koeter HBWM (eds), 155-192. Elsevier, Amsterdam, The Netherlands
"An important, and often neglected, source of social enrichment, especially when animals must be isolated from conspecifics, is attention from caretakers and technicians. That many scientists lack detailed information about their animals, especially their behavior, is distressing and reflects a serious disregard for the single most important element of their research. The animal is the key to the entire experiment. ... The proper handling of laboratory animals is as essential to the collection of valid data as it is to the animals' comfort and well-being. The more the animal is handled properly, the more docile it becomes, especially if handling begins at an early age. Conversely, the more an animal is mishandled, the more difficult, frightened, and aggressive it is likely to become ... Successful shaping requires the right attitude, a thorough understanding of the individual animal and of the task to be performed, and clinical skills. There is only one 'right' attitude, and that is respect for the individual animal. ... My students must name their animals, and I do not let them put an animal in the apparatus until they show me it will eat from their hands."

Reinhardt V 2003. Compassion for animals in the laboratory: Impairment or refinement of research methodology. Journal of Applied Animal Welfare Science 6, 123-130
http://www.awionline.org/Lab_animals/biblio/jaaws10.html
"Compassion for animals used in research, testing and teaching should not be regarded as subjective but as a sound methodological base for scientifically valid animal research."

Russow L-M 2002. Ethical implications of the human-animal bond. ILAR Journal 43(1), 33-37
http://dels.nas.edu/ilar_n/ilarjournal/43_1/Implications.shtml
"Researchers must continue to question the barriers that have traditionally been errected against forming HABs in the name of objectivity and to investigate seriously the ways in which fostering the formation of HABs can promote animal welfare without compromising the scientific respectability of research."

Sokol KA 1993. Commentary: Thinking like a monkey - "primatomorphizing" an environmental enrichment program. Lab Animal 22(5), 40-45
"We encouraged animal caretakers to visit the animals at times other than their normal routines to reinforce positive interactions and associations. Instead of identifying the monkeys by just a tattoo number, we gave them names. Thus, we could refer to them as individuals and better identify them."

Southey ER, Baldwin CM 2006. Socialisation of rhesus macaques at CFM. Animal Technology and Welfare 5(2), 119-122
The Centre for macaques in England is an example of best practice in the care and welfare of old world primates in addition to an evolving centre for the education and training of people working in the area of primate research. Husbandry techniques and socialisation of the macaques are described. Socialisation comprises of hand feeding through cage room and lobby bars, going into the playpen to hand out food and sitting in with the animals and interacting on a closer basis.

Wolfle TL 1987. Control of stress using non-drug approaches. Journal of the American Veterinary Medical Association 191, 1219-1221
"Human interaction with monkeys and apes is essential for the well-being of the animal, data validity, and ease of handling." The 'social bond' "conveys to the animal a quiet sense of assurance on which coping strategies can be developed for dealing with other stressful aspects of the laboratory."

Wolfle TL 2002. Introduction. ILAR [Institute for Laboratory Animal Research] Journal 43(1), 1-3
http://dels.nas.edu/ilar_n/ilarjournal/43_1/introduction.shtml
"I was encouraged not to assign names to the many rhesus monkeys in my charge. I was admonished that the animals are research subjects, not pets. The concern was that having names for the animals might blur this distinction between a research subject and a pet.... It did not seem possible to remain distant - emotionally isolated - from the animals. In fact, the inevitable closeness that resulted from those intimate interactions was precisely what made us capable of doing what we were asked to do. ... Eventually, we all came to know that F49 was Sam, A12 was Rosie, and Z13 was Curious. ... Such attachments are the results of compassionate people doing their job right."

(3) Promoting Intelligent Behavior: Positive Reinforcement Training

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK
http://scienceandresearch.homeoffice.gov.uk/animal-research/legislation/
"The least distressing method of handling is to train the animal to co-operate in routine procedures. Advantage should be taken of the animal's ability to learn."

Prentice ED, Zucker IH, Jameton A 1986. Ethics of animal welfare in research: The institution's attempt to achieve appropriate social balance. The Physiologist 29, 1,19-21
"Physical restraint procedures should be used on awake animals only after alternative procedures have been considered and found to be inadequate. If a restraint will be utilized the animal should be trained or conditioned to the restraining device, using positive reinforcement, prior to the beginning of the experiment"

(3,1) Basic Recommendations

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 7.2. Injection and Blood Collection—How to minimize Stress Reactions. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/working.html#training

"If the animals are under stress while you are working with them, there is a great risk that they show aggressive reactions to you, in an attempt to get away from the stressful situation. One of the conditions of successful and safe positive reinforcement training is a stress-free work environment, both for the animal and for you. This means, neither the animal nor you should be under the emotional influence of fear, apprehension or frustration. These emotions are dangerous when your handle monkeys or, for that matter, any other animals.

You should reach a stage when you know that you can trust the trainee while you work with him or her. This does not mean that you should not be alert, but any traces of mistrust and fear puts you into a seriously dangerous position. Do not work with an animal, unless you have trust in him or her! For your additional safety, you will always have to make sure that your interaction with the trainee will not be disturbed or disrupted by any unexpected event, such as personnel entering the room or loud personnel passing in hallways."

Chambers DR, Gibson TE, Bindman L, Guillou PJ, Herbert WJ, Mayes PA, Poole TB, Wade AJ, Wood RKSBC 1992. Guidelines on the Handling and Training of Laboratory Animals. Universities Federation for Animal Welfare, Potters Bar, UK

Very helpful outline of what has to be taken into consideration when training animals to cooperate during handling procedures. "Non-human primates, particularly the larger macaques, vervets, baboons and apes, are readily trained to cooperate in procedures such as presenting an arm for blood collection."

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK http://scienceandresearch.homeoffice.gov.uk/animal-research/legislation/

" The least distressing method of handling is to train the animal to co-operate in routine procedures. Advantage should be taken of the animal's ability to learn."

Klein HJ, Murray KA 1995. Part C. Restraint. In Nonhuman Primates in Biomedical Research - Biology and Management Bennett BT, Abee CR, Henrickson R (eds), 286-297. Academic Press, New York, NY

"The importance of training and adaptation cannot be overemphasized. This not only reduces stress to the animal but promotes safety and quality data collection."

Laule GE, Desmond T 1998. Positive reinforcement training as an enrichment strategy. In Second Nature Shepherdson DH, Mellen JD, Hutchins M (eds), 302-313. Smithsonian Institution Press, Washington, DC

Principles of positive reinforcement training are clearly outlined and applications reviewed. "Animals are reinforced with pleasurable rewards for the desired behavioural response. Operationally, this means that positive alternatives are exhausted before any kind of negative reinforcement is used." Punishment "is only appropriate in a situation that is life threatening for person or animal. ... Positive reinforcement training does not require any food deprivation. ... This training regime relies on voluntary cooperation by the animal to be successful."

Laule G 1999. Training laboratory animals. In The UFAW [Universities Federation for Animal Welfare] Handbook on the Care and Management of Laboratory Animals Seventh Edition Poole T, English P (eds), 21-27. Blackwell Science, Oxford, UK

Very helpful discussion of positive reinforcement training for cooperation during procedures. "By making the shift to a more positive reinforcement-based system, the welfare of the animals is significantly enhanced while providing better (less stressed) research models for the biomedical community."

T-W-Fiennes RN 1972. Primates - General. In The UFAW Handbook on the Care and Management of Laboratory Animals Fourth Edition Universities Federation for Animal Welfare (ed), 374-375. Churchill Livingstone, London, UK
"Chimpanzees and baboons, are intelligent and sensitive. If handled with sympathy and understanding they can become more than research tools - even cooperative partners in experimentation. To achieve this, a little time .. must be spent on conditioning the animals. A chimpanzee, for instance, will sit quietly and hold his arm out for a blood sample to be taken. ... An animal treated unsympathetically is liable to become aggressive and uncooperative; furthermore, unless care is taken over its comfort and needs, it is liable to become stressed and the results of the experiment may be vitiated for this reason."

(3,2) Species-specific Recommendations

Baboons (*Papio* spp.)

Levison PK, Fester CB, Nieman WH, Findley JD 1964. A method for training unrestrained primates to receive drug injection. Journal of the Experimental Analysis of Behavior 7, 253-254
Training technique by which an adult, single-housed male baboon learned to offer his arm through a pothole and accept intramuscular injection in this home cage is described and the result demonstrated with a photo. Injection was reliably obtained after approximately nine one-hour training sessions.

Turkkan JS, Ator NA, *et al* 1989. Beyond chronic catheterization in laboratory primates. In Housing, Care and Psychological Well-being of Captive and Laboratory Primates Segal EF (ed), 305-322. Noyes Publications, Park Ridge, NJ
Training protocols are described to ensure cooperation of single-housed baboons during blood pressure measurement and during oral drug dosing in the homecage.

Chimpanzees *(Pan troglodytes)*

Bloomsmith MA, Laule GE, Alford PL, Thurston RH 1994. Using training to moderate chimpanzee aggression during feeding. Zoo Biology 13, 557-566
"Positive reinforcement training techniques were applied to reduce a dominant male chimpanzee's aggression and chasing during meals. Verbal commands and food reinforcers were used to train him to sit and remain seated while other group members received and ate their share of produce."

Bloomsmith MA, Stone AM, Laule GE 1998. Positive reinforcement training to enhance the voluntary movement of group-housed chimpanzees within their enclosure. Zoo Biology 17, 333-341
Positive reinforcement was applied to train groups of chimpanzees to move voluntarily into the indoor portions of their enclosures at the request of trainers and to be briefly restricted to those areas.

Kessel-Davenport AL, Gutierrez T 1994. Training captive chimpanzees for movement in a transport box. The Newsletter 6(2), 1-2
http://www.awionline.org/Lab_animals/biblio/jo-6.htm

Training technique is described. "Thirty-seven [group-housed] captive chimpanzees were trained using operant conditioning to enter a transfer box." [Age and sex of subjects is not provided.]

Lambeth SP, Perlman JE, Schapiro SJ 2000. Positive reinforcement training paired with videotape exposure decreases training time investment for a complicated task in female chimpanzees. American Journal of Primatology 51(Supplement), 79-80 (Abstract)
"Five females were exposed to a 10-minute videotape of female chimpanzees being positively reinforced for successfully urinating into a cup. Immediately following videotape exposure, these subjects participated in a training session." On average experimental and control subjects received 56 minutes of training. "Subjects with videotape exposure successfully responded to the command to urinate in significantly less time than did controls."

Laule GE, Thurston RH, Alford PL, Bloomsmith MA 1996. Training to reliably obtain blood and urine samples from a diabetic chimpanzee (*Pan troglodytes*). Zoo Biology 15, 587-591
Training techniques are described to gain the cooperation of a 3-year old female chimpanzee in obtaining blood and urine samples. "The first blood draw occurred during the 18th training session, with a total of 275 minutes invested prior to that. The first successful [urine] collection occurred in session 4 in less than 4 min after a total of 42 min of training time."

Laule G 1999 Training laboratory animals. In The UFAW [Universities Federation for Animal Welfare] Handbook on the Care and Management of Laboratory Animals Seventh Edition Poole T, English P (eds), 21-27. Blackwell Science, Oxford, UK
Very helpful discussion of positive reinforcement training for cooperation during procedures. "By making the shift to a more positive reinforcement-based system, the welfare of the animals is significantly enhanced while providing better (less stressed) research models for the biomedical community."

Perlman JE, Thiele E, Whittaker MA, Lambeth SP, Schapiro SJ 2004. Training chimpanzees to accept subcutaneous injections using positive reinforcement training techniques. American Journal of Primatology 62(Supplement), 96 (Abstract)
http://www.asp.org/asp2004
"Positive reinforcement training techniques were used to train four socially-housed, adult chimpanzees to present their abdomen for a subcutaneous injection. .. Subjects had been previously trained to present body parts for inspection, including the abdomen. For the present study, subjects were trained to 1) present the abdomen, 2) tolerate a pinch of the skin, 3) accept the subcutaneous insertion of a needle, and 4) remain stationary while the contents of the syringe were injected. Three of the four chimpanzees were reliably trained to voluntarily accept the subcutaneous injection. A mean of 98 minutes of training time was required for the animals to reliably accept penetration and injection of up to 10 cc through a 25-gauge needle. Training sessions lasted 5 to 8 minutes and 13 - 20 sessions (mean = 17) were required to achieve reliable performance."

Russell JL, Taglialatela JP, Hopkins WD 2006. The use of positive reinforcement training in chimpanzees (*Pan troglodytes*) for voluntary presentation for IM injections. American Journal of Primatology 68(Supplement), 122 (Abstract)
"Positive reinforcement has been used to gain the cooperation of captive primates for research and management needs. In this study, ten chimpanzees .. were trained to present for intramuscular (IM) injections. Clicker training was used to teach subjects to present their leg and accept an injection. .. Subjects reached criterion for presenting for a touch from a needle in

7 to 44 training sessions. .. These results suggest that through the use of positive reinforcement, chimpanzees can be quickly and reliably trained to present for injections as part of a research protocol requiring multiple accesses."

Schapiro SJ, Perlman JE, Thiele E, Lambeth S 2005. Training nonhuman primates to perform behaviors useful in biomedical research. Lab Animal 34(5), 37-42
Training protocols are described and the time investments to achieve cooperation for semen collection [7 subjects: 29-453 minutes], subcutaneous [2 subjects: 90-104 minutes; 1 subject could not be trained] and intramuscular injection [39 subjects: 0.1-396 minutes; 43 subjects could not be trained] are presented.

Spragg SDS 1940. Morphine addiction in chimpanzees. Comparative Psychology Monographs 15, 1-132
Author provides formal description of training four unrestrained chimpanzees to approach an investigator and accept an injection of physiological saline solution. The training comprised a combination of adaptation, desensitization, and shaping, with fruit, praise, and patting as reinforcers. "It is the writer's contention that this preliminary adaptation to the injection situation was an important factor for the experiment; it obviated many undesirable aspects which would have appeared if it had been necessary to inject the animals by force."

Videan EN, Fritz J, Murphy J, Borman R, Smith HF, Howell S 2005. Training captive chimpanzees to cooperate for an anesthetic injection. Lab Animal 34(5), 43-48
Training protocol is described in detail and the time investment presented.

Videan EN, Fritz J, Murphy J, Howell S, Heward CB 2005. Does training chimpanzees to present for injection lead to reduced stress? Laboratory Primate Newsletter 44(3), 1-2
http://www.brown.edu/Research/Primate/lpn44-3.html#videan
"Subjects were 17 captive chimpanzees living at the Primate Foundation of Arizona, aged 10.6 to 34.5 years at the time of the study. The sample included 8 males and 9 females. Eleven of the subjects were trained, using positive reinforcement techniques, over 21 months (Videan et al., 2005). Individuals were trained to present an arm or leg to the cage mesh for anesthetic injection, using the verbal cues "arm" and "leg". Training procedures were transferred from the trainer to either the colony manager or the assistant colony manager, after behaviors were under stimulus control, in 5 of the trained subjects. .. When all trained individuals were pooled, trained subjects exhibited significantly lower levels of cortisol than untrained (U=7, p<0.010, Table 1)."

Drills *(Mandrillus* spp.)

Priest GM 1991. Loon, the Diabetic Drill (videotape) Mac & Mutley, San Francisco
Training technique for in-homecage blood collection of an adult male drill is clearly demonstrated.

Priest GM 1991. The methodology for developing animal behavior management programs at the San Diego Zoo and Wild Animal Park. AZA Annual Conference Proceedings, 553-562
"Within a few weeks, Loon was voluntarily allowing the veterinarians to draw blood from his forearm. Loon has voluntarily accepted his daily insulin injections and blood withdrawals for over two years."

Gorillas *(Gorilla* spp.)

Bettinger T, Kuhar C, Sironen A, Laudenslager M 1998. Behavior and salivary cortisol in gorillas housed in an all male group. AZA Annual Conference Proceedings, 242-246
Gorillas were successfully trained to voluntarily chew on the cotton plugs then return them to the caretaker.

Bond M 1991. How to collect urine from a gorilla. Gorilla Gazette 5(3), 12-13
Training technique is clearly described. Mandara "not only urinates on demand but has been known to go get a drink of water if we happen to ask for a sample when her bladder is empty."

Brown CS 1997. Training gorillas *(Gorilla gorilla gorilla)* for noninvasive semen collection. Proceedings American Association of Zoo Veterinarians, 201-203
"Appropriate behaviors, in response to verbal prompts, were rewarded with praise and food treats. Collection of the first semen sample [from single-housed subjects] varied from 5-14 months after the initiation of training, with collections occurring earliest on the animal that appeared to have the best relationship with the trainer."

Brown CS 1998 A Training Program for Semen Collection in Gorillas (video). Henry Doorly Zoo, Omaha, MB
Training technique to ensure cooperation of single-housed adult male gorillas during physical examination, injection, semen collection are described and very clearly demonstrated.

Segerson L, Laule GE 1995. Initiating a training program with gorillas at the North Carolina Zoological Park. American Zoo and Aquarium Association Annual Conference Proceedings, 488-489
Technique is clearly described to facilitate wound treatment of an unrestrained, single-housed female.

Macaques *(Macaca* spp.)

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 7.2. Injection and Blood Collection—How to minimize Stress Reactions. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/working.html#training
"With positive reinforcement, I have trained adult female cynos to cooperate during intramuscular injection in home cages that are not equipped with squeeze-backs. When they can trust you, they readily learn to cooperate during this common procedure. These animals work with rather than against me, which automatically implies that they show no fear or stress reactions during the procedure."

Bunyak SC, Harvey NC, Rhine Rj, Wilson MI 1982. Venipuncture and vaginal swabbing in an enclosure occupied by a mixed-sex group of stumptailed macaques *(Macaca arctoides)*. American Journal of Primatology 2, 201-204
By the end of five training sessions "it was no longer necessary to net and restrain the females. Indeed, some of the females began voluntarily to approach the researcher and present for vaginal swabbing."

Clarke MR, Phillippi KM, Falkenstein JA, Moran EA, Suomi SJ 1990. Training Corral-living Rhesus Monkeys for Fecal and Blood Sample Collection (Videotape). Delta Primate Research Center, Covington, LA
Training technique is explained and the animals' reactions demonstrated.

Down N, Skoumbourdis E, Walsh M, Francis R, Buckmaster C, Reinhardt V 2005. Pole-and-collar training: A discussion by the Laboratory Animal Refinement and Enrichment Forum. Animal Technology and Welfare 4, 157-161
http://www.awionline.org/Lab_animals/biblio/atw7.html
Experiences with the pole-and-collar training training are shared. "Yes, most monkeys can be trained but some cannot, or let's say they should not be trained because their personality — which is presumably conditioned through negative experiences with people — is very difficult to deal with.".

Friscino BH, Gai CL, Kulick AA, Donnelly MJ, Rockar RA, Aderson LC, Iliff SA 2003. Positive reinforcement training as a refinement of a macaque biliary diversion model. AALAS 54th National Meeting Official Program, 101 (Abstract)
"Animals that adapted to wearing jackets were surgically implanted with a biliary diversion cannula system, a venous cannula and three subcutaneous access ports. .. The animals [three females and nine male rhesus] were trained to present the pouch and to remain stationary while the catheters were accessed. The length of time required for training was variable between individuals, but generally required three to four training sessions during a two-week period. These in-cage procedures precluded the need for chair or manual restraint of animals during sample collection. Instead, positive reinforcement was used to reward the animals with food for their cooperation during sample collection. This has also increased the efficiency of conducing metabolic studies and minimized the potential stress of sample collection for both the personnel and animals."

Goodwin J 1997. The application, use, and effects of training and enrichment variables with Japanese snow macaques (*Macaca fuscata*) at the Central Park Wildlife Center. American Zoo and Aquarium Association Regional Conference Proceedings, 510-515
Training protocol is briefly described which allows the keepers through vocal and visual cues to herd the animals to a holding area.

Heath M 1989. The training of cynomolgus monkeys and how the human/animal relationship improves with environmental and mental enrichment. Animal Technology 40(1), 11-22
http://www.awionline.org/Lab_animals/biblio/at40heath.html
"A relatively short, but predictable, course of routine handling and feeding enabled the monkeys to co-operate with their handlers and made working practices a lot easier, quicker and safer for both the animals and technicians."

Luttrell L, Acker L, Urben M, Reinhardt V 1994. Training a large troop of rhesus macaques to cooperate during catching: Analysis of the time investment. Animal Welfare 3, 135-140
http://www.awionline.org/Lab_animals/biblio/aw5train.htm
"Using a simple chute system and applying a training technique based on patience, all 45 troop members were successfully conditioned in less then 15 work-hours to voluntarily enter a transport cage one by one."

Phillippi-Falkenstein K, Clarke MR 1992. Procedure for training corral-living rhesus monkeys for fecal and blood-sample collection. Laboratory Animal Science 42, 83-85
Clear description of training technique. "By day 9, the male stopped resisting, and three of the [five] females extended their legs voluntarily."

Reinhardt V 1990. Avoiding undue stress: Catching individual animals in groups of rhesus monkeys. Lab Animal 19(6), 52-53
http://www.awionline.org/Lab_animals/biblio/la-avoid.htm
Training technique is described. "We have successfully trained two heterogeneous rhesus troops of 28 and 33 members. The catching procedure has become a routine that is no longer associated with excitation and distress. It is now possible for one experienced person to catch animals at any given time without extra help."

Reinhardt V 1990. Catching Individual Rhesus Monkeys Living in Captive Groups (videotape). Wisconsin Regional Primate Research Center, Madison, WI
Using vocal commands, a single person swiftly catches all members of a trained rhesus breeding group one-by-one in a transport cage without causing any disturbance or stress.

Reinhardt V 1996. Refining the blood collection procedure for macaques. Lab Animal 32(1), 32-35
http://www.awionline.org/Lab_animals/biblio/la-refin.htm
A training technique is described for ensuring the active cooperation of pair-housed/single-housed adult male and female rhesus and stump-tailed macaques during in-homecage venipuncture. Mean cumulative training time investment per individual was less than one hour. The training eliminated significant cortisol responses which typically occur during conventional, i.e., enforced blood collection.

Reinhardt V, Cowley D 1990. Training stumptailed monkeys to cooperate during in-homecage treatment. Laboratory Primate Newsletter 29(4), 9-10
http://www.brown.edu/Research/Primate/lpn29-4.html#vik
One to 14 training sessions, each lasting for 1-5 minutes, were required to train adult, pair- and single-housed stump-tailed macaques of both sexes to cooperate during topical treatment in the homecage.

Skoumbourdis EK 2008. Pole-and-collar-and-chair training. Laboratory Animal Refinement & Enrichment Forum (electronic discussion group) , January 24, 2008
http://groups.yahoo.com/group/LAREF/members
"All the monkeys I have pole/collar/chair trained have gone through an initial phase of resistance both when the pole was being attached to the collar, and when they were first put into the chair, but for the most part they finally did settle down and cooperate. All it takes is patience and gentle determination on the part of the trainer.

Trust in the trainer is the ultimate key for success. Nonhuman primates are intelligent; when they are free of apprehension or fear, they quickly figure out that it is much easier and even rewarding for them to cooperate with you rather than resist. A successfully trained monkey will have developed so much trust in you that he/she will never fight against you when you pole and chair him/her.

To pole-collar-chair train a monkey can be a very rewarding process that is not necessarily time-consuming. I have successfully trained 19 animals: two adult female rhesus, four adult male rhesus, five juvenile male rhesus, four adult female cynomolgus, and four adult male cynomolgus.

My quickest subject took just five days of training to reliably cooperate (I should mention that he was two years old and an angel!), while other animals have taken me well over a month to get going — especially older rhesus who can be very stubborn and hard to food-motivate. Also, I have had some animals who were just never meant to be put in a chair. This is a reality that both you and the investigators must acknowledge. You cannot force a monkey to cooperate and be relaxed in the chair. It's impossible. Sure, you can try, but you're not going to win."

Marmosets *(Callithrix* spp.)

Anzenberger G, Gossweiler H 1993. How to obtain individual urine samples from undisturbed marmoset families. American Journal of Primatology 31, 223-230
"An apparatus and a method are described, which allow simultaneous urine collection from all individual members of undisturbed marmoset families. By the end of the third week of training, it was not unusual to collect urine samples from an entire family."

McKinley J, Buchanan-Smith HM, Bassett L, Morris K 2003. Training common marmosets (*Callithrix jacchus*) to cooperate during routine laboratory procedures: Ease of training and time investment. Journal of Applied Animal Welfare Science 6, 209-220
Behaviours taught were target training to allow in homecage weighing and providing urine samples from 12 pairs of marmosets. "Between 2 to 13, 10-minute training sessions established desired behaviors. .. Trained animals proved extremely reliable, and data collection using trained animals was considerably faster than collection using current laboratory techniques."

Smith TE, McCallister JM, Gordon SJ, Whittikar M. 2004. Quantitative data on training new world primates to urinate. American Journal of Primatology 64(1), 83-93
0*"This study assessed the effectiveness of operant conditioning in training three species of captive callitrichid primates (Leontopithecus rosalia, Callithrix geoffroyi, and Saguinus imperator) to urinate on demand...Training sessions (30 min each) were conducted at dawn thrice weekly during five consecutive phases: habituation, control, training (animals were rewarded for urinating), maintenance (animals had reached a defined training criteria and continued to be rewarded for urinating), and collection (animals were rewarded for urinating, and the trainer entered the cage to collect the sample). The numbers of 30-min training sessions required to train the three monkey species (L. rosalia, C. geoffroyi, and S. imperator) were five, six, and eight, respectively. For the three species, the mean number of urinations per animal was*

significantly greater during the training, maintenance, and collection phases compared to the control phase... The entry of the trainer into the cage to collect the urine sample did not appear to alter urination behavior. We demonstrate that operant conditioning techniques, which typically incur minimal cost, time investment, and disturbance, can be used to increase the quantity of urine samples collected for physiological analysis, the proportion of animals that urinate, and the speed of sample collection."

Orangutans *(Pongo pymgmaeus)*

Berman N, Greenblatt H 1989. Training Medical Behaviors in Orangutans at Brookfield Zoo (videotape). Chicago Zoological Society, Chicago, IL
Training technique is clearly described and demonstrated to ensure cooperation of two pair-housed female/male orangutans during daily insulin injection.

Moore BA, Suedmeyer K 1997. Blood sampling in 0.2 Bornean orangutans at the Kansas City Zoological Gardens. Animal Keepers' Forum 24, 537-540
Training technique is clearly described to ensure cooperation during in-homecage blood collection of adult, pair-housed female orangutans.

Sakis *(Pithecia* spp.)

Shideler SE, Savage A, Ortuño AM, Moorman EA, Lasley BL 1994. Monitoring female reproductive function by measurement of fecal estrogen and progesterone metabolites in the white-faced saki *(Pithecia pithecia)*. American Journal of Primatology 32, 95-108
"Fist morning void urine was collected directly in a polypropylene container hand-held under the female subject. A second container was held under the female to collect fecal material. [The group-housed] females urinated and defecated within 5-20 min. Following sample collection, females were rewarded for their cooperation with more sunflower seeds."

Spider monkeys *(Ateles* spp.)

Hernándes-López L, Mayagoitia L, Esquivel-Lacroix C, Rojas-Maya S, Mondragón-Ceballos R 1998. The menstrual cycle of the spider monkey *(Ateles geoffroyi)*. American Journal of Primatol. 44, 183-195
Four of the five females were trained to enter a small cage attached to the door of their enclosure and to "allow a cotton swab to be introduced in the vagina. This procedure was slightly modified [not described], and the animals were trained to be injected with ketamine" for subsequent blood collection.

Squirrel monkeys (*Saimiri* spp.)

Panneton M, Alleyn S, Kelly N 2001. Chair restraint for squirrel monkeys. AALAS 52nd National Meeting Official Program, 92 (Abstract)
“Our facility has trained squirrel monkeys to cooperate during various procedures such as capture from their homecage and chair restraint for periods not exceeding 1 h. ... Each squirrel monkey is constantly supervised and given positive reinforcement during and after the training sessions. ... The initial training period starts at 5-10 min three times a week. Additional training sessions of 5-20 min are added until 1h of chair restraint is achieved. At this time, training is reduced to twice a week for 1 h and then once a week for maintenance.” Concerns are weight loss, chair abrasions and hypoglycemia.

Tamarins *(Saguinus* spp.)

Smith TE, McCallister JM, Gordon SJ, Whittikar M. 2004. Quantitative data on training new world primates to urinate. American Journal of Primatology 64(1), 83-93
"This study assessed the effectiveness of operant conditioning in training three species of captive callitrichid primates (Leontopithecus rosalia, Callithrix geoffroyi, and Saguinus imperator) to urinate on demand...Training sessions (30 min each) were conducted at dawn thrice weekly during five consecutive phases: habituation, control, training (animals were rewarded for urinating), maintenance (animals had reached a defined training criteria and continued to be rewarded for urinating), and collection (animals were rewarded for urinating, and the trainer entered the cage to collect the sample). The numbers of 30-min training sessions required to train the three monkey species (L. rosalia, C. geoffroyi, and S. imperator) were five, six, and eight, respectively. For the three species, the mean number of urinations per animal was significantly greater during the training, maintenance, and collection phases compared to the control phase... The entry of the trainer into the cage to collect the urine sample did not appear to alter urination behavior. We demonstrate that operant conditioning techniques, which typically incur minimal cost, time investment, and disturbance, can be used to increase the quantity of urine samples collected for physiological analysis, the proportion of animals that urinate, and the speed of sample collection."

Snowdon CT, Savage A, McConnell PB 1985. A breeding colony of cotton-top tamarins (*Saguinus oedipus*). Laboratory Animal Science 35, 477-480
Group-housed females were conditioned to urinate into containers each morning for a food reward.

Vervet monkeys *(Cercopithecus aethiops)*

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 7.3. Oral Drug Administration—How to minimize Stress Reactions. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/working.html#oral-prim
"Our vervet monkeys voluntarily swallow drugs when we mix these with their regular diet, consisting on pre-cooked maize, fortified with vitamins, minerals and other ingredients. The dry ingredients are blended with water and form a stiff putty-like paste, which is an ideal vehicle for mixing in test substances. If the flavor needs to be masked, there are a variety of possibilities, such as honey and syrup, depending on what the protocol permits. We usually administer the compound in about a third of the morning feed. The bulk of the food is offered after this portion has been consumed. Some substances we even mix into the entire bulk of the morning feed. Keeping the compound too long in cheek pouches or spitting it out has never been a problem. We have used this simple oral administration technique for pharmacokinetic studies very successfully. Over a time period of 20 years, we have not had to deal with any substance that we could not feed to the vervets, including bitter herbal mixtures in fairly high concentrations."

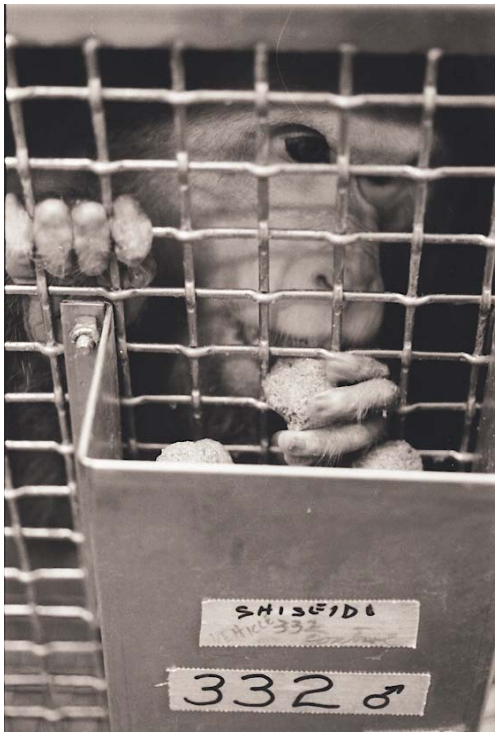
Kelley TM, Bramblett CA 1981. Urine collection from vervet monkeys by instrumental conditioning. American Journal of Primatology 1, 95-97
Training technique is described. Six of eight group-housed males reliably produced clean urine samples after a two-month period of training.

Woolly monkeys *(Lagothrix* spp.)

Logsdon S 1995. Use of operant conditioning to assist in the medical management of hypertension in woolly monkeys. American Zoo and Aquarium Association Regional Conference Proceedings, 96-102
Training technique is described. "Currently, two monkeys [one adult female and one adult male] have had their blood pressure measured in the group without being restrained."

(4) Promoting Foraging and Food Processing Behavior

(4,1) Foraging Devices



Bayne K, Dexter SL, Mainzer H, McCully C, Campbell G, Yamada F 1992. The use of artificial turf as a foraging substrate for individually housed rhesus monkeys *(Macaca mulatta).* Animal Welfare 1, 39-53
http://www.awionline.org/Lab_animals/biblio/aw1-39.htm
Subjects spent on average 15.7 minutes per 30 minute-observation sessions foraging from the device. "An increasing trend in time spent foraging with a concomitant decline in aberrant behaviour over a time period of six months was particularly noteworthy."

Bayne K, Mainzer H, Dexter SL, Campbell G, Yamada F, Suomi SJ 1991. The reduction of abnormal behaviors in individually housed rhesus monkeys *(Macaca mulatta)* with a foraging/grooming board. American Journal of Primatology 23, 23-35
All of the single-housed "animals foraged from the board to the point that a significant reduction in the level of abnormal behavior was noted." Subjects spent on average 12.1 minutes foraging from the board per 30 minute-observation sessions.

Bertrand F, Seguin Y, Chauvier F, Blanquié JP 1999. Influence of two different kinds of foraging devices on feeding behaviour of rhesus macaques *(Macaca mulatta)*. Folia Primatologica 70, 207 (Abstract)
A foraging device fitted on the ceiling of the cage (H), and a foraging device fitted on the front of the cage (V) and filled with pellets were tested in 12 individually housed animals. "The animals moved the pellets from the reserve to a hopper. ... We found that the amount of waste food was up to 17 times lower in the V foraging device than in the control feeder and that the feeding time was much longer with the foraging device than with the control feeder. Over 90% of the food was eaten within the first 15 minutes with the control feeder, whereas it took 60 or 75 minutes to reach this percentage using the foraging device, whether it was a V or an H one. Each puzzle required specific skills. Whichever the feeding device, the subjects ate their whole daily ration and their weight remained stable."

Bjone SJ, Price IR, McGreevy PD 2006. Food distribution effects on the behaviour of captive common marmosets, *Callithrix jacchus*. Animal Welfare 15, 131-140
"Both the cluster and dispersed feeder distributions increased foraging, and there was a trend of reduced scratching and grooming."

Blanchard M, Gruver S, Kirk P, McLain V, Zebrun M 2005. Look what's hanging around! Foraging feeder cup puzzles for cynomolgus macaques. Tech Talk 10(3), 3
Foraging device is described and demonstrated. It is used by pair-housed cynos to retrieve their daily biscuit ration. No changes in body weights were noticed.

Bloom KR, Cook M 1989. Environmental enrichment: Behavioral responses of rhesus to puzzle feeders. Lab Animal 18(5), 25,27,29,31
A commercial puzzle feeder loaded with 10 whole peanuts is tested in two single-housed adult males. Average time spent foraging from the feeder was about 15 minutes.

Bloomstrand M, Riddle K, Alford PL, Maple TL 1986. Objective evaluation of a behavioral enrichment device for captive chimpanzees *(Pan troglodytes)*. Zoo Biology 5, 293-300
Group-housed individuals spent on average 13 minutes per 120 minute-observation sessions "contacting" the puzzle box. "The most dominant males displayed the highest levels of overall use of this enrichment device. It may be desirable to use this device in groups of animals with relatively stable relationships and/or to increase the number of puzzles available to the group."

Brent L, Eichberg JW 1991. Primate puzzleboard: A simple environmental enrichment device for captive chimpanzees. Zoo Biology 10, 353-360
Treat-loaded transparent board with finger holes is attached to the top of the cage. Mean 'puzzle use' during four 60-minute trials was 17%.

Brent L, Long KE 1995. The behavioral response of individually caged baboons to feeding enrichment and the standard diet: A preliminary report. Contemporary Topics in Laboratory Animal Science 34(2), 65-69
PVC pipe with finger holes, filled with a mixture of peanut butter and seeds. The mean amount of feeder use was 51 minutes per 60 minute observation sessions. "Increasing foraging opportunities in this study reduced abnormal behaviors from 16.4% of the data points in the baseline condition to 4.9% and 5.7% in the chow [normal feeding condition] and feeder condition, respectively."

Celli ML, Tomonagaa M, Udonob T, Teramotob M, Naganob K 2003. Tool use task as environmental enrichment for captive chimpanzees. Applied Animal Behaviour Science 81, 171-182
“A device—honey in a bottle to be "fished" with artificial materials—that elicits tool use was presented to six captive chimpanzees housed in pairs. The task successfully reduced inactivity by about 52%, increased foraging opportunity from 0 to around 31% and elicited tool use and manipulation. ... There was no statistical evidence of habituation to the device.”

Corleto J 1997. A-mazing orangutans. The Shape of Enrichment 6(2), 9-10
A food puzzle was constructed and modified several times to take into account the subject's high level of intelligence. "The results were everything I could have hoped for. Not only did he maneuver the [food] items through the maze, he also did it with remarkable speed and concentration."

Crockett CM, Bellanca RU, Heffernan KS, Ronan DA, Bonn WF 2001. Puzzle Ball foraging device for laboratory monkeys. Laboratory Primate Newsletter 40(1), 4-7
http://www.brown.edu/Research/Primate/lpn40-1.html#ball
"Puzzle Balls are attached outside of the cage. .. Each animal was observed for 10 minutes after six pieces of cereal were placed in the ball. .. Overall, the subjects manipulated the Puzzle Ball during 69.5% of the scan samples. ... Four of the seven subjects were able to successfully empty (eat plus spill) at least one type of Puzzle Ball in less than 10 minutes. (Most spilled about as much as they ate.) For the successful animals, it took an average of five minutes to empty the puzzle. ...Even though the Puzzle Balls were empty during observations [four of seven cases], the subjects manipulate them. ... We were pleased that the empty Puzzle Balls were associated with a reduction in abnormal behavior."

Evans HL, Taylor JD, Ernst J, Graefe JF 1989. Methods to evaluate the well-being of laboratory primates. Comparison of macaques and tamarins. Laboratory Animal Science 39, 318-323
Single-caged long-tailed macaques took on average 8.7 seconds, paired tamarins took on average 15 seconds to retrieve one raisin from the pickup board [miniature ice cube tray attached to front of cage]. Experienced macaques emptied the commercial puzzle filled with the standard food pellet ration within 20 minutes. "After a few days experience with the puzzle, macaques ate from both sources [puzzle feeder and conventional food cup] at the same time, showing no clear preference for either source. This indicates a motivation other than taste or caloric need for performing the puzzle. The puzzle was not adaptable for tamarins since they displayed little or no appetite for any hard food items which could be pushed through the puzzle. Soft foods, such as grapes, raisins, marshmallows or marmoset diet were squeezed out through the small holes rather than being pushed through the maze of the puzzle."

Fekete JM, Norcross JL, Newman JD 2000. Artificial turf foraging boards as environmental enrichment for pair-housed female squirrel monkeys. Contemporary Topics in Laboratory Animal Science 39(2), 22-26
"Five groups of pair-housed female squirrel monkeys were videotaped the week prior to, the week following, and for 2 weeks during the enrichment phase, when treat-enhanced boards were provided for 2 h daily. During the first 30 min of daily enrichment, inactivity declined 35.3%, locomotion increased 3.8%, and board-related behavior occupied 36.3% of the activity budget; these changes were not evident after 1.5 h." Behavioral disorders were not altered by the foraging opportunity.

Gilloux I, Gurnell J, Shepherdson D 1992. An enrichment device for great apes. Animal Welfare 1, 279-289
http://www.awionline.org/Lab_animals/biblio/aw1-279.htm
The animals could manipulate food items to the end of the pipe by poking sticks through holes drilled along the side of the pipe facing them. When the food items reached the end of the pipe, the animals could reach them with their fingers through the welded mesh. No habituation to the feeder was observed during 12 trials. Average time spent in 'feeder-oriented behaviour' during 30 minute trials was approximately 8 minutes for [pair-housed] orangutans and [group-housed] chimpanzees and 5 minutes for [group-housed] gorillas.

Glenn AS, Watson J 2007. Novel nonhuman primate puzzle feeder reduces food wastage and provides environmental enrichment. AALAS [American Association for Laboratory Animal Science] 58th National Meeting Official Program, 45 (Abstract)
"The feeder dispenses monkey chow and fits on nonhuman primate group four quad rack cages. .. The original feeders dispensed 18 to 20 biscuits. At feeding time, the macaques removed all the biscuits within 3 min, and those that were not eaten or stored in cheek pouches were pushed back through the feeder onto the room floor or dropped through the cage floor grid. .. Each feeder took approximately 1 h to make and cost approximately $60 in materials. .. Puzzle feeder implementation increased time spent foraging (approximately 20 min per biscuit), reduced food wastage, and decreased clean-up time."

Goodwin J 1997. The application, use, and effects of training and enrichment variables with Japanese snow macaques (*Macaca fuscata*) at the Central Park Wildlife Center. American Zoo and Aquarium Association Regional Conference Proceedings, 510-515
"Although the [commercial] primate puzzles proved to be a learning success, they were best used sporadically to prevent the macaques from becoming bored with the puzzles."

Kinsey JH, Jorgensen MJ, Platt DM, Hazen TJ 1996. Food puzzle feeders: Effects on self-biting and stereotypy in individually housed monkeys. XVIth Congress of the International Primatological Society/XIXth Conference of the American Society of Primatologists, Abstract No. 683
Subjects were "observed not only when the food puzzle feeder had just been filled in the early morning but at several other time points throughout the day. ... There was no effect on self-aggression; however, a reduction in active stereotypic behavior was noted but only in the first hour of each daily exposure."

Lam K, Rupniak NMJ, Iversen SD 1991. Use of a grooming and foraging substrate to reduce cage stereotypies in macaques. Journal of Medical Primatology 20, 104-109
http://www.awionline.org/Lab_animals/biblio/jmp20-1.htm
"Monkeys given fleece sprinkled with morsels of food did not groom the fleece, but foraged for long periods (up to 27 min/h). Stereotyped behaviours were reduced by up to 73% by use of the fleece pad both alone and with foraging crumbles."

LeBlanc D 1993. A simple device for stimulating gummivory in tamarins (S*aguinus*). American Zoo and Aquarium Association Regional Conference Proceedings, 212-219
A simple, custom-made gum-tree was tested. "The artificial gum-tree was hung vertically from the top of the cage with two screw hooks, and placed ideally two or more feet from existing branches and cage walls. All tamarins under 3.5 years in the study utilized the artificial gum-tree. Older tamarins in general ignored this device, but did take gum arabic and diluted maple syrup from a small food bowl."

Line SW, Markowitz H, Morgan KN, Strong S 1989. Evaluation of attempts to enrich the environment of single-caged non-human primates. In Animal Care and Use in Behavioral Research: Regulation, Issues, and Applications Driscoll JW (ed), 103-117. Animal Welfare Information Center, Beltsville, MD
"Rhesus macaques removed monkey biscuits from a puzzle feeder "despite the fact that the same kind of food was available free-choice at the twice-daily feedings."

Lutz CK, Farrow RA 1996. Foraging device for singly housed longtailed macaques does not reduce stereotypies. Contemporary Topics in Laboratory Animal Science 35(3), 75-78
"All [ten] subjects manipulated the foraging boards, but stereotyped behaviors and activity levels were not significantly affected by the presence of the boards." Subjects "used" the boards approximately 2 minutes per 30 minute-observation sessions. "No reduction in board usage was observed over time of day or on repeated presentation, indicating that there was no novelty effect or reduction in motivation."

Maki S, Alford PL, Bloomsmith MA, Franklin J 1989. Food puzzle device simulating termite fishing for captive chimpanzees (*Pan troglodytes)*. American Journal of Primatology 19(Supplement), 71-78
"Significant reductions of abnormal behavior and significant increases in activity occurred with the pipe feeder's availability. Species-typical tool-using activity occurred, and the use of the pipe feeder increased subjects' foraging and feeding activity toward more species-normative levels. ... Multiple puzzle devices should be available to group-housed animals to preclude ... aggression arising from competition."

Markowitz H 1979. Environmental enrichment and behavioral engineering for captive primates. In Captivity and Behavior Erwin J, Maple T, Mitchell G (eds), 217-238. Van Nostrand Reinhold, New York, NY
Food dispensing apparatuses were developed and successfully implemented as feeding enrichment options for group-housed gibbons, siamangs and diana monkeys. "Frequently, often with free food in their hands, they [gibbons] attempted to get the lights and levers to respond" and missed the opportunity to 'produce' food. "The problem of excess food lying around and decaying on the floor had been reduced to a minimum."

Maloney MA, Meiers ST, White J, Romano MA 2006 . Effects of three food enrichment items on the behavior of black lemurs (*Eulemur macaco macaco*) and ringtail lemurs (*Lemur catta*) ath the Henson Robinson Zoo, Springfield, Illinois. Journal of Applied Animal Welfare Science 9, 111-127
"The lemurs' behavior appeared [sic] to be most affected by the food enrichment item that required the most manipulation."

Mentz I, Perret K 1999. Environmental enrichment bei Flachlandgorillas *(Gorilla g. gorilla)* - Beobachtungen zur Nahrungsaufnahme und zum Manipulationsverhalten. Der Zoologische Garten 69, 1-15
"Behavioural enrichment possibilities include greater dispersal of food as well as the providing of food boxes or raisin sticks. Each gorilla was engaged intensively with the raisin sticks [5.8% of day], but were especially responsive to the food boxes [15,2% of day]."

Molzen EM, French JA 1989. The problem of foraging in captive callitrichid primates: Behavioral time budgets and foraging skills. In Housing, Care and Psychological Wellbeing of Captive and Laboratory Primates Segal EF (ed), 89-101. Noyes Publications, Park Ridge
The group-housed animals had to hang from above, or sit on the covered bowl to obtain raisins that were mixed with ground corn cob. "The device reduced foraging yield and increased foraging effort to levels similar to those observed in free-ranging populations. These dramatic changes in behavioral profiles were produced even though the foraging device was supplemental to, rather than a replacement for, standard provisioning."

Murchison MA 1992. Task-oriented feeding device for singly caged primates. Laboratory Primate Newsletter 31(1), 9-11
http://www.brown.edu/Research/Primate/lpn31-1.html#task
A perforated hard plastic ball loaded with peanuts was attached to the outside of the cage. "The animals spent most of their time sitting on their cage perches. Manipulating the foraging device was the second most time-consuming activity [males 22%, females 8%]."

Murchison MA 1994. Primary forage feeder for singly-caged macaques. Laboratory Primate Newsletter 33(1), 7-8
http://www.brown.edu/Research/Primate/lpn33-1.html#mark
"Apparently the animals consumed nearly all the food retrieved from the forage feeders, leaving less on the cage floor to become contaminated. The animals spent significantly more time foraging with the forage feeder than the standard feeder."

Murchison MA 1995. Forage feeder box for single animal cages. Laboratory Primate Newsletter 34(1), 1-2
http://www.brown.edu/Research/Primate/lpn34-1.html#forage
Standard feeder with small access holes rather than one big access hole. Time spent foraging during the first hour after biscuit distribution increased from 51 seconds when 40 biscuits were presented in the standard feeder [one large access hole] to 400 seconds when 40 biscuits were presented in the forage feeder [four small access holes]. "There were no differences between the standard and forage feeders in number of biscuits fed and consumed." More biscuits fell on the cage floor and beneath the cage on the floor of the room in the standard feeder situation than in the forage feeder situation.

Murphy DE 1976. Enrichment and occupational devices for orang utans and chimpanzees. International Zoo News 137(23.5), 24-26
http://www.awionline.org/Lab_animals/biblio/izn-mur.htm
"A heavy metal cylinder, 60 cm long and 45 cm in diameter, was capped on each end and bolted to a platform. Three 8 cm holes in the cylinder allowed access to the inside. A short section of a rubber hose was chained near one hole in the cylinder. The chimps were able to use the hose as a tool in a manner similar to fishing for termites or opening a beehive in the wild. The chimpanzees rapidly emptied the container of their morning meal with ingenious manipulation and intense interest. .... Chimps and orangs manipulated their feeders even though ample food was available. On days when the device could be operated by the orang utans, they were observed climbing in the structure about thirty per cent more often than when the device was not operating. There was an apparent increase in general activity. The most encouraging result was a reduction in the female's stereotyped pacing. The environmental enrichment of the chimp exhibit has resulted in a decrease in observable coprophagy."

Novak MA, Kinsey JH, Jorgensen MJ, Hazen TJ 1998. Effects of puzzle feeders on pathological behavior in individually housed rhesus monkeys. American Journal of Primatology 46, 213-227
"Manipulation of the puzzle feeder was associated with a reduction in pacing and rocking in all subjects; but this effect was transient, occurring only during the first hour after the puzzle feeder was filled with treats. Puzzle feeder manipulation had no effect on self-injurious behavior."

Nishimura S 2006. Owl monkey enrichment ideas. Tech Talk 11(1)
"One enrichment item we use is a small suet basket. We place pieces of fresh fruits, dried fruits, nuts, and ice cubes inside the basket and hang it inside the cages and kennels. The holes in the suet basket are too small for the Aotus to reach through, so they spend a good amount of time trying to manipulate the food pieces with their fingers and teeth. Another form of enrichment used is a small plastic baskets filled with hay, pine shavings, or Sani Chips to which we add a few nuts, cereal pieces, or mealworms." These two items increase foraging time.

O'Connor E, Reinhardt V 1994. Caged stumptailed macaques voluntarily work for ordinary food. In Touch 1(1), 10-11
http://www.awionline.org/Lab_animals/biblio/tou-food.htm
"Dan spent 286 seconds retrieving 12 biscuits from the food puzzle after leaving 21 freely available dish-biscuits untouched."

Perret K, Büchner S, Adler HJ 1998. Beschäftigungsprogramme für Schimpansen *(Pan troglodytes)* im Zoo. Der Zoologische Garten 68, 95-111
An effective feeding enrichment program for group-housed chimpanzees is described and assessed. The program resulted in a more than two-fold increase in time spent foraging (23.6% vs. 57.4% per day).

Poffe A, Melotto S, Gerrard PA 1995. Comparison of four environmental enrichment strategies in captive common marmosets *(Callithrix jacchus)*. Primate Report 42, 24-25
"Access to the puzzles was accompanied by increase in social interaction and activity and decrease in stereotypic behaviour. This behavioural profile was also observed, to a lesser extent, in animals exposed to the 'gum tree'. ... Novel objects alone [toys] failed to significantly alter behaviour."

Preilowski B, Reger M, Engele H 1988. Combining scientific experimentation with conventional housing: A pilot study with rhesus monkeys. American Journal of Primatology 14, 223-234
"The testing apparatus ... was connected to a computer that controlled the test and the distribution of regular monkey chow as reward." Manipulatory activity required by the apparatus reduced motor stereotypies but not self-biting in single-housed subjects.

Prist. P., Pizzutto CS, Hashimoto C 2004. Woven vine balls and baskets as feeding enrichment for howler monkeys. Shape of Enrichment 14(2), 1-2
http://www.enrichment.org/articles/142Howlers.pdf
"Our results showed that the animals spent more time foraging when the feeder balls were used [compared to the baskets], since it was more difficult to reach the leaves. The monkeys also explored each of the baskets and stopped spending most of their time on the floor. We concluded that these two enrichment ideas increased the animals' activity through play and exploration, and also increased their use of vertical space and reduced their time on the floor. These behaviors are more species-typical and appropriate for arboreal monkeys."

Reinhardt V 1992. Foraging for commercial chow. Laboratory Primate Newsletter 31(2), 10
http://www.brown.edu/Research/Primate/lpn31-2.html#chow
While sitting on swings, platforms or other elevated structures, or clinging to the mesh, individual animals seize a piece of chow and retrieve it through the mesh of the ceiling. "This simple 'food puzzle' not only promotes non-injurious foraging skills but also keeps the floor relatively clean by avoiding undue spoilage of food. The animals only work for food that they actually eat."

Reinhardt V 1993. Enticing nonhuman primates to forage for their standard biscuit ration. Zoo Biology 12, 307-312
http://www.awionline.org/Lab_animals/biblio/zb12-30.htm
Ordinary feeder-boxes were converted into food puzzles by remounting them onto the mesh of the front of the cages, away from original access holes. The total amount of time [pair-housed] adult male rhesus macaques engaged in gathering the standard biscuit ration was 141 times higher at food puzzles [42.2 min] than at feeder-boxes [0.3 min].

Reinhardt V 1993. Evaluation of an inexpensive custom-made food puzzle used as primary feeder for pair-housed rhesus macaques. Laboratory Primate Newsletter 32(3), 7-8
http://www.brown.edu/Research/Primate/lpn32-3.html#food
"Working for their standard food rather than collecting it from freely accessible food boxes did not impair the [pair-housed] animals' body weight maintenance, suggesting that their general health was not impaired by the new feeding technique."

Reinhardt V 1993. Promoting increased foraging behaviour in caged stumptailed macaques. Folia Primatologica 61, 47-51
"Simply remounting the food box [of single-housed subjects] a few centimeters away from the access hole resulted in a 69-fold increase in total time engaged in [biscuit ration] food-retrieving activities."

Reinhardt V 1993. Using the mesh ceiling as a food puzzle to encourage foraging behaviour in caged rhesus macaque (*Macaca mulatta*). Animal Welfare 2, 165-172
http://www.awionline.org/Lab_animals/biblio/aw3mesh.htm
"Daily commercial dry food rations consisting of 33 bar-shaped or 16 star-shaped biscuits per animal were placed on the mesh ceiling of the cages instead of in the feed-boxes. This induced an 80-fold increase and 289-fold increase, respectively, in foraging time" in the pair-housed males.

Reinhardt V 1994. Caged rhesus macaques voluntarily work for ordinary food. Primates 35, 95-98
http://www.awionline.org/Lab_animals/biblio/primat~1.htm
Individuals spent on average 32 sec retrieving biscuits from the ordinary food box, and 673 sec retrieving biscuits from the food puzzle. "It was inferred that the animals voluntarily worked for ordinary food, with the expression of foraging activities serving as its own reward."

Riviello MC 1995. The use of feeding board as an environmental enrichment device for tufted capuchin monkeys *(Cebus apella)*. Primate Report 42, 23-24
http://www.awionline.org/Lab_animals/biblio/pr42-2~2.htm
"Results show that the feeding board [on which seeds were scattered] were almost always in use [during 30-minute observations]" by the group-housed animals.

Schapiro SJ, Suarez SA, Porter LM, Bloomsmith MA 1996. The effects of different types of feeding enhancements on the behaviour of single-caged, yearling rhesus macaques. Animal Welfare 5, 129-138
http://www.awionline.org/Lab_animals/biblio/aw5-129.htm
"Enrichment use" in minutes/observation hour was as follows: Turf mats 25.8 minutes; Acrylic puzzles 22.1 minutes; Produce 17.4 minutes; Frozen juice 14.6 minutes.

Spector M, Kowalczky MA, Fortman JD, Bennett BT 1994. Design and implementation of a primate foraging tray. Contemporary Topics in Laboratory Animal Science 33(5), 54-55
"Excreta trays have been modified to include [small] foraging trays. The trays are placed under the cages. Videotape observation of [single-housed] 24 animals indicates the trays provide from 30 to over 120 min of foraging activity."

(4,2) Substrates

Anderson JR, Chamove AS 1984. Allowing captive primates to forage. In Standards in Laboratory Animal Management. Proceedings of a Symposium 253-256. Universities Federation Animal Welfare, Potters Bar, UK
http://www.awionline.org/Lab_animals/biblio/ufaw-2~1.htm
A woodchip litter substrate reduces abnormal behaviours, primarily self-aggression, and encourages foraging, even in the absence of grain.

Baker KC 1997. Straw and forage material ameliorate abnormal behaviors in adult chimpanzees. Zoo Biology 16, 225-236
"In an [successful] effort to reduce abnormal behaviors, especially regurgitation and reingestion, and promote higher activity levels [locomoting and playing], straw and scattered forage material were added to the enclosures of 13 indoor-housed chimpanzees living in pairs and trios."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.3. Feeding Enrichment. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/enrich.html#feed-prim
"Wood shavings in the catch pans provide an ideal substrate to foster foraging activities. On days when we change the pans — three times a week — we sprinkle sunflower seeds on the shavings. Our rhesus and squirrel monkeys then search with their fingers through the litter and pull the seeds through the floor grids, eat them or store them in their cheek pouches. Since we change the pans, rather than dump the bedding, we don't have any drainage problems in the rooms. This feeding enrichment technique doesn't require undue extra work time in our colony of approximately 130 monkeys. I'd say the benefit of being able to provide even a brief period of "natural" foraging behavior for our caged primates is worth the little additional time it takes to put the bedding in the pans and add a handful of seeds."

Blois-Heulin C, Jubin R 2004. Influence of the presence of seeds and litter on the behaviour of captive red-capped mangabeys *Cercocebus torquatus torquatus*. Applied Animal Behaviour Science 85, 340-362
"The addition of both litter and seeds induced a significant decline in self-directed activities and a significant increase in search for food. The presence of litter, with or without seeds, induced diversification of occupation of space."

Boccia ML 1989. Long-term effects of a natural foraging task on aggression and stereotypies in socially housed pigtail macaques. Laboratory Primate Newsletter 28(2), 18-19
http://www.brown.edu/Research/Primate/lpn28-2.html#maria
"A supplementary feeding of ... sunflower seeds were dispersed throughout the cage in the woodchip bedding ... 4-6 hours after the group was fed their daily ration of chow and fruit. ... Two months following the introduction of the foraging task ... stereotypies remained depressed, and hairpulling remained rare. ... Exploration remained elevated, and agonistic behaviors remained low."

Brown DL, Gold KC 1997. Effects of straw bedding on non-social and abnormal behavior of captive lowland gorillas *(Gorilla gorilla gorilla)*. In Proceedings on the 2nd International Conference on Environmental Enrichment Holst B (ed), 27-35. Copenhagen Zoo, Frederiksberg, Denmark
"Two individuals were frequently observed to hold their ears or head while the exhibit was in an unbedded condition. This behavior virtually disappeared in the enriched condition. ... Of the eight individuals found to engage in coprophagy, five individuals were observed to exhibit this behavior in solely the unbedded condition."

Bryant CE, Rupniak NMJ, Iversen SD 1988. Effects of different environmental enrichment devices on cage stereotypies and autoaggression in captive cynomolgus monkeys. Journal Medical Primatology 17, 257-269
http://www.awionline.org/Lab_animals/biblio/jmp17-2.htm
"Of the many activities available in the playpen, those that consistently captured the attention of all the [single-housed] animals throughout the 3-week observation period were foraging [in woodchip litter scattered with sunflower seeds placed below the grid floor of the cage]."

Burt DA, Plant M 1990. Observations on a caging system for housing stump-tailed macaques. Animal Technology 41, 175-179
http://www.awionline.org/Lab_animals/biblio/at-burt.htm
"The removal of metal grids at the bottom of the cage and the introduction of direct access to a substrate mixed with cereals and seeds, had a beneficial effect on the psychological well-being of the [single-housed] macaques by allowing foraging and, in our experience, up to 60% of our macaques' day is now spent in this pursuit."

Byrne GD, Suomi SJ 1991. Effects of woodchips and buried food on behavior patterns and psychological well-being of captive rhesus monkeys. American Journal of Primatology 23, 141-151
The addition of woodchips increased exploration and feeding levels. Burial of regular monkey chow in woodchips had little effect on behavior beyond that of the woodchips alone, increasing exploration and decreasing passivity. The addition of sunflower seeds to the woodchips encouraged increased feeding and exploration and led to decreased passivity and social interaction. No effect on abnormal behavior.

Chamove AS 2001. Floor-covering research benefits primates. Australian Primatology 14(3), 16-19
http://www.lisp.com.au/~primate/arnold.htm
"The basic study involved scattering the smallest food items we could find either onto the bare floor or into some substrate... Aggression was reduced. .. Food intake was more evenly distributed. ... We found NO bad effects ... The monkeys were foraging 14% of the time through

the wood-chips looking for and eating grain even though that same grain was available from hoppers full of the stuff nearby."

Combette C, Anderson JR 1991. Réponses à deux techniques d'enrichissement environmental chez deux espèces de primates en laboratoire *(Cebus apella, Lemur macaco).* Cahiers d'Ethologie 11, 1-16
"Locomotion almost doubled in the lemurs when small food items were added to the litter, but only the [group-housed] capuchins engaged in foraging activities to any extent."

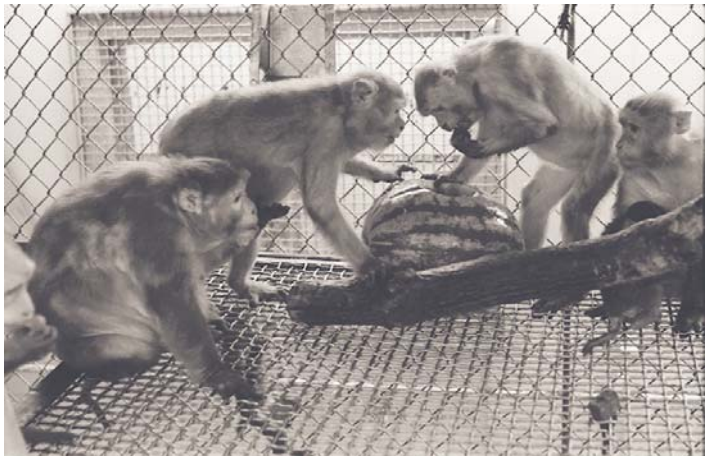
Grief L, Fritz J, Maki S 1992. Alternative forage types for captive chimpanzees. Laboratory Primate Newsletter 31(2), 11-13
http://www.brown.edu/Research/Primate/lpn31-2.html#grief
"Chicken scratch, because it is small and harder to find [in the litter], elicited the most foraging of the three foods ['sweet feed', popcorn]. It is very encouraging to see the chimpanzees still foraging late in the day for these small kernels. In addition, for subjects such as our blind animal, who had one of the highest foraging scores in our study, this [inexpensive] enrichment cannot be overemphasized."

Lutz CK, Novak MA 1995. Use of foraging racks and shavings as enrichment tools for groups of rhesus monkeys (*Macaca mulatta*). Zoo Biology 14, 463-474
Antagonism decreased when the animals had to search for food in wood shavings.

Mahoney CJ 1992. Some thoughts on psychological enrichment. Lab Animal 21(5), 27,29,32-37
Pans from rabbit cages can be used as foraging trays. "We fill the trays with wood chips or other types of bedding scattered with crushed maize, rice, or raisins, and attach them to the underside of the cage floors with bungie cords, thereby providing the animals with hours of searching activity."

Stegenga L 1993. Modifying spider monkey behavior with the use of environmental variables. The Shape of Enrichment 2(3), 3-4
"During baseline observations, the monkeys spent 7.3% of the time feeding, but when leaves were added to the enclosure, feeding activities increased to 13.1% of the time. ... When the leaves were added to the enclosure, playtime was more significant."

(4,3) Produce



Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.4. Coconuts. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/enrich.html#coconuts
"Rhesus don't care much about coconuts, but stump-tailed macaques are fascinated by them and do not get tired "working" on them until the last morsel has disappeared in the drop pan. It never occurred that one of the monkeys somehow became injured while processing a nut.

I give whole coconuts to our individually caged cynos. More than anything, they like them for grooming purposes. It gives them something else to do besides bite themselves. I also had a female who carried her coconut around as if it was a baby, constantly clutching it to her chest, and lip smacking to it, grooming it, etc. She was a chronic alopecia case. The coconut alleviated some — unfortunately not all — of her stereotypical hair pulling behavior."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.3. Feeding Enrichment. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/enrich.html#feed-prim
"I have given whole watermelons to group-housed rhesus, cynos, bonnet and stump-tailed macaques for several years without noticeable adverse effects. It would be a waste of time to cut the melons into small pieces. The monkeys first gnaw a hole into the rind and then "dig" into the soft and juicy part. They really like this and are kept busy until the last morsel has been eaten. They usually discard the rind, but before they do so they thoroughly remove any soft material and eat it. This usually creates quite a mess, but I don't mind cleaning it up, because the animals enjoy this type of feeding enrichment so much.

We give whole pumpkins to rhesus and cynos in both single- and group-housed environments. I would say that this is one of the most effective foraging device we have ever given our animals. All of them spent hours processing their pumpkin!

I give whole corn with the husk to our pair- and group-housed rhesus and baboons. They love it, and I enjoy observing them "peel and eat," leaving a big mess after they have finished. They gnaw the cob into little pieces that finally fall through the grid floor on the pans. I cannot say whether they actually also eat pieces of the cob, but we have never encountered any health-related problem. I don't mind cleaning up the mess; its worth the treat!

We use corn on the cob for all our caged cynos, rhesus and vervets. The animals give the impression that they love processing and eating the corn. They typically pick the kennels both with their hands and their teeth. When they are done, they proceed gnawing on the cob. I don't know if they actually ingest pieces of it. Even if they do, we have never encountered any clinical problems."

Beirise JH, Reinhardt V 1992. Three inexpensive environmental enrichment options for group-housed *Macaca mulatta*. Laboratory Primate Newsletter 31(1), 7-8
http://www.brown.edu/Research/Primate/lpn31-1.html#three
"We distributed the following enrichment materials on the floor once a week, each on a different day: (1) 1 kg roasted peanuts in their shells; (2) 32 ears of hard corn; (3) one non-corrugated cardboard box. ... After a habituation period of 8 weeks, [2-hour] behavioral observations were made. ...The corn was the most effective eliciter of foraging activity, engaging the animals about 77% of the time. Next in effectiveness was the box (65%) and finally the peanuts (47%)."

Bennett BT, Spector MR 1989. The use of naturally occurring manipulanda to improve the psychological well-being of singly housed baboons. Journal of the American Veterinary Medical Association 194, 1782 (Abstract)
The single-housed animals demonstrated a marked reduction of cage stereotypy during the time they had the corn to manipulate.

Nadler RD, Herndon JG, Metz B, Ferrer AC, Erwin J 1992. Environmental enrichment by varied feeding strategies for individually caged young chimpanzees. In Chimpanzee Conservation and Public Health: Environments for the Future Erwin J, Landon JC (eds), 137-145. Diagnon/Bioqual, Rockville, MD
Providing an ear of unhusked corn daily or on alternate days, in addition to laboratory chow, resulted in more time spent contacting food [primarily the corn] an hour after feeding [34% & 55%] than feeding laboratory chow alone [8% & 5%]. Seven of eight [single-housed] animals exhibited less stereotypy on the days they received the ear of corn. Stereotypical behavior, which occurs at relatively low frequencies under natural conditions, was reduced somewhat when the animals were fed three [vs. one] meals."

Waugh C 2002. Coconuts as enrichment item for macaques.Wisconsin Primate Research Center, University of Wisconsin-Madison, Primate Enrichment Forum (electronic discussion group), October 24, 2002
"I give whole coconuts, and have had them last a long time (days/weeks), until we exchange them with new ones (they are really durable). I have had one male cyno break one open by throwing it around his cage for a few days in a row, and even then it just cracked - he loved the milk and continued to amuse himself by trying to get to the fleshy part inside until we eventually had to take it away from him because it got kind of gross! More than anything, I think they like them for grooming purposes - it gives them something else to do besides bite themselves. I also had a female cyno who carried her coconut around like it was a baby, constantly clutching it to her chest, and lip smacking to it, grooming it, etc. She was a chronic alopecia case, and the coconut aided in her problem somewhat also. In my experience, it is a cheap, quite helpful, and interesting alternative!"

(4,4) Ice and Water

Anderson JR, Peignot P, Adelbrecht C 1992. Task-directed and recreational underwater swimming in captive rhesus monkeys *(Macaca mulatta)*. Laboratory Primate Newsletter 31(4), 1-4
http://www.brown.edu/Research/Primate/lpn31-4.html#swim
"Facilitating thermoregulation and increasing [solitary and social] play are two reasons to consider a swimming facility to be a cheap and clean environmental enrichment."

Anonymous 2006. Is a swimming pool safe for macaques? A discussion. Laboratory Primate Newsletter 45(3), 13
http://www.brown.edu/Research/Primate/lpn45-3.html#swim
Experience suggest that the provision of a shallow swimming pool provides an effective, safe environmental enrichment option for macaques.

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 8.7. Swimming Pools for Macaques. Washington, DC: Animal Welfare Institute http://www.awionline.org/pubs/LAREF/safety.html#swim

”We give our pair-housed cynos ”bathtubs,“ filled with 30 to 40 cm deep warm water, a few times a week, and have never encountered any problems other than a lot of splashing. Some monkeys take luxurious baths, others climb a perch and jump into the water, others sit on the side walls and drag their hands in the water, and others wash their fruit in the water. Usually the monkeys make a real mess within the first half hour, and yes they do urinate/defecate in the water. We empty the tubs after about two hours, if the monkeys haven’t done it already themselves — which is often the case.

There are a few published articles on the use of swimming pools for rhesus, long-tailed and Japanese macaques. None of these papers mention any safety or hygienic problems.“

Fritz J, Howell S 1993. The disappearing ice cube. Laboratory Primate Newsletter 32(1), 8
http://www.brown.edu/Research/Primate/lpn32-1.html#ice
Ice ”cubes are distributed across the floor, hidden in high plastic barrels (we call these igloos), tucked into corners of the cages, etc. As the animals come out, the excitement of the hunt starts and continues until the last ice cube is found. Hoarders clutch them to their chests, ... others fill their mouths and carry the cubes to the top of the cage, where they lay them down and watch carefully as the cubes get smaller and smaller. Still others have learned to skate through the puddles, making mad dashes in order to slide further and further.“ No detrimental effects have been found of providing the ice cubes.

Gilbert SG, Wrenshall E 1989. Environmental enrichment for monkeys used in behavioral toxicology studies. In Housing, Care and Psychological Wellbeing of Captive and Laboratory Primates Segal EF (ed), 244-254. Noyes Publications, Park Ridge, NJ
"The pools [stainless-steel frame with 3/8” Plexiglas sides] have been a tremendous success with the younger [cynomolgus] monkeys, who adapt easily to water and are instinctively good swimmers. They will swim under water with their eyes open looking for the raisins and playing with each other."

Hazlewood SJ 2001. From beagles to marmosets - The development of a marmoset breeding cage. Animal Technology 52, 149-152
A “water bath was found to be of little interest to the marmosets, other than to use it as a toilet!"

McNulty J 1993. Enrichment for primates in a toxicology facility. Laboratory Primate Newsletter 32(2), 16
http://www.brown.edu/Research/Primate/lpn32-2.html#judi
Ice cubes have "been given to hundreds of monkeys, and we found no ill effects (e.g., broken teeth)."

Parks KA, Novak MA 1993. Observations of increased activity and tool use in captive rhesus monkeys exposed to troughs of water. American Journal of Primatology 29, 13-25
"These results suggest that exposure to water sources may elicit a broad spectrum of species-typical activity and may be a simple and inexpensive way to enrich the environment of captive [group-housed] rhesus monkeys. ... Standing water was more effective than running water in increasing exploration and object manipulation."

Poulsen E 1994. Monkeys on ice. The Shape of Enrichment 3(1), 7
"I spent an hour or so shoveling fresh, clean new snow into a huge plastic bin and dumped the lot on the floors of each small primate and prosimian indoor enclosure... The event was a tremendous success"

Rademacher A 1997. Gorilla treats served poolside. The Shape of Enrichment 6(3), 11
"Initially, [Rocky, the gorilla], was hesitant and seemed a bit irritated at this presentation of food [floating on the pool's surface], but eventually he waded into the water and retrieved the treats. Rocky will now wade into the pool when food items are tossed in; we no longer need to float them on the surface. He even makes use of the pool occasionally during our hot Arkansas summers, sitting on the bottom, with his arms stretched along the pool's edge."

Schafer J 2005. Primate popsicles. Tech Talk 10(3), 4
"When the frozen enrichment treats were first provided to our rhesus macaques, they showed a great deal of interest and worked steadily at removing the food from the ice. After several months of using this enrichment, the primates still enjoy their frozen treats."

Steele TL, Butler NA, Segar MT, Olson SM 1995. Preferences for food location and foraging requirements in white-handed gibbons. American Zoo and Aquarium Association Regional Conference Proceedings, 151-158
"Mixing ice with the food [in buckets] reduced eating time slightly but substantially increased foraging time. Foraging was much more extensive from the top bucket and significantly more food was gathered from this source than from the bottom bucket. The dominance of the male during feeding suggests that more than one food source should be available for multiple animals."

(4,5) Food Preparation and Feeding Schedule

Kerridge FJ 2005. Environmental enrichment to address behavioral differences between wild and captive black-and-white ruffed lemurs (*Varecia variegata*). American Journal of Primatology 66, 71-84
"Behavioral enrichment experiments were carried out in which whole rather than chopped fruit was provided and presented in a more naturalistic manner [whole fruit suspended by sisal or jute from wooden polses]. ... Manual manipulation of dietary items increased. Time spent feeding also increased significantly. .. The novel feeding method successfully stimulated the animals to

use their hands to obtain and process fruit. It also necessitated bipedal and tripedal suspension. .. The enrichment increased the time spent feeding to levels similar to those seen in the wild."

Parks KA, Novak MA 1993. Observations of increased activity and tool use in captive rhesus monkeys exposed to troughs of water. American Journal of Primatology 29, 13-25
"These results suggest that exposure to water sources may elicit a broad spectrum of species-typical activity and may be a simple and inexpensive way to enrich the environment of captive [group-housed] rhesus monkeys. ... Standing water was more effective than running water in increasing exploration and object manipulation."

Potratz KR, Boettcher C 2006. Rhesus diet smoothies. Tech Talk 11(4), 5
There are a number of situations in which non-human primates need a special diet to provide additional calories. The receipe for a Chow Smoothie for Rhesus macaques is described and consists in incorporating the animal's regular food, tailoring the smoothie to the individual animal's needs, and adding specific supplements, medications, and different flavors. The smoothie was tested on 40 Rhesus macaques ranging in age from 2 to 25 years.

Poulsen E 1994. Monkeys on ice. The Shape of Enrichment 3(1), 7
"I spent an hour or so shoveling fresh, clean new snow into a huge plastic bin and dumped the lot on the floors of each small primate and prosimian indoor enclosure... The event was a tremendous success."

Rademacher A 1997. Gorilla treats served poolside. The Shape of Enrichment 6(3), 11
"Initially, Rocky was hesitant and seemed a bit irritated at this presentation of food [floating on the pool's surface], but eventually he waded into the water and retrieved the treats. Rocky will now wade into the pool when food items are tossed in; we no longer need to float them on the surface. He even makes use of the pool occasionally during our hot Arkansas summers, sitting on the bottom, with his arms stretched along the pool's edge."

Steele TL, Butler NA, Segar MT, Olson SM 1995. Preferences for food location and foraging requirements in white-handed gibbons. American Zoo and Aquarium Association Regional Conference Proceedings, 151-158
"Mixing ice with the food [in buckets] reduced eating time slightly but substantially increased foraging time. Foraging was much more extensive from the top bucket and significantly more food was gathered from this source than from the bottom bucket. The dominance of the male during feeding suggests that more than one food source should be available for multiple animals."

(5) Promoting Arboreal Behavior

(5,1) The Importance of Access to Vertical Dimension of Space

Bernstein IS, Draper WA 1964. The behaviour of juvenile rhesus monkeys in groups. Animal Behaviour 12, 84-91
Subjects spent 48%-72% of the time in the upper one-third of the compound.

Bloomsmith MA, Lambeth SP, Haberstroh MD 1999. Chimpanzee use of enclosures. American Journal of Primatology 49, 36
Group-housed chimpanzees spent 43% of their time off the ground.

Buchanan-Smith HM 1991. A field study on the red-bellied tamarin, *Saguinus l. labiatus*, in Boliva. International Journal of Primatology 12, 259-276
Tamarins spent 90% of their time in the upper half of their 186 cm-high cages when observations were made from a hide.

Clarence WM, Scott JP, Dorris MC, Paré M 2006. Use of enclosures providing vertical dimension by captive rhesus monkeys (*Macaca mulatta*) involved in biomedical research. JAALAS [Contemporary Topics in Laboratory Animal Science], 45(5), 31-34
"The monkeys visited more often and occupied for longer time regions at or above human eye level [perches and top home cage] than lower regions." The total percentage of time spent in the top home cage was found to be significantly greater than in the bottom home cage."

European Commission 2002. The Welfare of Non-human Primates - Report of the Scientific Committe on Animal Health and Animal Welfare. European Commission, Strasbourg, France
http://europa.eu.int/comm/food/fs/sc/scah/out83_en.pdf
"Enclosures for nonhuman primates should be equipped with one or more elevated resting surfaces (to a position higher than the level at which they perceive threatening factors, e.g., humans) and installed in such a way that an animal can sit on them comfortably. Perches or shelves should be provided in all cages. Arboreal species should be given adequate vertical space to allow the expression of normal locomotory behaviour. Primates should not be placed in double-tiered caging unless the arrangement permits adequate vertical movement for the animal."

Goff C, Howell SM, Fritz J, Nankivell B 1994. Space use and proximity of captive chimpanzees (*Pan troglodytes*) mother/offspring pairs. Zoo Biology 13, 61-68
"Results confirmed the importance of vertical cage dimension and suggested the provision of horizontal substrates above the enclosure floor is important."

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK
http://scienceandresearch.homeoffice.gov.uk/animal-research/legislation/
"The use of space by primates means that cage volume is important. Virtually all show a vertical flight reaction. Cage height should allow for this and should permit the animals to stand erect, jump and climb, and to sit on a perch without head or tail touching the cage."

International Primatological Society 1993. IPS International guidelines for the acquisition, care and breeding of nonhuman primates, Codes of Practice 1-3. Primate Report 35, 3-29
http://pin.primate.wisc.edu/ips/codes.txt
"The vertical dimension of the cage is of importance [because of the vertical flight response] and cages where the monkey is able to perch above human eye level are recommended."

Kaumanns W, Schönmann U 1997. Requirements for cebids. Primate Report 49, 71-91
"Arboreal species need ... enclosures which allow a differentiated moving in the vertical dimension. They should be able to use spatial positions which are above the level ... of threatening humans or potential dangerous events in their environment. Cage positions in a keeping room below the eye level of human can be a source of permanent stress, because they are incompatible with adaptive tendencies of arboreal primates to avoid risks by using higher parts of the habitat."

MacLean E, Roberts Prior S 2006. View from the top. AWI (Animal Welfare Institute) Quarterly 55(3), 7
http://www.awionline.org/quarterly/view_from_top.html
"Across both conditions, monkeys showed a strong preference for the upper-row cage indicating that elevation was more important than illumination in guiding location preference. Although monkeys did increase the amount of time that they spent in the lower row during periods of reversed lighting, this trend was not significant. Nonetheless, we do not interpret this result as evidence that sufficient lighting is not important to captive monkeys. Rather, we believe that monkeys' consistent preference for the upper-row reflects the paramount importance of access to elevated space."

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates National Academy Press, Washington, DC
http://fermat.nap.edu/books/0309052335/html/index.html
"Under natural conditions, many primates spend much of their lives aboveground and escape upward to avoid terrestrial threats. Therefore, these animals might perceive the presence of humans above them as particularly threatening. ... Even macaques, which some describe as semiterrestrial, spend most of the day in elevated locations and seek the refuge of trees at night. ... Optimal use of available cage space might well depend more on the placement of perches, platforms, moving and stationary supports, and refuges than on cage size itself."

Reinhardt V, Liss C, Stevens C 1996. Space requirement stipulations for caged nonhuman primates in the United States: A critical review. Animal Welfare 5, 361-372
http://www.awionline.org/Lab_animals/biblio/aw4space.htm
"Having no stimulatory value, space alone does not enhance an animal's environment. ... Legal space requirements for non-human primates are not adequate unless they stipulate that sufficient height be provided to accommodate properly placed elevated structures."

Ross SR, Lukasb KE 2006. Use of space in a non-naturalistic environment by chimpanzees (*Pan troglodytes*) and lowland gorillas (*Gorilla gorilla gorilla*) . Applied Animal Behaviour Science 96, 143-152
"Chimpanzees preferred the highest tier of the enclosure and the gorillas preferred the floor level. Both species showed preferences for doorways, corners and the mesh barriers adjacent to keeper areas."

Taylor L, Owens A 2004. Enclosure use by aged squirrel monkeys (*Saimiri sciureus*). American Journal of Primatology 62(Supplement), 85 (Abstract)
http://www.asp.org/asp2004/abstractDisplay.cfm?abstractID=800&confEventID=808
A group of squirrel monkeys was translocated from an indoor exhibit to an outdoor enclosure. "The monkeys were scored most often among the largest and highest branches in the tallest tree in the enclosure (17.7%). .. None were ever scored on the ground, despite the water source being there and the insect foraging opportunities."

Westlund K Preference of the vertical dimension of cyno pairs living in high cages. Laboratory Animal Refinement and Enrichment Forum (electronic discussion group), November 28, 2002
"In a quantitative study I did on pair-housed cynos the animals spent 95% of their waking time in the upper part of the cage (being housed in a system that resembles a double-tier system, but with vertical access to upper and lower sections) - which suggests that their preference along the gradient of height is unequivocal! No bedding was provided on any of the cage floors, and all

food was given in the bottom section. Even so, animals would bring the food to the upper part and consume it there."

(5,2) Elevated Structures

Abee CR 1985. Medical care and management of the squirrel monkey. In Handbook of Squirrel Monkey Research Rosenblum LA, Coe CL (ed), 447-488. Plenum Press, New York, NY
"Squirrel monkeys .... lack ischeal callosities and therefore are prone to the development of sores if they are not provided with suitable structures on which to climb and perch. Squirrel monkeys prefer a flat, shelf-type surface for sleeping, but animals using such perches frequently develop pressure ulcers on the dorsal aspect of the tail. By using large-diameter plastic pipe (1.5 inch), a highly desirable perch can be provided. These perches have a broad surface yet are sufficiently contoured to avoid tail sores."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.17. Vertical Space Enhancement. Washington, DC: Animal Welfare Institute
hhttp://www.awionline.org/pubs/LAREF/enrich.html#vertical-prim
"Most of the primates' natural environment is "fixed.“ Even a tree is "fixed;“ it's only at the end of branches where a monkey in nature would have the sensation of anything like a swinging perch. A fixed perch is a great thing for a monkey. We used to hang numerous swings and movable raised structures into the enclosure of our group-housed cynos, but we could see very clearly that they prefer the stable perches or platforms. Our animals very rarely used ropes or swings. The only ones using those elements were babies and juveniles.

In the caging systems we use there is no bottom tier. All cages are 0.6 m off of the floor. Each cage is furnished with a 1 m high perch; so it is pretty much at human eye level — 1.6 m height. It seems to me that the animals feel relaxed when they sit on their perch and can meet me at eye level. A low perch has little or no value as a ”safe“ resting location from our monkeys point of view."

Bayne K, Hurst JK, Dexter SL 1992. Evaluation of the preference to and behavioral effects of an enriched environment on male rhesus monkeys. Laboratory Animal Science 42, 38-45
"With simultaneous exposure, the single-housed subjects spent the greatest portion of the interactive time [30 minute-observation sessions] on the perch [16.8%], the second greatest amount of time spent divided approximately equally between interacting with the Kong [5.0%] and Tug-A-Toy [4.9%], and the least amount of time spent manipulating the grooming board [0.4%]."

Brinkman C 1998. Usefulness of swings for macaques. Primate Enrichment Forum (electronic discussion group), August 17, 1998
"I have used swings with cynos and pigtails... My impression is that adult animals do not really use them, that is, to 'swing'. Young animals like moving things, be they swings, or other suspended items. My adults did not even use the swings much to perch on; my explanation is that on a swing, you simply cannot easily relax. Animals cannot really sit on them, and especially with the cynos, you can see almost continuous movement in the tail, compensating in balance."

Crockett CM, Bellanca RU, Bowers CL, Bowden DM 1997. Grooming-contact bars provide social contact for individually caged laboratory primates. Contemporary Topics Laboratory Animal Science 36(6), 53-60
"Monkeys in upper cages averaged 48%±27% SD of the time on the perch, compared with 40%±25% SD for monkeys in lower cages."

Davis E 2006. More fun with a barrel full of monkeys: A nonhuman primate swing made by recycling plastic barrels. Laboratory Primate Newsletter 45(3), 9-11
http://www.brown.edu/Research/Primate/lpn45-3.html#swing
"The NIH Shared Animal Facilities' enrichment program has developed a primate swing created from recycling our discarded plastic 30- and 55-gallon detergent barrels. These swings are easy to construct and are effective in increasing our animals' behavioral repertoires. Additionally, these swings are safe, portable, non-toxic, easy to sanitize, and almost indestructible. We have used these barrels in our socially-housed monkey runs for over three years, and they are still going strong!"

Dexter SL, Bayne K 1994. Results of providing swings to individually housed rhesus monkeys (*Macaca mulatta*). Laboratory Primate Newsletter 33(2), 9-12
http://www.brown.edu/Research/Primate/lpn33-2.html#bayne
The single-housed adult test subjects manipulated the swings but showed little inclination to actually use them for swinging.

European Commission 2002. The Welfare of Non-human Primates - Report of the Scientific Committe on Animal Health and Animal Welfare. European Commission, Strasbourg, France
http://europa.eu.int/comm/food/fs/sc/scah/out83_en.pdf
Comprehensive updated recommendations on the species-appropriate care of nonhuman primates.
"Enclosures for nonhuman primates should be equipped with one or more elevated resting surfaces (to a position higher than the level at which they perceive threatening factors, e.g., humans) and installed in such a way that an animal can sit on them comfortably. Perches or shelves should be provided in all cages."

Günther MM 1998. Influence of habitat structure on jumping behaviour in *Galago moholi*. Folia Primatologica 69(Supplement), 410 (Abstract)
There was a statistically significant preference for wooden versus PVC perches and for high versus low perches. "These results suggest that support material as well as height, influences the behaviour of G. maholi. Studies which do not take these factors into account are to some extent vitiated."

Howell SM, Mittra E, Fritz J, Baron J 1997. The provision of cage furnishings as environmental enrichment at the Primate Foundation of Arizona. The Newsletter 9(2), 1-5
http://www.awionline.org/Lab_animals/biblio/jo-5.htm
"Adults infrequently used 'moving' furnishings (e.g., swinging ropes, hanging tubes, etc...) and seemed to prefer 'stable' horizontal furnishings (e.g., benches, logs) above the enclosure floor."

Kopecky J, Reinhardt V 1991. Comparing the effectiveness of PVC swings versus PVC perches as environmental enrichment objects for caged female rhesus macaques. Laboratory Primate Newsletter 30(2), 5-6
http://www.brown.edu/Research/Primate/lpn30-2.html#vik
Single-housed subjects' "preference for perches was probably related to the fact that perches, unlike swings, are fixed structures permitting continuous relaxed postures rather than short-term balancing. Moreover, perches, unlike swings, permit the animals to sit right in front of the cage with optimal visual control of the environment outside of the cage."

Millere KE, Laszlo K, Suomi SJ 2006. Using recycled barrel swings vs. Prima-Hedrons in primate enclosures. Laboratory Primate Newsletter 45(3), 12
http://www.brown.edu/Research/Primate/lpn45-3.html#swing2
"To document the utility of using recycled barrel swings vs. Prima-Hedrons as enrichment objects, we observed a socially housed group of 28 tufted capuchins (Cebus apella). .. We found no significant difference in the average frequency of use of hanging Prima-Hedrons vs. hanging barrels."

Neveu H, Deputte BL 1996. Influence of availability of perches on the behavioral well-being of captive, group-living mangabeys. American Journal of Primatology 38, 175-185
"A total deprivation of perches yielded an increase in aggressive behaviors and locomotion, and a decrease in cohesiveness. Placing perches progressively in the experimental cage restored the level of all the variables to levels found in the control cage [with five perches]. ... Therefore, perches constitute a necessary feature of an adequate environment for mangabeys."

O'Neill-Wagner PL 1994. When trying to get your monkeys to behave, try perches. In Touch 1(2), 6-8
http://www.awionline.org/Lab_animals/biblio/tou-pegg.htm
The group-housed animals preferred perches at high elevation over perches at low elevation.

Ochiai T, Matsuzawa T 1999. Environmental enrichment for captive chimpanzees *(Pan troglodytes)*: Introduction of climbing frames 15 m high. Reichorui Kenkyu/Primate Research 15, 289-296
"Tall climbing frames were introduced into an outdoor compound for captive chimpanzees as a way of environmental enrichment. ... Chimpanzees spent 81% of the observation time on the climbing structures. ... All chimpanzees used the climbing structure throughout the day with little individual difference."

Phillippi-Falkenstein K 1998. Usefulness of swings for macaques. Primate Enrichment Forum (electronic discussion group), August 19, 1998
"In group runs, corncribs and corrals, swings provide a dimension of environmental complexity for rhesus and pig-tailed macaques. The swings are primarily used by young animals, while adults rarely use them. Tire swings seem to be the favorite. It has been my experience that the animals - even juveniles - do not benefit from swings when housed in 'small' standard cages: They simply don't use them."

Plesker R, Herzog A 2001. Prima hedrons, puzzle feeders and television as environmental enrichment for captive African Green Monkeys. Primate Eye 74, 4 (Abstract)
http://www.psgb.org/Meetings/Spring2001.html
"The prima hedrons had no significant effect on any of the behaviours investigated. These were infrequently used as objects for playing, resting or observation."

Reinhardt V 1989. Evaluation of the long-term effectiveness of two environmental enrichment objects for singly caged rhesus macaques. Lab Animal 18(6), 31-33
http://www.awionline.org/Lab_animals/biblio/la-eval.htm
Singly caged monkeys spent 28% of the 120 min observation time with the PVC pipe. "While perching, the monkeys sat in front of the cage for 95% of the time, in the middle or rear of the cage for 5% of the time. ... The proportion of time spent with the pipes was three times greater for animals living in lower-row cages than for animals living in upper-row cages. .. In the elevated position, the light exposure was increased, a fact that made the pipes of particular value for the lower-row caged animals."

Reinhardt V, Pape R 1991. An alternative method for primate perch installation. Lab Animal 20(8), 47-48
http://www.awionline.org/Lab_animals/biblio/la-an.htm
Modification of squeeze cages is described allowing the installation of a perch that does not interfere with the normal operation of the cage.

Reinhardt V 1990. Comparing the effectiveness of PVC perches versus wooden perches as environmental enrichment objects for singly caged rhesus monkeys. Laboratory Primate Newsletter 29(1), 13-14
http://www.brown.edu/Research/Primate/lpn29-1.html#comp
"One half of each cage was provided with a PVC pipe, the other with an oak branch." Both perches had the same diameter and were installed in the same manner. During one-hour observation sessions, single-caged subjects showed no clear preference but spent on average 19% of the time on the PVC pipe and another 24% of the time on the oak branch.

Reinhardt V 1992. Environmental enrichment branches that do not clog drains. Laboratory Primate Newsletter 31(2), 8
http://www.brown.edu/Research/Primate/lpn31-2.html#branch
"More than 700 caged rhesus and stump-tailed macaques housed in 29 rooms have been exposed to red oak perches and/or loose branch segments for a period of six months. Drains did not clog in any of the 29 rooms during this time although the animals gnawed the wood extensively."

Reinhardt V 1992. Space utilization by captive rhesus macaques. Animal Technology 43, 11-17
http://www.awionline.org/Lab_animals/biblio/at.htm

"The area covered by the floor was 3 times larger than that covered by elevated structures; nonetheless the animals were located significantly more often (89.8% of 108 scan samples) on elevated structures than on the floor (8.6% of 108 scan samples). ... The higher an animal's rank position, the more pronounced was its habit to utilize high-level (>130 cm above floor) structures of the pen, while low ranking animals had to be content with low-level structures (40 cm above floor) and the floor. .. All members of the group would inevitably take to elevated sites whenever they heard or saw fear-inducing personnel. ... The animals huddled together with regularity on high-level structures but never on low-level structures or on the floor. ... It was concluded that laboratory rhesus macaques prefer the vertical dimension over the horizontal dimension as primary living space."

Reinhardt V 2003. Legal loophole for subminimal floor area for caged macaques. Journal of Applied Animal Welfare Science 6, 53-56
http://www.awionline.org/Lab_animals/biblio/jaaws9.html
"The USDA regulations pertaining to the minimum space requirements of nonhuman primates and the fitting of elevated resting surfaces are contradictory. They implicitly condone the prevailing perch design that allows maximal usage of animal room space by stacking the cages on top of each other but fails to address the animals minimal spatial needs for normal postural adjustments with freedom of movement. An amendment to the regulations is needed to clarify that perches, ledges, swings, or other suspended fixtures have to be installed in such a way that they do not block part of the minimum floor space that is needed by an animal to make species-typical postural adjustments with freedom of movement."

Ricker RB, Williams LE, Brady AG, Gibson SV, Abee CR 1995. Environmental enhancement for laboratory-housed squirrel monkeys: Fifteen-year retrospective analysis of procedures. Contemporary Topics in Laboratory Animal Science 34(4), 55 (Abstract)
"Two types of perching material were tried: polyvinyl chloride and hemp (rope). The PVC was preferred by the animals and was set up in multiple levels, allowing use of vertical as well as horizontal space."

Schmidt EM, Dold GM, McIntosh JS 1989. A perch for primate squeeze cages. Laboratory Animal Science 39, 166-167
Modification of single squeeze-cages is described allowing the installation of a perch that does not interfere with the normal operation of the cage. "The monkeys make use of their perch for feeding, grooming and sleeping" for 30% to 95% of the day.

Seier JV 2000. Usefulness of wooden material for environmental enrichment for rhesus macaques. Primate Enrichment Forum (electronic discussion group), February 12, 2000
"We have been using wood extensively in our vervet monkey colony (about 300 monkeys, indoors) and communal cages we make climbing apparatus from wood. Wood perches for resting were also installed but they use the metal perches equally well. ...The vervets use the wood as described for other species, stripping the bark and climbing. They eventually reduce and medium branches to a single pole. We find this desirable since it keeps them occupied for hours. ... They do not loose interest in the wood as they do in other objects which we have tried. ... There is obviously the problem of sanitation but we replace the wood regularly and autoclave it before we place inside the cage (luckily we have a very large autoclave). Clogging of drains and mould has not occurred, neither have problems such as injury through splintering. ... We consider wood as our most important enrichment tool."

Shimoji M, Bowers CL, Crockett CM 1993. Initial response to introduction of a PVC perch by singly caged *Macaca fascicularis*. Laboratory Primate Newsletter 32(4), 8-11
http://www.brown.edu/Research/Primate/lpn32-4.html#pvc
The height of the cage is important for allowing the animals to withdraw from potentially stressful or alarming situations. "Monkeys spent significantly more time clinging to the cage wall in the absence of the perch. ... Monkeys in lower level cages [26% of daytime] averaged somewhat more time on the perch than those in upper cages [14% of daytime]. ... There was less stereotypy when the perch was present."

Smith K, St. Claire M, Byrum R, Harbaugh S, Harbaugh J, Erwin J 2003. Use of space, cage features, and manipulable objects by laboratory primates: individual differences and species variability. American Journal of Primatology 60(Supplement), 76-77 (Abstract)
"Rhesus (74%), longtailed (71%), vervets (94%), and patas (82%) significantly exceeded the expected rate of perch use (25%), while pigtailed (28%) did not differ from expectation."

Taylor LL 1998. Promoting species typical behavior in Coquerel's sifakas *(Propithecus Verreauxi Coquereli)*. American Zoo and Aquarium Association Regional Conference Proceedings, 599-603
"The sifakas rarely were observed on the ground, preferring to locomote on vertical substrates and rest on vertical and horizontal elevated substrates. ...If vertical surfaces were absent from captive habitats, these rare lemurs could not display their preferred mode of arboreal locomotion."

Taylor L, Owens A 2004. Enclosure use by aged squirrel monkeys (*Saimiri sciureus*). American Journal of Primatology 62(Supplement), 85
http://www.asp.org/asp2004/abstractDisplay.cfm?abstractID=800&confEventID=808
A group of squirrel monkeys was translocated from an indoor exhibit to an outdoor enclosure. "Static substrates were preferred (64.3%). Dynamic substrates, like rope walkways, were used primarily during locomotion (33.8%) from one static location to another."

van Wagenen G 1950. The monkeys. In The Care and Breeding of Laboratory Animals Farris EJ (ed), 1-42. John Wiley, New York, NY
"Sitting on the board [approximately 1 m off the ground], facing the center of the room, is the favorite position of the monkeys. At this height these intensely alert animals have a better view of activities within the room, and they can meet visitors on the same eye level. ... and they sleep on the board at night."

Watson DSB 1991. A built-in perch for primate squeeze cages. Laboratory Animal Science 41, 378-379
Perch installation design for single squeeze-back cages is described. "Independent of gender the monkeys were seen using their perches more than 84% of the time."

Watson SL, Shively CA 1996. Effects of cage configuration on behavior in cynomolgus macaques. XVIth Congress of the Internatational Primatological Society/XIXth Conference of the American Society of Primatologists, Abstract No. 674
"Stereotypies occurred more often in the STD [standard single cage] than in the VE [vertically-enhanced; probably with perche(s)]. ... The results indicate that VE cages provide more suitable individual housing environments for nonhuman primates than STD cages."

Watson SL, Gray A, Taylor E, Johnson B, Fahm B, McGee A, Bingham W, Banks P 2002. Efficacy of environmental enrichment for garnett's bushbaby (*Otolemur garnettii*). American Journal of Primatology 57, 38-39
"Bushbabies interacted with swinging/climbing apparati significantly more than with manipulanda.... All animals spent significantly more time at the top than at the bottom of their cages (t(17)=3.3, p=.004). ... These results suggest that provision of vertical space and swinging/climbing opportunities may be more effective forms of enrichment for bushbabies than provision of manipulanda."

Williams LE, Abee CR, Barnes SR, Ricker RB 1988. Cage design and configuration for an arboreal species of primate. Laboratory Animal Science 38, 289-291
Squirrel monkeys preferred a PVC pipe perch (rigid) over rope perches (non-rigid). For an arboreal animal, a higher perch may be perceived as safer." Perches decreased the propensity for tail ulcers associated with floor contact. "With only one perch level, males were forced to spend a large percentage of their time sitting on the floor rather than the main perches [which were occupied by females]."

Wolff A 1989. Polyvinyl chloride piping as perch material for squirrel monkeys. Laboratory Primate Newsletter 28(1), 7
http://www.brown.edu/Research/Primate/lpn28-1.html#pvc
"An additional unexpected benefit of the PVC piping has been a decrease in dorsal tail-head abrasions, frequently seen in squirrel monkeys that sit on the stainless steel flooring of standard primate cages."

Woodbeck T, Reinhardt V 1991. Perch use by *Macaca mulatta* in relation to cage location. Laboratory Primate Newsletter 30(4), 11-12
http://www.brown.edu/Research/Primate/lpn30-4.html#perch
Single-housed "animals living in lower-row cages spent an average of 31.6% of the time perching on their pipes while animals living in upper-row cages perched only 6.9% of the time. Access to the vertical dimension of the cage was more important for the lower-row caged monkeys who continuously live close to the ground, in the horizontal dimension of the room."

(6) Promoting Object-oriented Behavior

(6,1) Commercial Toys

photo by Peggy O'Neill-Wagner

Anonymous 1991. The psychological well-being of primates. Primate News 25(Fall), 3-5
"The problems with all these devices is that they are expensive to purchase (foraging boards cost $60 each) and to maintain (they require many hours to fill and clean). ... We could live with the expense if we were certain that these devices really improve the well-being of the animals. It seems, however, that after a short time the animals lose interest in foraging boards, and fleece boards, just as they lose interest in balls and toys."

Bayne K 1989. Nylon balls re-visited. Laboratory Primate Newsletter 28(1), 5-6
http://www.brown.edu/Research/Primate/lpn28-1.html#ball
"Approximately 10% of the [single-housed] monkeys in a room utilize the ball at any given time."

Bayne K, Hurst JK, Dexter SL 1992. Evaluation of the preference to and behavioral effects of an enriched environment on male rhesus monkeys. Laboratory Animal Science 42, 38-45
"With simultaneous exposure, the single-housed subjects spent the greatest portion of the interactive time [30 minute-observation sessions] on the perch [16.8%], the second greatest amount of time spent divided approximately equally between interacting with the Kong [5.0%] and Tug-A-Toy [4.9%], and the least amount of time spent manipulating the grooming board [0.4%]."

Bayne K, Dexter SL, Hurst JK, Strange GM, Hill EE 1993. Kong toys for laboratory primates: Are they really an enrichment or just fomites? Laboratory Animal Science 43, 78-85
"The use of simple toys for environmental enrichment of laboratory primates is an economical means of increasing the complexity of the cage environment to a limited degree. The limitations presented by this method of enrichment include the finite ways in which a simple device can elicit normative behaviors and the relatively rapid habituation to the device." It was demonstrated that microbial growth can persist on enrichment devices - such as Kong toys - after they have been sanitized in a commercial cagewasher.

Bloomsmith MA, Finlay TW, Merhalski JJ, Maple TL 1990. Rigid plastic balls as enrichment devices for captive chimpanzees. Laboratory Animal Science 40(3), 319-322
"The mean percentage of ball-use time for all subjects during the study [first ten hours after initial presentation] was 7.1%. ... Age and housing effects were obtained, with younger animals and those housed in more barren environments exhibiting higher levels of ball use. It is concluded that the balls were worthwhile additions to the chimpanzee environments with use stabilizing at a mean of 2.5% of the subjects' time."

Brent L, Stone AM 1998. Destructible toys as enrichment for captive chimpanzees. Journal of Applied Animal Welfare Science 1, 5-14
Nine singly caged chimpanzees were provided with eight different toys made of plastic, vinyl, or cloth one at a time or several at once. The toys remained in the cages an average of three days. "The chimpanzees varied greatly in their interest in the toys. One subject rarely contacted the toys and others used them a great deal and quickly destroyed them."

Cardinal BR, Kent SJ 1998. Behavioral effects of simple manipulable environmental enrichment on pair-housed juvenile macaques (*Macaca nemestrina*). Laboratory Primate Newsletter 37(1), 1-3
http://www.brown.edu/Research/Primate/lpn37-1.html#kent
"Toy use declined with time, indicating that rotation of toys ... may increase use."

Crockett CM, Bielitzki JT, Carey A, Velez A 1989. Kong toys as enrichment devices for singly-caged macaques. Laboratory Primate Newsletter 28(2), 21-22
http://www.brown.edu/Research/Primate/lpn28-2.html#kong
"Providing objects such as Kong toys ... is mildly enriching to some of the monkeys. Periodically removing and reintroducing the toys would increase their enrichment value."

Hamilton P 1991. Enrichment toys and tools in recent trials. Humane Innovations and Alternatives in Animal Experimentation 5, 272-277
"When toys were left with an animal for several days, the individual became accustomed to and desinterested in the toy."

Kessel AL, Brent L 1998. Cage toys reduce abnormal behavior in individually housed pigtail macaques. Journal of Applied Animal Welfare Science 1, 227-234
Providing multiple "toys as enrichment for [single-caged] pigtail macaques was effective in reducing abnormal behavior" during 30-min observation session. "The use of the toys was reduced over time."

Line SW, Markowitz H, Morgan KN, Strong S 1989. Evaluation of attempts to enrich the environment of single-caged non-human primates. In Animal Care and Use in Behavioral Research: Regulation, Issues, and Applications Driscoll JW (ed), 103-117. Animal Welfare Information Center, Beltsville, MD
"Our experience with cage toys suggests that after a very short time (a few days or less), most macaques will lose interest in the objects that are offered."

Novak MA, Musant A, Munroe H, O'Neill PL, Price C, Suomi SJ 1993. Old, socially housed rhesus monkeys manipulate objects. Zoo Biology 12, 285-298
"More than 10% of the [group-housed] females' time was spent in object [toy] manipulation. ... Socially housed rhesus monkeys ranging in age from 14 to 22 years showed steady rates of object manipulation, and their interest in familiar objects did not appear to wane over time. ... Several factors [for interpreting higher interaction rates in groups-housed than in single-housed animals] should be considered, the first of which is social facilitation ... Failure to manipulate objects in rhesus macaques appears to be more a function of individual housing than of old age."

Paquette D, Prescott J 1988. Use of novel objects to enhance environments of captive chimpanzees. Zoo Biology 7, 15-23
"Following their familiarization with the novel objects [rubber or plastic toys for small children], the [group-housed] chimpanzees' manipulation frequency decreased whereas self-grooming and abnormal behaviors were increased." The importance of a periodical substitution of the objects was suggested to enhance their usefulness.

Plesker R, Heller-Schmidth J, Hackbarth H 2006. Environmental enrichment objects for the improvement of locomotion of caged rhesus macaques (*Macaca mulatta*). Laboratory Primate Newsletter 45(1), 7-10
http://www.brown.edu/Research/Primate/lpn45-1.html#plesker
Juveniles used the mobile objects [treadmill and rotating barrel] more than the adults. "Due to the increase in locomotion, the amount of time spent in aggressive behavior significantly decreased."

Pruetz JD, Bloomsmith MA 1992. Comparing two manipulable objects as enrichment for captive chimpanzees. Animal Welfare 1, 127-137
http://www.awionline.org/Lab_animals/biblio/aw1-12.htm
"Paper was used a mean 27 per cent of the available time [one hour], while the Kong Toys were used a mean 10 per cent of the available time. ... Object use steadily declined over the first hour of exposure. ... Object use when the Kong Toy was present declined over the course of the study, but use of the paper remained consistent. ... The destructible wrapping paper was more worthwhile enrichment object than the indestructible Kong Toy for the [group-housed] captive chimpanzees of this study."

Shefferly N, Fritz J, Howell S 1993. Toys as environmental enrichment for captive juvenile chimpanzees *(Pan troglodytes)*. Laboratory Primate Newsletter 32(2), 7-9
http://www.brown.edu/Research/Primate/lpn32-2.html#jo
"Whereas contact with the indestructible toy ball decreased over time, destructible objects maintained a consistent level of interest throughout the toys lifespan. ... Provision of both types of toys did not result in significant differences in the time individuals spent in abnormal, or aggressive behavior. ... There were no health problems or injuries associated with the destructible objects. No pieces of plastic were found in feces, indicating that none had been ingested."

Weick BG, Perkins SE, Burnett DE, Rice TR, Staley EC 1991. Environmental enrichment objects and singly housed rhesus monkeys: Individual preferences and the restoration of novelty. Contemporary Topics in Laboratory Animal Science 30(5), 18
"We found that the extent of physical contact with the [Kong toy, Nylabone ring and Nylabone ball] toys habituated during a short time. ... The introduction of a different toy every Monday was accompanied by a restoration of the apparent novelty of the toys."

(6,2) Wooden Objects

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.10. Wooden Objects. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/enrich.html#wood
"I give our single-caged baboons 20 cm long gnawing sticks made of pecan branches. They love them! It takes one to two weeks for a stick to be "widdled" down to about half of its size."

Eckert K, Niemeyer C, Anonymous , Rogers RW, Seier J, Ingersoll B, Barklay L, Brinkman C, Oliver S, Buckmaster C, Knowles L, Pyle S 2000. Wooden objects for enrichment: A discussion. Laboratory Primate Newsletter 39(3), 1-4
http://www.brown.edu/Research/Primate/lpn39-3.html#wood
"It seems that there is a general consensus that wooden objects provide inexpensive, safe, long-term and effective stimulation for the expression of non-injurious, species-typical behaviors such as perching, gnawing, gouging, manipulating and playing" without causing health and hygienic problems.

Hienz RD, Zarcone TJ, Turkkan JS, Pyle DA, Adams RJ 1998. Measurement of enrichment device use and preference in singly caged baboons. Laboratory Primate Newsletter 37(3), 6-10
http://www.brown.edu/Research/Primate/lpn37-3.html#hienz
"Baboons generally interacted less with Kongs than with logs or swings. This trend, however, was not consistent for each individual animal. Of the six baboons, three clearly "preferred" the log (i.e., moved the log more than the other two devices), two preferred the swing, and one preferred the Kong. Thus the trends expressed in the averaged data can be quite misleading."

Hienz RD, Pyle DA, Frey JJ, Zarcone TJ, Adams RJ, Turkkan JS 2000. Enrichment device use by baboons during long-term vs. intermittent availability. Laboratory Primate Newsletter 39(2), 1-3
http://www.brown.edu/Research/Primate/lpn39-2.html#hienz
"Four of the six baboons increased their [cherry] log use over the exposure period [104 days], while the remaining two baboons decreased their interactions with their logs over this period. ...When the logs were available only every other day, or every fourth day, log use was considerably enhanced on those days. When the logs were withheld longer, log use declined to the same level of use observed when the logs were continuously available. These results suggest that leaving enrichment devices out of a monkey's cage for extended periods would not be beneficial for generating greater use."

Hienz RD, Jones A, Pyle DA, Johnson J 2002. Effectiveness of enrichment devices during brief periods of social restriction in singly housed baboons. Laboratory Primate Newsletter 41(3), 1-3
http://www.brown.edu/Research/Primate/lpn41-3.html#hienz
"Data were collected on the animals' (three singly caged adult males) daily biscuit intake and activity levels as well as log activity prior to, during, and following social restriction (housed in separate room in which no other animals are present), and also in the absence and presence of a log (hand-cut cherry hardwood logs; 9 cm diameter x 35 cm long). .. All three baboons in the current study showed a marked decrease in activity during the brief periods of social restriction when the log enrichment devices were not available. However, once these devices were provided, general activity increased again, with two of the three baboons increasing their activity levels to near-normal. ... These findings present further support for the importance of enrichment devices for laboratory primates, showing that in the presence of such devices, the behavior of the animal is positively influenced. While the devices themselves were not manipulated greatly in this study, their presence affected the activity of the baboons."

Line SW, Morgan KN 1991. The effects of two novel objects on the behaviour of singly caged adult rhesus macaques. Laboratory Animal Science 41, 365-369
Single-housed subjects engaged in stick use 5.8% of 15 minute-observations. The corresponding figure for nylon ball use was 2%. "No adverse health effects of stick ingestion were noted among the subjects."

Reinhardt V 1990. Time budget of caged rhesus monkeys exposed to a companion, a PVC perch and a piece of wood for an extended time. American Journal of Primatology 20, 51-56
60 animals were exposed for at least 1.5 years to a compatible companion, a suspended plastic pipe, and a branch segment. Individuals spent an average of 23.5% of the time interacting with the companion, 10.4% with the plastic pipe and 4.8% with the branch segment.

Reinhardt V 1997. The Wisconsin Gnawing Stick. Animal Welfare Information Center Newsletter 7(3-4), 11-12
http://www.nal.usda.gov/awic/newsletters/v7n3/7n3reinh.htm
The sticks consist of branch segments cut of dead red oak trees. They are used by caged macaques about 5% of the time - more by young animals, less by adult animals - for gnawing, manipulating and playing. "Long-term exposure to the sticks has resulted in no recognizable health hazards."

(6,3) Mirrors

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.5. Mirrors. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/enrich.html#mirrors
"All of our single-housed long-tailed macaques have mirrors mounted on swivels that are attached to the outside of their cages, low enough so that an animal can chose to either bend down and intentionally look into the mirror or to make no extra effort, hence not be confronted — bothered? — by the mirror reflection. Our monkeys use their mirrors frequently.

Our rhesus love mirrors too. They like to check us out by looking at us through the mirror. I guess they don't feel so threatened when they can look at us without being seen. They also like to check out the room, by looking at the reflections in the mirror. We have one male who never looks at people directly, but holds up a polished stainless steel mirror to watch people who have just entered the room. Of course, we named him Mirror Man.

We have found an acrylic sheet mirror that we can cut into different-size pieces. Some get hung on the walls, using double sided tape, while other pieces get hung right inside the enclosures, using zip ties. We also cut small pieces and give these directly to the primates. Our rhesus macaques often combine the wall and hand mirrors to get extra viewing advantage! It's really fun to watch them. The acrylic leaves no sharp edges when it breaks; this means it is safe for the animals. We never encountered a problem.

Our singly housed baboons get the most enjoyment from their mirrors, while pair- and group-housed animals show little interest in them.

I have a male olive baboon in my charge who regularly sits for long periods at a time looking at himself in a mirror. He is housed with two females but appears to prefer looking at his own mirror reflection versus the nice tumescent females hovering around him! He also uses his mirror to see reflections of what is going on behind him, sitting diagonally with his back facing the main traffic area for techs, as if he was spying on us! I do believe he is entertaining himself quite a bit with the mirror.“

Brent L, Stone AM 1996. Long-term use of television, balls, and mirrors as enrichment for paired and singly caged chimpanzees. American Journal of Primatology 39, 139-145
"Chimpanzees used televisions, balls, and mirrors for 0.27-1.53% of the observation time after several years of exposure. ... Television and ball use were significantly higher than mirror use."

Goode TL, McPherson H, Hughes J, Conboy T, Smith S, Bone A, Zimmerman W, Holder D, Klein H 1998. Evaluation of stainless steel reflective discs as enrichment devices for rhesus monkeys *(Macaca mulatta)* housed in a toxicological facility. Contemporary Topics in Laboratory Animal Science 37, 100 (Abstract)
"The enrichment device was used [probably by single-caged subjects] primarily for manipulation and banging. ... The usage of polished stainless steel discs declines over time and therefore alternative methods of environmental enrichment and rotation of enrichment devices should be considered."

Harris H 2002. Mirrors as enrichment for monkeys. Laboratory Animal Refinement and Enrichment Forum (electronic discussion group), November 13, 2002
“Our African green monkeys (all males) and cynomolgus macaques use the mirrors more than the rhesus and squirrel monkeys. .. The mirrors are utilized by singly-caged, paired and group housed monkeys. They use them to look at themselves and at other things inside and outside the room. We have had a few (less than 10) occurrences where the monkeys were too fearful or self-aggressive to keep a mirror on their cage, but by far, the majority benefit from them. The mirrors, in my opinion, are one of our most useful object enrichment items."

Harris HG, Edwards AJ 2004. Mirrors as environmental enrichment for African green monkeys. American Journal of Primatology 63, 459-467
"Stainless steel circular mirrors were employed in an enrichment plan for 105 singly housed male African green monkeys. We observed 25 randomly selected males to measure mirror use and to assess the mirrors' effectiveness as an enrichment item. We conducted additional mirror-use surveys on all 105 males using fingerprint accumulation as an indicator (rated on a scale of 0 to 4). Use was defined as either being in contact with the mirror (contact use (CU)) or looking directly into the mirror without contact (non-contact use (NC)). Mirror-use data were collected 10 months after the initial introduction of the mirrors and again at 16 months. The two time points were compared by paired t-tests. No significant difference in use was found between the two data collection points. On average, the monkeys used the mirrors 5.2% of the total time intervals recorded (approximately 3 min/hr). Results from the five fingerprint-accumulation surveys showed that 102 of 105 males (97%) had CU with their mirrors over the survey points. Based on the sustained use of the mirrors over a 6-month period, we concluded that the mirrors were an effective enrichment tool that the vast majority of our monkeys routinely used. Habituation did not appear to occur even a year after the mirrors were introduced."

O'Neill PL, Wright AC, Weed JL 1997. Curious response of three monkey species to mirrors. American Zoo and Aquarium Association Regional Conference Proceedings, 95-101
One mirror was hung on the front of each subject's cage for a two-week study period. Pig-tailed macaques contacted the mirror at a fairly constant rate of 12-18 times per hour. Rhesus macaques were initially interested, but contact rate progressively dropped to only 6/h at the end of the second week. Long-tailed macaques showed little interest in the beginning, but contact rates reached those of pig-tailed macaques at the end of the study.

(7) Promoting Curiosity Behavior

(7,1) Television and Videos

Bloomsmith MA, Lambeth SP 2000. Videotapes as enrichment for captive chimpanzees *(Pan troglodytes)*. Zoo Biology 19, 541-551
"Individually housed subjects watched the videotapes more than socially housed subjects. When viewing time was averaged across all videotapes, the chimpanzees watched the monitor a mean of 38.4% of the time available. ... Subjects habituated to repeated presentations of the videotapes, although the effect was small numerically. Although this type of enrichment did not extensively alter behavior, it did occupy a significant portion of the subjects activity budget."

Bloomsmith MA, Lambeth SP, Perlamn JE, Hook MA, Schapiro SJ 2000. Control over videotape enrichment for socially housed chimpanzees. American Journal of Primatology 51(Supplement), 44-45 (Abstract)
Social behavior and solitary play were higher in subjects with control over the onset of videotapes, while scratching [generally regarded as a sign of tension] was higher in those groups who lacked control. "The results indicate that giving chimpanzees control over videotaped enrichment had limited, but positive, effects on behavior."

Harris LD, Briand EJ, Orth R, Galbicka G 1999. Assessing the value of television as environmental enrichment for individually housed rhesus monkeys: A behavioral economic approach. Contemporary Topics in Laboratory Animal Science 38(2), 48-53
"The negative demand curve suggested that TV is not a valued commodity" for single-caged animals.

Lambeth S, Bloomsmith M, Baker K, Perlman J, Hook M, Schapiro S 2001. Control over videotape enrichment for socially housed chimpanzees: Subsequent challenge tests. American Journal of Primatology 54(Supplement), 62-63 (Abstract)
"The lower expression of stress–related behaviors by chimpanzees that took advantage of the opportunity to control the videotape apparatus implies that exerting control over the environment may have a generalized effect by lessening disturbance caused by mildly challenging situations."

O'Neill-Wagner P 2001. Videotape exposure may facilitate recovery for monkeys in a clinical setting. American Journal of Primatology 54(Supplement), 59 (Abstract)
"During videotape exposure monkeys did not remove their sutures. Animals that had previously withdrawn from food were observed eating during videotapes showing primates eating."

Platt DM, Novak MA 1997. Videostimulation as enrichment for captive rhesus monkeys (*Macaca mulatta*). Applied Animal Behaviour Science 52, 139-155
The animals spent substantially more time watching selected videotapes than manipulating the joystick.

Plesker R, Herzog A 2001. Prima hedrons, puzzle feeders and television as environmental enrichment for captive African Green Monkeys. Primate Eye 74, 4 (Abstract)
http://www.psgb.org/Meetings/Spring2001.html
"The access to television (mainly nature films) enhanced the observation behaviour of the whole group for a short time. Again, the adult males, but also the youngest offspring did not appear to be interested."

Rumbaugh DM, Washburn DA, Savage-Rumbaugh ES 1989. On the care of captive chimpanzees: Methods of enrichment. In Housing, Care and Psychological Wellbeing of Captive and Laboratory Primates Segal EF (ed), 357-375. Noyes Publications, Park Ridge
"Television can be a great source of environmental enrichment if the chimpanzee can perceive the relevance of what it sees on the screen to the world it knows."

(7,2) Windows

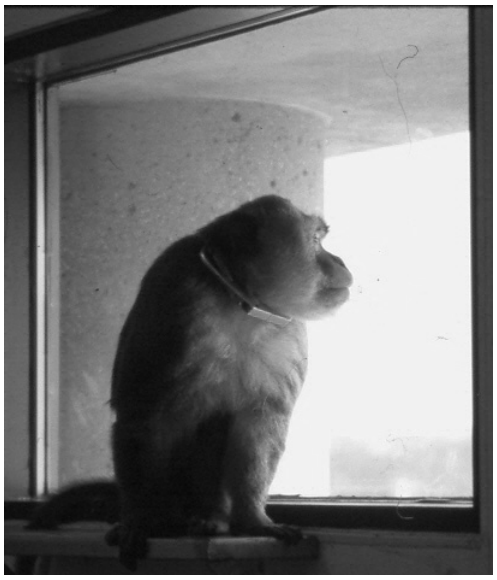


Photo by Richard Lynch

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 4.7. Windows. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/enrich.html#windows
"We expose our squirrel monkeys to natural daylight via big windows during the summer. This is supplemented with artificial light in late fall and early spring, when the days are short, and throughout the winter. Some of our squirrel monkeys will lie as close to the window as possible and let the sun rays dance on their belly.

I've seen the same behavior in our marmosets. As soon as the sunlight hits the window, the animals stop what they are doing, run over to the window ledge, and start stretching out and basking in the sunrays. There is no doubt in my mind that exposure to natural light, especially sunlight, is highly appreciated by the animals.

All our rhesus macaques have access to one-way glass exterior windows mounted high

above ground level. I very often see the animals gather up, attentively gazing out of the windows towards the source of some noise, at caretakers, activities in the garden and birds. One would think that exposure to daylight and the natural diurnal rhythm couldn't be anything else but a good thing for these animals."

Lynch R, Baker D 2000. Primate Enrichment: A room with a view. Laboratory Primate Newsletter 39(1), 12
http://www.brown.edu/Research/Primate/lpn39-1.html#room
Pairs were transferred to a play room with windows for 1½ hours every ten days. "During the past year, we have observed that the primates spend about an hour of their time looking out the windows."

(8) Safety Concerns

Eckert K, Niemeyer C, Anonymous , Rogers RW, Seier J, Ingersoll B, Barklay L, Brinkman C, Oliver S, Buckmaster C, Knowles L, Pyle S 2000. Wooden objects for enrichment: A discussion. Laboratory Primate Newsletter 39(3), 1-4
http://www.brown.edu/Research/Primate/lpn39-3.html#wood
"It seems that there is a general consensus that wooden objects provide inexpensive, safe, long-term and effective stimulation for the expression of non-injurious, species-typical behaviors such as perching, gnawing, gouging, manipulating and playing" without causing health and hygienic problems.

Etheridge MA, O'Malley J 1996. Diarrhea and peritonitis due to traumatic perforation of the stomach in a rhesus macaque (hardware disease). Contemporary Topics in Laboratory Animal Science 35(5), 57-78
"Abdominal radiographic views indicated ingestion of approximately 20 pieces of wire that came from an old automobile tire hung in the outdoor monkey pen to provide environmental enrichment."

Hahn NE, Lau D, Eckert K, Markowitz H 2000. Environmental enrichment-related injury in a macaque (*Macaca fascicularis*): Intestinal linear foreign body. Comparative Medicine 50, 556-558
"As a result of this incidence [ingested sisal rope pieces leading to multiple ulcerations, perforations, septic peritonitis] sisal rope enrichment devices were immediately removed from all macaque cages in the facility."

Mahoney CJ 1992. Some thoughts on psychological enrichment. Lab Animal 21(5), 27,29,32-37
"Facilities must exercise caution when installing such climbing devices as vertically hanging or horizontally suspended ropes and chains - these must not crisscross or be too slack, because an animal can strangle its neck, limbs, or other body parts."

Murchison MA 1993. Potential animal hazard with ring toys. Laboratory Primate Newsletter 32(1), 1-2
http://www.brown.edu/Research/Primate/lpn32-1.html#ring
"Recently one animal, a 2-year-old pigtail macaque (Macaca nemestrina), approximate weight 3.1 kg, became trapped inside a Nylaring. The ring went around the neck, across the body, and under one arm. Since the animal was apparently unable to remove the ring, he was anesthetized and the ring manually removed."

Novak MA, Rulf A, Munroe H, Parks K, Price C, O'Neill PL, Suomi SJ 1995. Using a standard to evaluate the effects of environmental enrichment. Lab Animal 24(6), 37-42
Monkeys maintained on pine wood shavings showed an increase in agonism, scratch, and stereotypy.

Reinhardt V 1997. The Wisconsin Gnawing Stick. AWIC Newsletter 7(3-4), 11-12
http://www.nal.usda.gov/awic/newsletters/v7n3/7n3reinh.htm
All 700 caged rhesus and 36 stumptailed macaques had continual access to gnawing sticks for more than 10 years. "Long-term exposure to the sticks has resulted in no recognizable health hazards."

Shefferly N, Fritz J, Howell S 1993. Toys as environmental enrichment for captive juvenile chimpanzees *(Pan troglodytes)*. Laboratory Primate Newsletter 32(2), 7-9
http://www.brown.edu/Research/Primate/lpn32-2.html#jo
"Whereas contact with the indestructible toy ball decreased over time, destructible objects maintained a consistent level of interest throughout the toys lifespan. ... There were no health problems or injuries associated with the destructible objects. No pieces of plastic were found in feces, indicating that none had been ingested."

Tresz H 1997. Providing enrichment at no cost. The Shape of Enrichment 6(4), 1-4
"Green pine cones can cause severe diarrhea. Keepers should work only with old, opened-up pinecones."

Regulations and Guidelines

American Society of Primatologists 2000. American Society of Primatologists guidelines for the ethical treatment of nonhuman primates. ASP Bulletin 24(4), 4
"ASP members hold the following general principles in common:
1. The most important of these principles is that we accept the responsibility of stewardship for nonhuman primates, and this responsibility must [sic] be reflected in our husbandry practices and research protocols whether in field, laboratory, or other setting.
3. Research with nonhuman primates should avoid pain and distress at every opportunity.
5. We should make use of information on a species natural history to improve management and enrich environments, because physical and psychological well-being are essential not only to the health of the animals but also to the validity of the research results.
6. Finally, we recognize that our concern should be extended to nonhuman primates once they have become 'surplus' to our research needs. This obligation entails ensuring quality care to the end of their natural lives whenever possible. .. While recognizing that some professional believe euthanasia is an acceptable way to deal with surplus animals in some cases, we strongly urge that other solutions be found whenever possible."

Canadian Council on Animal Care 1984. Chapter XX: Non-human primates. In Guide to the Care and Use of Experimental Animals, Volume 2 Canadian Council on Animal Care (ed), 163-173. Canadian Council on Animal Care, Ottawa, ON
http://www.ccac.ca/en/CCAC_Programs/Guidelines_Policies/GUIDES/ENGLISH/V2_84/CHXX.HTM
"Any primate housed alone will probably suffer from social deprivation, the stress from which may distort processes, both physiological and behavioural."

Canadian Council on Animal Care 1993. Guide to the Care and Use of Experimental Animals, Volume 1, 2nd Edition. Canadian Council on Animal Care, Ottawa, ON
http://www.ccac.ca/en/CCAC_Programs/Guidelines_Policies/GUIDES/ENGLISH/V1_93/CHAP/CHVI.HTM
"All animals must be observed at least once daily. .. The social needs of animals used in research, teaching, or testing, should be given equal consideration with environmental factors such as lighting, heating, ventilations and containment (caging). Particularly in the case of singly housed animals, daily observation provides an alternative from of social contact for the animal and commonly facilitates handling in that the animal becomes accustomed to the human presence. .. Most animals should not be housed singly unless required by medical condition, aggression, or dictates of the study. Singly housed animals should have some degree of social contact with others of their own kind. .. In the interest of well-being, a social environment is desired for each animal which will allow basic social contacts and positive social relationships. Social behaviour assists animals to cope with circumstances of confinment. .. Restraint procedures should only be invoked after all other less stressful procedures have been rejected as alternatives. ... Physiological, biochemical and hormonal changes occur in any restraint animal ... and investigators should consider how these effects will influence their proposed experiments."

Council of Europe 2006 Appendix A of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (ETS No. 123) enacted June 15, 2007. Strasbourg, France: Council of Europe
http://conventions.coe.int/Treaty/EN/Treaties/PDF/123-Arev.pdf
Progressive regulations pertaining to the species-appropriate housing and handling of animals kept in research labs.

"Because the common laboratory non-human primates are social animals, they should be housed with one or more compatible conspecifics. .. Single housing should only occur if there is justification on veterinary or welfare ground. Single housing on experimental grounds should be determined in consultation with the animal technician and with the competent person charged with advisory duties in relation to the well-being of the animals.

Primates dislike being handled and are stressed by it; training animals to co-operate should be encouraged, as this will reduce the stress otherwise caused by handling. Training the animals is a most important aspect of husbandry, particularly in long-term studies. .. Training can often be employed to encourage the animals to accept minor interventions, such as blood sampling.

The flight reaction of non-human primates from terrestrial predators is vertical, rather than horizontal; even the least arboreal species seek refuge in trees or on cliff faces. As a result, enclosure height should be adequate to allow the animal to perch at a sufficiently high level for it to feel secure. .. The minimum enclosure height for caged marmosets and tamarins is 1.5 m; the minimum enclosure height for caged squirrel monkeys, macaques, vervets and baboons is 1.8 m. .. The structural division of space in primate enclosures is of paramount importance. It is essential that the animals should be able to utilise as much of the volume as possible because, being arboreal, they occupy a three-dimensional space. The make this possible, perches and climbing structures should be provided."

Home Office 1989. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Used in Scientific Procedures. Her Majesty's Stationery Office, London, UK
http://scienceandresearch.homeoffice.gov.uk/animal-research/legislation/
"Experimental results may be influenced by environmental conditions. .... Unstable environmental conditions are likely to introduce avoidable variability into biological responses.

To demonstrate any experimental response against such a variable background generates a requirement for greater animal usage if the result is to be statistically valid. Good control of variables ... can therefore contribute both to good science and to the minimisation of animal use. .. The shape of the cage and the furniture provided may be as important to the animal as the overall size of the cage. ..All animals must be allowed to exercise. For the smaller species, this should usually be achieved by providing adequately sized cages or pens and sometimes play objects. ... For larger species, special arrangements will usually be required for social contact as well as exercise. ... The behaviour of an animal during a procedure depends on the confidence it has in its handler. This confidence is developed through regular human contact and, once established, should be preserved. .. Where appropriate, time should be set aside for handling and grooming. All staff, both scientific and technical, should be sympathetic, gentle and firm when dealing with animals. .. The least distressing method of handling is to train the animal to co-operate in routine procedures. Advantage should be taken of the animal's ability to learn."

Institute of Laboratory Animal Resources 1980. Laboratory Animal Management: Nonhuman Primates. National Academy Press, Washington, DC
"Lighting should be uniformly diffused throughout the area and provide adequate illumination for good house-keeping practices, adequate inspection of animals, and safe working conditions for personnel."

Institute for Laboratory Animal Research 1992. Recognition and alleviation of pain and distress in laboratory animals. National Academy Press, Washington, DC
http://www.nap.edu/books/0309042755/html
"The purposes of this book are to increase awareness of the sources and manifestations of stress and distress in laboratory animals and to increase ethical sensitivity in those who use and care for them. (It might also, indirectly, help to reduce the number of animals needed for experimental purposes: uncontrolled pain or distress can increase variability in experimental data and so require the use of more animals in a study for it to achieve statistical significance.)
***Stress** is the effect produced by external (i.e., physical or environmental) events or internal (i.e., physiologic or psychologic) factors, referred to as **stressors**, which induce an alteration in an animal's biologic equilibrium. ... Examples of potential stressors that cause psychological stress [include] fear, anxiety, boredom, loneliness, separation.*
***Distress** is an aversive state in which an animal is unable to adapt completely to stressors and the resulting stress and shows maladaptive behaviors" such as "coprophagy, hair-pulling, self-biting, and repetitive stereotyped movements. ... Such behaviors, like maladaptive ones, should be interpreted as causing harm to the animal and producing unwanted variability in research data. ... The identification and control of these [environmental] stressors from the animals' or species' perspective constitute good husbandry and are a primary responsibility of all who care for or use animals in a laboratory setting. ... Behavioral changes, however, are the earliest signs of stress or distress that most animal care staff and researchers are likely to confront. Skilled observers who know the behavior of a particular species or strain of animal and of the individual animals under their care could provide a reliable assessment of the state of the animals. That reliability is seriously compromised when few animal care staff and researchers are afforded the time or training necessary for them to become skilled observers. ... Recognition, or anticipation, that a particular event will be perceived as an important stressor by an animal requires knowledge not only of the stressor, but of the species-typical responses to situations and of the experience of the particular animal. ... Stroking and handling by humans can be a practical and effective technique for calming animals in situations where they are distressed, particularly animals that have been positively socialized by humans."*

International Primatological Society 1989. IPS International Guidelines for the acquisition, care and breeding of nonhuman primates. Primate Report 25, 3-27

"Illumination should be uniform and sufficient for adequate inspection of animals and safe working conditions for personnel, but not obtrusive to the well-being of the animals. .. Restraint procedures should be used only when less stressful alternatives are not feasible. .. Primates of many species can be trained for sample procedures, such as presenting a limb for a blood collection, and such training is advocated whenever possible, using positive reinforcement."

International Primatological Society 2007. IPS International Guidelines for the Acquisition, Care and Breeding of Nonhuman Primates. Bronx, NY: International Primatological Society http://www.internationalprimatologicalsociety.org/docs/IPS_International_Guidelines_for_the_Acquisition_Care_and_Breeding_of_Nonhuman_Primates_Second_Edition_2007.pdf

"There is an acute need for the training of professional and technical personnel in veterinary care, psychological well-being, handling and general management of captive primates and the requirements of species and individuals. Well-trained, competent and motivated personnel can make an enormous difference in improving the welfare of captive primates.

Pair or group housing in an enclosure must be considered the norm for gregarious animals, but only compatible (socially, virological status, etc.) animals should be kept together. Infectious disease study does not necessarily preclude the ability to keep primates in pairs or groups in the same enclosure, without interfering with study validity. Many infectious disease studies are carried out in paired or grouped primates. the same is true of many other types of studies and procedures, such as pharmacokinetic studies and drug safety testing. .. Individual subjects can be accessed for testing and manipulation through good enclosure design, separation chutes and training using positive reinforcement techniques. .. For experimental animals, where housing in groups is not possible, keeping them in compatible pairs is a viable alternative social arrangement. Single caging should only be allowed where there is an approved protocol justification on veterinary or welfare grounds.

A two-tiered system is not recommended as these cages are usually too small. The lower tiers do not allow primates to engage in their vertical flight response, are often darker, and animals in the lower cages tend to receive less attention from attending personnel.

Adequate space alone does not in itself provide for good welfare, but larger enclosures allow greater complexity of cage furnishings and other enrichments, and greater flexibility for meeting social needs.

Illumination of each cage should be uniform and sufficient for adequate inspection of animals.

As animals like to work for their food, increasing processing time, increasing foraging, or providing puzzle feeders or other feeding devices is encouraged.

Infants should not be separated from their natal group at an early age but should remain with their mother until weaning age which varies greatly between species.

Primates of many species can be quickly trained using positive reinforcement techniques to cooperate with a wide range of scientific, veterinary and husbandry procedures. Such training is advocated whenever possible as a less stressful alternative to traditional methods using physical restraint. Techniques that reduce or eliminate adverse effects not only benefit animal welfare but can also enhance the quality of scientific research, since suffering in animals can result in physiological changes which are, at least, likely to increase variability in experimental data and, at worst, may even invalidate the research. Restraint procedures should be used only when less stressful alternatives are not feasible."

Medical Research Council 2004. MRC Ethics Guide: Best Practice in the Accomodation and Care of Primates used in Scientific Research. Medical Research Council, London, UK
http://www.mrc.ac.uk/index/publications/publications-electronic_publications.htm
"Primates must [sic] be provided with a complex and stimulating environment that promotes good health and psychological well-being and provides full [sic] opportunity for social interactions, exercise and to express a range of behaviours appropriate to the species. .. The volume and height of the cage (or enclosure) are particularly important for macaques and marmosets, which flee upwards when alarmed. Their cages and enclosures should be floor-to-ceiling high whenever possible, allowing the animals to move up to heights where they feel secure. Double-tiered cages should not be used since they restrict the amount of vertical space available to the animals. Special justification should be given for using cages with grid floors (eg, compelling scientific or veterinary reasons) as this restricts the opportunity to provide substrate and forage. In the case of macaques, cages should be linked to a play area or enclosure .. They should have unlimited access to this area unless it is necessary to confine them for scientific, husbandry, veterinary or welfare purposes. Where security permits, the accommodation should have natural light. .. Primates should be socially housed as compatible pairs or groups, depending on their age and sex and the nature of the scientific procedures or study. .. Primates should not be singly housed unless there is exceptional scientific or veterinary justification. .. Cages and enclosures should be furnished to encourage primates to express their full [sic] range of behaviours. Depending on the species, this should normally include provision for resting, running, climbing, leaping and foraging. ..Shelves, ladders and branches should be made from wood wherever possible even though they will have to be replaced more often. .. The cage and enclosure should provide the animals with an area of privacy. .. To help prevent boredom, novelty should be regularly introduced into the environment, for example, by re-arranging some of the cage furniture. .. The MRC will require justification for the use of scientific procedures that restrict the opportunity to forage. .. Positive reinforcement techniques should be used to train primates to cooperate with catching, handling, restraint and research procedures. The routine use of squeeze-back cages and nets should be actively discouraged."

National Center for the Replacement, Refinement and Reduction of Animals in Research. 2006 NC3Rs Guidelines: Primate Accomodation, Care and Use. London: National Center for the Replacement, Refinement and Reduction of Animals in Research
http://www.nc3rs.org.uk/page.asp?id=277
"The guidelines were developed by reviewing the published literature and through consultation with the scientific community, veterinary and animal care staff, the Animals (Scientific Procedures) Inspectorate, and animal welfare organisations. They represent a framework for applying and reviewing the expectations of the funding bodies in the humane [sic] use of primates. The guidelines set out contemporary best practice in the use of primates in biomedical, biological, veterinary and behavioural research, and include principles relating to the source, housing, capture, handling, restraint and training of primates. .. They are readily applicable to the majority of research programmes using primates. .. Cages and enclosures should be floor to ceiling high whenever possible, with adequate perching to allow all animals to move up to heights where they feel more secure. .. Double-tiered cages should not be used since they restrict the amount of vertical space available to the animals. .. Where security permits, the accomodation should have natural light. .. Primates should be socially-housed as compatible pairs or groups. .. Primates should not be housed singly unless there is exceptional [sic] scientific or veterinary justification. .. The vertical and horizontal dimensions of the cage and enclosure should be exploited fully by incorporating shelves, logs, ladders, climbing structures, branches, hammocks, swings, ropes and objects to manipulate. .. Shelves, ladders and branches should be made from wood wherever possible. .. All primates should be given the opportunity to

forage daily, by scattering food in litter or substrate on the floor, or in a tray, and by using devices that encourage foraging activity. .. Positive reinforcement techniques should be used to train primates to cooperate with capture, handling, restraint and research procedures. The routine use of squeeze-back cages and nets should be actively discouraged."

National Health and Medical Research Council 2004. Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 7th Edition. Australian Government Publishing Service, Canberra, Australia
http://www7.health.gov.au/nhmrc/publications/synopses/ea16syn.htm
"People who use animals for scientific purposes have an obligation to treat them with respect and consider their welfare as an essential factor when planning and conducting studies."

National Health and Medical Research Council Animal Welfare Committee 2003. Policy on the Care and Use of Non-Human Primates for Scientific Purposes. National Health and Medical Research Council, Canberra, Australia
http://www7.health.gov.au/nhmrc/ethics/animal/issues/nonhuman.htm
"Social interaction is paramount for well-being. Social deprivation in all its forms must be avoided. ... Animals that need to be individually caged, either for experimental or holding purpose (for example, aggressive adult males), must be given contact with conspecific animals. ... Accomodation should provide an environment which is as varied as possible. It should meet the behavioural requirements of the species being used and must provide access to an outside enclosure for animals held long-term (that is, longer than six weeks). ... Emphasis must be placed on environmental enrichment."

National Research Council 1996. Guide for the Care and Use of Laboratory Animals, 7th Edition. National Academy Press, Washington, DC
http://www.nap.edu/books/0309053773/html/
"Proper care, use, and humane treatment of animals used in research, testing, and education .. require scientific and professional judgment based on knowledge of the needs of the animals. .. A good management program provides the environment, housing, and care that ... minimizes variations that can affect research. .. Animals should be housed with the goal of maximizing species-specific behaviors and minimizing stress-induced behaviors. For social species, this normally requires housing in compatible pairs or groups. .. In general, lighting should be diffused throughout an animal holding area and provide sufficient illumination for the well-being of the animals and to allow good housekeeping practices, adequate inspection of animals - including the bottom-most cages in racks - and safe working conditions for personnel."

National Research Council 1998. The Psychological Well-Being of Nonhuman Primates. National Academy Press, Washington, DC
http://fermat.nap.edu/books/0309052335/html/index.html
Meeting the criteria of psychological well-being implies:

- *"Appropriate social companionship.*
- *Opportunities to engage in behavior related to foraging, exploration, and other activities appropriate to the species, age, sex, and condition of the animal.*
- *Housing that permits suitable postural and locomotor expression.*
- *Interactions with personnel that are generally positive and not a source of unnecessary stress.*

Procedures that reduce reliance on forced restraint ... are less stressful for animals and staff, safer for both, and generally more efficient. .. Social interactions are considered to be one of the

most important factors influencing the psychological well-being of most nonhuman primates. ... Knowing that most primates benefit from social interactions, it should be obvious that they can be harmed by a lack of social interaction. .. The common practice of housing rhesus monkeys singly calls for special attention. .. Every effort should be made to house these [singly caged] animals socially (in groups or pairs), but when this is not possible, the need for single housing should be documented by investigators and approved by the IACUC. ... Although the causes of self-directed biting are poorly understood, prolonged individual housing is probably an influential contributing factor. ... To reduce the stress of physical restraint, many primates can be trained for routine procedures. ... Under natural conditions, many primates spend much of their lives aboveground and escape upward to avoid terrestrial threats. Therefore, these animals might perceive the presence of humans above them as particularly threatening .. Even macaques, which some describe as semiterrestrial, spend most of the day in elevated locations and seek the refuge of trees at night ..Optimal use of available cage space might well depend more on the placement of perches, platforms, moving and stationary supports, and refuges than on cage size itself. .. The animal technician's and caregiver's roles are pivotal to the social support of primates, particularly animals that are singly caged. .. Enrichment methods that have not been subjected to empirical testing should be viewed simply as invalidated ideas, regardless of how well intended they might be."

Office of Laboratory Animal Welfare (OLAW) 2006 Enrichment for Nonhuman Primates. Bethesda, MD: Office of Laboratory Animal Welfare
http://grants.nih.gov/grants/olaw/request_publications.htm
"This book serves as an introduction to the basic behavior and environmental enrichment." In baboons "boredom, stress and, ultimately, problem behavior may result from confinement in small enclosures, lack of enrichment activities, solitary housing ... Examples of abnormal behavior patterns .... are hair eating and regurgitation. .. More severe problems, such as self-biting, also have been reported in captive baboons. ... Captive chimpanzees may develop bad habits, including strange behaviors not normally seen in the wild. [e.g. hair plucking] ... Diarrhea may be a response to psychological stress. ... Because of the intrinsic social nature of macaques, pair or group housing of compatible animals is extremely important. ... Because of the animals' [macaques] tendency to flee upward when escaping a perceived threat, they benefit from perches, shelves or other structures that increase the three-dimensional space of the enclosure. Generally, older macaques prefer a non-moving shelf or perch, while the younger ones will readily use swings. ... Because the monkeys will chew on these toys, they should be relatively durable, such as heavy-duty dog toys. ... Rotating different toys in the enclosure and removing them periodically will help to keep the toys novel and increase the animals' interest in them. ... Abnormal behaviors are an undesirable consequence of captive housing, reflecting an inadequate environment for maintaining the animal. ... Redirection of an abnormal behavior [e.g., via fleece etc.] is not a 'cure' and should only be regarded as a temporary correction." ... "Self-injurious behaviors" ... "such as self hair-pulling and self-biting, often are the result of unusual stress". They also occur in squirrel monkeys where "'pacing' may be eliminated by increasing the animal's available travel paths by installing additional perches."

Organisation for Economic Co-Operation and Development [OECD] 2000. Guidance Document on the Recognition, Assessment, and Use of Clinical Signs as Humane Endpoints for Experimental Animals Used in Safety Evaluation [OECD Guidance Document No. 19 on Humane Endpoints]. OECD, Paris, France
http://www.olis.oecd.org/olis/2000doc.nsf/LinkTo/env-jm-mono(2000)7
"A humane endoint can be defined as the earliest indicator in an animal experiment of severe pain, severe distress, suffering, or impending death. .. Pain can be defined as an unpleasant

sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage." Distress is "An aversive state resulting from maladaptation or inability to adapt to stressors. .. Distress is usually associated with a change in motility or locomotion, and can result in stereotype behaviour. .. Retreat to a corner of the cage or excessive struggling or vocalisation on dosing are examples of distress in anticipation of an experimental procedure. .. If something is known to cause suffering in humans, it should be assumed to cause suffering in animals."

Prentice ED, Zucker IH, Jameton A 1986. Ethics of animal welfare in research: The institution's attempt to achieve appropriate social balance. The Physiologist 29, 1&19-21
"Physical restraint procedures should be used on awake animals only after alternative procedures have been considered and found to be inadequate. If a restraint will be utilized the animal should be trained or conditioned to the restraining device, using positive reinforcement, prior to the beginning of the experiment"

Public Health Service (PHS) 1996. U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training. In Guide for the Care and Use of Laboratory Animals National Research Council 117-118. National Academy Press, Washington, DC
http://grants.nih.gov/grants/olaw/references/phspol.htm#U.S.Government Principles
"Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals."

Smith JA, Boyd KM 2003. The Boyd Group of papers on: The use of non-human primates in research and testing. Animal Technology and Welfare 2, 89-97
"Unless specifically justified, infants should remain with their mothers until they are no longer dependent on them. .. The minimum cage sizes for both marmosets and macaques detailed in the Home Office guidance (1989), and the European standards, are inadequate - particularly in respect of vertical dimensions of cages - and do not reflect current best practices. ... Every effort should be made to train non-human primates to accept routine scientific procedures, and so minimise the stress caused to the animals."

USDA 2002. Animal Welfare Regulations Revised as of January 1, 2002 [Code of Federal Regulations, Title 9, Chapter 1, Parts 1-4 United States Department of Agriculture]. U.S. Government Printing Office, Washington, DC
http://www.access.gpo.gov/nara/cfr/waisidx_02/9cfrv1_02.html
"Handling of all animals shall be done as expeditiously and carefully as possible in a manner that does not cause trauma, overheating, excessive cooling, behavioral stress, physical harm, or unnecessary discomfort. ... Deprivation of food or water shall not be used to train, work, or otherwise handle animals. .. Lighting must be uniformly diffused throughout animal facilities and provide sufficient illumination to aid in maintaining good housekeeping practices, adequate cleaning, adequate inspection for animals, and for the well-being of the animals. .. Inadequate space may be indicated by ... stress, or abnormal behavior patterns. .. Primary enclosures .. must [sic] provide sufficient space for the nonhuman primates to make normal postural adjustments with freedom of movement. .. These minimum space requirements must [sic] be met even if perches and ledges, swings, or other suspended fixtures are placed in he enclosure. .. Research facilities must [sic] develop, document, and follow an appropriate plan for environmental enhancement. .. The plan must [sic] include specific provisions to address the social needs of nonhuman primates. .. The physical environment in the primary enclosures must be enriched by providing means of expressing species-typical activities."

Zimmermann M 1987. Ethical principles for the maintenance and use of animal in neuroscience research. Neuroscience Letters 73, 1
"Animals are generally accepted to be sentient and capable of suffering, and to have species-specific requirements of living. ... Maintenance of experimental animals should account for species-specific needs of accommodation, activity, feeding and social interactions to the degree possible."

Surveys

Baker KC, Weed JL, Crockett CM, Bloomsmith MA 2007. Survey of environmental enhancement programs for laboratory primates. American Journal of Primatology 69, 377-394
"Here we report the results of a 2003 survey that was sent to individuals overseeing enrichment programs at a variety of primate research institutions. Data were obtained on the management of 35,863 primates in 22 facilities. While most primates were reported to be housed socially (73%), social housing for indoor-housed primates appears to have changed little over the past 10 years. Research protocol issues and social incompatibility were commonly cited constraints. Implementation of feeding, manipulanda, and structural enrichment was relatively unconstrained, and contributions to these aspects of behavioral management generally included individuals in a wide variety of positions within a facility. In contrast, enrichment devices were used on a less widespread basis within facilities, and positive reinforcement programs that involved dedicated trainers were rare."

"Social Housing: We focused on the indoor population to assess the current status of efforts to reduce the use of single housing in research. With outdoor-housed primates excluded from the analysis, our sample included 17,663 individuals, 46% of which were housed socially."

"Feeding Enrichment: All facilities included feeding enrichment in their plans. No facilities provided fewer than half (1-50%) of their nonhuman primates with feeding enrichment... Fruit was distributed at all facilities, nuts and seeds at 95%, vegetables at 91%, manufactured treats at 73%, and other items at 64% of facilities."

"Manipulanda: All facilities employed manipulable objects. Of the categories of manipulanda provided as response choices, the items used most frequently were mirrors (100%), balls (95%), synthetic chew toys (86%), and hanging toys (86%). Rattles were provided at 68% of the facilities, wood at 59%, and bells at 18%."

"Devices: Ninety-one percent of facilities reported the use of enrichment devices. Of the devices offered as response choices, the most common were puzzle tube feeders (77% of facilities) and Astroturf foraging boards (77%), followed by puzzle balls (59%), fleece boards (36%) and other devices (36%)."

"Structural Enrichment: Most facilities reported providing structural enrichment to all of their animals. All facilities reported the use pf perches, 73% swings, 59% used barrels, 50% bedding/nesting materials, 36% exercise cages or playrooms."

With respect to social housing, in the 1994 survey 38% of indoor-housed macaque species were housed socially. In the current survey, among these species, 44% of the individuals in cages wee housed socially. This comparison indicates that the use of social housing for caged primates has not expanded as substantially as many applied behavioral scientists would have hoped.

Since the practice of single housing is a major risk factor for the development of abnormal behavior, the continued prevalence of single housing perpetuates the need for intervention."

Bayne K 1989 Resolving issues of psychological well-being and management of laboratory nonhuman primates. In Housing, Care and Psychological Wellbeing of Captive and Laboratory Primates. Segal EF (ed), 27-39 . Noyes Publications, Park Ridge, NJ
"The survey indicated that approximately 83% of adult captive primates at NIH are caged alone. As only 9% of scientists interviewed currently train their animals to go into transport cages, the majority use squeeze panels to transfer animals or to restrain them at the front of the cage. ..The most frequent recommendations [of NIH scientists interviewed] were for larger and more complex cages."

Prescott MJ, Buchanan-Smith HM 2007. Training laboratory-housed non-human primates, part I: a UK survey. Animal Welfare 16(1), 21-36
Training using positive reinforcement is increasingly recognised as a valuable tool for the humane and effective management and use of laboratory-housed non-human primates. A survey was carried out on the use of training and other learning processes (socialisation, habituation and desensitisation) in over half of UK establishments using and breeding primates. There is widespread awareness of training as a refinement technique but it not used as widely or as fully as it might be. We conclude that there is opportunity for refinement of common scientific, veterinary and husbandry procedures (such as blood and urine collection, injection, capture from the group and weighing) through use of positive reinforcement training, especially when combined with appropriate socialisation, habituation and desensitation. Recommendations on best practice, training techniques and staff education are given.

Reinhardt V 1994. Survey of environmental enhancement for research macaques. Laboratory Primate Newsletter 33(3), 1-2
http://www.brown.edu/Research/Primate/lpn33-3.html#victor
A survey of 11 facilities. The percentage of caged macaques permanently: a) exposed to enrichment objects ranged from 18% to 100% with a mean of 86%, b) housed in pairs or small groups ranged from 0% to 98% with a mean of 38%.

Ethical Considerations

Öbrink KJ, Rehbinder C 1999. Animal definition: a necessity for the validity of animal experiments? Laboratory Animals 22, 121-130
"'Material and Methods' section mostly reveals an obvious or almost total lack of information about the animals. ... If a researcher, through carelessness or ignorance, should use more animals for a project than is necessary, it must be considered unethical. ...Without hesitation, it is a scientific demand that all factors that have not proven to be insignificant should be checked, controlled or kept constant."

American Society of Primatologists 2000. American Society of Primatologists guidelines for the ethical treatment of nonhuman primates. ASP Bulletin 24(4), 4
"Despite their varied disciplines, ASP members hold the following general principles in common:
1. The most important of these principles is that we accept the responsibility of stewardship for nonhuman primates, and this responsibility must [emphasis added] be reflected in our husbandry practices and research protocols whether in field, laboratory, or other setting.
5. We should make use of information on a species natural history to improve management and enrich environments, because physical and psychological well-being are essential not only to the health of the animals but also to the validity of the research results."

Arluke A 1994. The ethical socialization of animal researchers. Lab Animal 23(6), 30-35
"In all but two of the 35 laboratories, newcomers faced a closed moral universe where issues of morality were defined institutionally, and hence rarely confronted by individuals. ... It was controversial or risky to admit to having ethical concerns, because to do so was tantamount to admitting that there really was something morally wrong with animal experimentation, thereby giving 'ammunition to the enemy'."

Association of Veterinarians for Animal Rights 2005. Contemporary Veterinarian's Oath. Association of Veterinarians for Animal Rights, Davis, CA
http://www.avar.org/
"Being admitted to the profession of veterinary medicine, I solemnly swear to use my scientific knowledge and skills to protect the health and well-being of all nonhuman animals, to relieve pain and suffering in nonhuman animals, to strengthen the understanding of the inherent needs and interests of all nonhuman animals, and to promote the preservation of wildlife and their natural environment. I will practice my profession conscientiously, with dignity, compassion, and integrity. I accept as a lifelong obligation the continual improvement of my professional knowledge and competence. "

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 2.1. How to Refer to an Animal—Using the Proper Pronoun. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/basic.html#pron
"As caregivers, we do not use the pronoun it when referring to an animal. An animal is not an object! We do not think that calling an animal he or she encourages anthropomorphism, but that it does acknowledge the fact that we are dealing with an individual sentient being who can feel discomfort, pain and distress in very similar ways as we do. Calling individual animals he or she helps us deal with something that deep down, we are not really comfortable with — namely the fact that these animals have no choice about deciding whether they want to be used in research and then killed.

Referring to an animal as it is neither correct nor scientific, because it overlooks the fact that animals, just like humans, have a biological gender. Therefore, they should be referred to accordingly with the correct pronouns he or she. When we label an animal with the incorrect pronoun it, we risk treating the animal like an inanimate object incapable of feeling discomfort, pain and distress."

Baumans V, Coke C, Green J, Moreau E, Morton D, Patterson-Kane E, Reinhardt A, Reinhardt V, Van Loo P 2007. Making Lives Easier for Animals in Research Labs - Chapter 2.2. Higher- Versus Lower-Order Species. Washington, DC: Animal Welfare Institute
http://www.awionline.org/pubs/LAREF/basic.html#spec
"It seems that Refinement in the use of animals for research includes choosing lower-order species rather than higher-order species, presumably due to the assumption that the lower-order animals suffer less and that their use in experiments poses fewer ethical problems. Where do we draw the line?

For people who are using these terms, lower simply means less like humans, and higher means more like humans. This terminology is tied in with the incorrect view of evolution as a ladder of progress toward especially evolved beings, such as humans. How would animals, used by humans for biomedical research, classify the human species? Of a high order? Crown of

creation? Very unlikely!

I think all animals deserve the same consideration, whether they are a rat or mouse — of presumed low order — or a dog or monkey — of presumed higher order. It seems strange to me to categorize animals into different orders and then treat them accordingly."

Canadian Council on Animal Care, Olfert ED, Cross BM, McWilliam AA 1993. Guide to the Care and Use of Experimental Animals, Volume 1, 2nd Edition. Canadian Council on Animal Care, Ottawa, ON
http://www.ccac.ca/en/CCAC_Programs/Guidelines_Policies/GUIDES/ENGLISH/toc_v1.htm
"We are morally responsible for any living thing that we cause to be dependent upon us, including animals used in research, teaching and testing."

Halpern-Lewis JG 1996. Understanding the emotional experiences of animal research personnel. Contemporary Topics in Laboratory Animal Science 35(6), 58-60
"Animal research personnel should be encouraged to join in the pursuit of progress with the recognition that, in addition to knowledge and skills, primary attributes must be feelings of compassion and sensitivity toward animals. Because animals cannot speak for themselves, it is up to empathetic and caring personnel to see that they are treated humanely and with respect. A variety of suggestions have been provided to enable research participants to perform necessary tasks without impeding experimental results or detracting from the integrity of the animal-human relationship. It is my belief that individuals who demonstrate caring behaviors while being allowed appropriate outlets for expression will remarkably enrich the overall research experience of humans and animals alike."

Herzog H 2002. Ethical aspects of relationships between humans and research animals. ILAR [Institute for Laboratory Animal Research] Journal 43(1), 27-32
http://dels.nas.edu/ilar_n/ilarjournal/43_1/Ethical.shtml
"More often than not, moral dilemmas are the result of good people trying to do the right thing when the right thing is unclear. ... I have spoken with some animal care staff who have complained about investigators who rarely set foot in their institution's animal colony and who appear to regard research animals as organ repositories. In addition, some researchers show little understanding of the ethical problems faced by technicians. ... There is every reason to believe that individuals who care about their wards on a personal level actually treat the animals better. .. Inevitably, individuals who work with animals in the context of biomedical and behavioral research will sometimes form bonds with the animals with whom they interact. When an animal is transformed from 'object' to 'pet,' its moral status is changed. Although human-research animal relationships may enhance the well-being of laboratory animals, they involve a moral cost to the human caretakers. Institutions should acknowledge the existence of these bonds and provide support mechanisms to help laboratory personnel deal with the moral challenges of their profession."

Mroczek NS 1994. Recognizing animal suffering and pain. Lab Animal 23(1), 27-31
Highlights the "human conditioning to the incongruous position that considers animals dissimilar to humans with respect to drive, need, or sensation, yet similar enough to be used as models for the study of humans themselves. ... Identification, sympathy, and positive regard by a scientist or animal care worker can, most of all, help to encourage optimum care and treatment of animals in pain. Recognition of animals suffering and pain is made possible by feeling for and interest in animals themselves, as sentient organisms, first and foremost, and feeling for and interest in animal behavior in totality."

Petto AJ, Buchanan-Smith H 1994. Psychological well-being and other projections of the human condition: Their meaning for research activities with non-human primates. XVth Congress of the International Primatological Society, 359
"The often cited paradox for researchers studying nonhuman primates is that we must consider them sufficiently similar to us so that our studies will be valid and significant; at the same time we must consider them sufficiently different that we can study them in ways that are ethically objectionable for studying fellow humans."

Public Health Service (PHS) 1996. U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training. In Guide for the Care and Use of Laboratory Animals National Research Council 117-118. National Academy Press, Washington, DC
http://grants.nih.gov/grants/olaw/references/phspol.htm#principle
Principle IV states that "Proper use of animals, including the avoidance or minimization of discomfort, distress, and pain when consistent with sound scientific practices, is imperative. Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals."

Reese EP 1991. The role of husbandry in promoting the welfare of laboratory animals. In Animals in Biomedical Research Hendriksen CFM, Koeter HBWM (eds), 155-192. Elsevier, Amsterdam, The Netherlands
"That many scientists lack detailed information about their animals, especially their behavior, is distressing and reflects a serious disregard for the single most important element of their research. ... The animal is the key to the entire experiment. ... There is only one 'right' attitude, and that is respect for the individual animal."

Röder EL, Timmermans PJA 2002. Housing and care of monkeys and apes in laboratories: adaptations allowing essential species-specific behaviour. Laboratory Animals 36, 222-241
"An animal is not a survival machine but a genetically programmed organism. A machine 'survives' longest if it is maintained properly but not used. An animal, however, needs to use the functions that evolved for its survival, in order to keep those functions from decay and deterioration. Whoever deliberately chooses a species because of its specific properties, in his own interest should be expected to take care that these properties remain unimpaired."

Reinhardt V 1996. Letter to the Editor. Lab Animal 25(5), 42
"I was a bit surprised that the animals of my article lost their biological gender and were referred to in the neuter gender, like things. Perhaps this sounds more scientific, but it actually is scientifically incorrect. Animals with neuter gender cannot reproduce. A female is a 'she' and not an 'it', and a male is a 'he' and not an 'it'."

Schwindaman D 1991. The 1985 animal welfare act amendments. In Through the Looking Glass Novak MA, Petto AJ (eds), 26-32. American Psychological Association, Washington, DC
"While we [veterinarians] pledge to take responsibility for the welfare of animals, we also vow to use scientific knowledge and skills for the advancement of medical knowledge. The wise composer of this oath saw no conflict between relieving animal suffering and advancing science. Indeed, there is none."

Spaeth GL 1994. Editorial: Caring for animals, caring for ourselves. Ophthalmic Surgery 25, 426

"Our behavior to other creatures reflects our own characters. We are shaped by what we do. When we act uncaringly toward experimental animals we become uncaring human beings. What is the worth of medical miracles achieved at the cost of inflicting trauma on others that cannot help but scar our own characters? When we act uncaringly towards experimental animals, we damage ourselves. When we hurt experimental animals, we hurt ourselves."

Traystman RJ 1987. ACUC, who needs it? The investigator's viewpoint. Laboratory Animal Science 37 (Special Issue), 108-110

"The academic and intellectual freedom to pursue these activities is crucial to the livelihood of any investigator... Most investigators think only briefly about the care and handling of their animals and clearly have not made it an important consideration in their work. .. All investigators consider themselves upstanding citizens of excellent ethical and moral character. Their feeling may be that since they are moral and ethical in every sense of the word, they are quite capable of monitoring their own animals without outside interference."

Zbinden G 1985. Ethical consideration in toxicology. Food and Chemical Toxicology 23, 137-138

"Toxicologists must realize that their important mission ... does not give them an unconditional license to kill as many animals as they wish and hide behind regulatory requirements, testing guidelines and bureaucratic prescriptions for good laboratory practice."