The biology of euthanasia and humane slaughter

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Introduction

Knowledge contained in the disciplines of general physiology and pathology provides ways, means and criteria for understanding and interpreting issues associated with euthanasia and humane slaughter, and virtually every issue that comes under the rubric of animal welfare. This same knowledge reinforces its reliability in day-to-day medical and veterinary practice. It includes topics that range from the energy metabolism of cells to the integrated function of the circulatory and the nervous systems, which are ultimately expressed in complex behaviour. The purpose now is to draw together some physiological and pathological concepts that are relevant to critical thinking about the issues of euthanasia and humane slaughter and essential to the application of ethics within the public policy framework of the Australian Animal Welfare Strategy (AAWS).

Applied ethics and the AAAWS are the essential context. “Applied ethics requires the systematic application of informed, structured and disciplined discernment to analysis of situations in relation to the ethical issues they raise and to decision-making in these situations” – Margaret Sommerville (2006). The AAWS recognises that animal welfare is a complex issue where science and ethics are both essential. “Science provides the body of evidence about animals that is used for moral and ethical judgments about their welfare”. At the same time, “decisions about animal welfare are influenced by cultural, social, economic and occupational health and safety considerations”. In other words, the AAWS requires the competent and dispassionate presentation and explanation of evidence from science rather than a final judgment from science.

The hybrid between physiology and pathology, so-called pathophysiology, provides a useful means for providing snapshots of contemporary knowledge about two key topics for euthanasia and humane slaughter. These are: (1) consciousness and unconsciousness, where consciousness is regarded as the waking state and where the

“content of consciousness” will be considered and (2) death and the process of dying, including points of no return and the concepts of brain and brainstem death.

Pathophysiology and comparative biology

Pathophysiology is based on the self-evident notion that knowledge of the normal structure and function of animals allows an understanding of disease such that rational treatments can be designed. “Diseases are often ‘experiments of nature’ that uncover previously unknown or unappreciated physiological mechanisms, and their investigation in normal individuals advances fundamental biomedical knowledge” (William Ganong, 2006). Pathophysiology applies to animal welfare as well and can be one of the tools for determining the manner by which animals should be treated. To explain, welfare is part of a chain that includes health and disease. The logical connections between disease, health and welfare can be made plain by the biomedical meaning of these terms. Disease occurs when the adaptive mechanisms of an organism fail to adequately counteract the stimuli or stresses to which it is subject, resulting in a disturbance in function or structure of any part, organ or system of the body (Blakiston’s New Gould Medical Dictionary. The concept of adaptation to stimuli or stresses is repeated when welfare is referred to as the “the state of an individual [animal] as regards its attempts to cope with its environment” (Donald Broom). Health lies at the interface between welfare and disease. The World Health Organization (WHO) describes health as a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity.

Pathophysiology applies to people and other animals. In fact, comparative pathophysiology is an old idea that dates to the time of Aristotle. It has recently been marketed as the “one medicine”. Comparative pathophysiology provides an intelligible basis for veterinary medicine and can bring the full breadth and depth of basic biomedical knowledge to bear on animal problems. At the same time, “veterinary science can offer much assistance in the study and prevention of the diseases to which mankind are liable. Some grave maladies of the human species are certainly derived from animals, and others may yet be added to the list” (Encyclopaedia Britannica 1911).

Consciousness and unconsciousness

Consciousness is considered from a so-called “materialist” viewpoint, which sees the phenomenon as an emergent property of the function of the brain and seeks to explain the function of the brain according to the concepts of physics and chemistry. The

principle of emergent properties is built on the basic idea that the structure and function of animals are inseparable. The forelimbs of a penguin are built for swimming. The forelimbs of a cockatoo are built for flying. The principle of emergent properties states that some of the properties of the whole are determined by the properties of the parts, but other properties of the whole result from the precise way in which those parts are arranged (David Kirk, 1980).

The concept that consciousness derives from the activities of the living brain has not always prevailed. The heart had centre stage in classical Greece and Rome. The heart, not the brain, was considered to be where mental processes like thinking, memory and imagination occurred. Galen (129 - 216) challenged the “cardiocentric” view and demonstrated, by experiments with animals, that the nerves could be traced back to the brain and that the brain was engaged in sensation, consciousness, speech and intelligence. The word consciousness remains a source of linguistic uncertainty.

It is not known as yet how brain processes based on neural circuits and the activity of nerve cells support consciousness. Two possibilities are that “specific groups of neurons mediate distinct conscious experiences” (Christof Koch, 2007) or that “consciousness is generated by a quantitative increase in the holistic functioning of the brain” (Greenfield, 2007). It could be that quantitative measures may eventually illuminate consciousness and conscious states in non-human animals, where the inability to speak presents a major handicap to understanding.

A more mundane approach to consciousness applies for present purposes. Two particular aspects of consciousness are relevant to the euthanasia and humane slaughter livestock. The first views consciousness as the waking or aware state, which depends upon a functioning nervous system. This is the state that general anaesthesia or the electrical or physical stunning of slaughter animals seeks to obliterate. In the unconscious state, there can be no experience of pain. The second aspect of consciousness refers to the perceptions and subjective experiences that the waking or aware state permits. This aspect of consciousness can be seen as “the content of consciousness”.

Perceptions and subjective experience relevant to euthanasia and humane slaughter can include pain and that form of distress associated with fear and anxiety or rage and anger. The challenge for people is to use the outward behaviour of animals to establish the presence or absence of consciousness and to infer internal perceptions and

experiences, “the content of consciousness”, in awake and aware animals.

Consciousness as the state of general wakefulness and awareness of the environment depends upon a continuing energy metabolism in specific and highly active parts of the nervous system. The metabolism involved requires an uninterrupted supply of fuel and oxygen, delivered via the blood. It also requires a functional cellular system that allows for the extraction of chemical energy in an ordered manner that is coupled to the rapid removal of the combustion product carbon dioxide. Energy is consumed in the transmission of signals between cells in the nervous system. Here it is required to restore sodium and calcium ions to the outside of cells and potassium ions to the inside of cells after the passage of a signal.

The phenomenon of consciousness covers a range of wakefulness states. First is coma where animals are unconscious, recumbent and unresponsive to stimuli including those causing pain. Then follows semi-coma or stupor, normal consciousness and various intensities of arousal where consciousness rises above background levels and eventually expresses. Depression, delirium, dementia, mania, frenzy and aggressive behaviour are altered states of consciousness that are named for livestock. Sleep, torpor, hibernation (winter sleep) and aestivation (summer sleep) are metabolic states in animals associated with altered consciousness.

Consciousness as the state of being awake and aware depends upon the effective function of two components of the brain. These are the cerebral cortex at the front of the brain and the complex known as the ascending reticular activating system (ARAS) or the reticular formation, which is situated in the brainstem. The brainstem and its reticular formation lie at the back of the brain. The reticular formation activates the waking state of the cerebral cortex.

The cerebral cortex is the site where perceptions are elaborated out of sensory inputs from the outside world and from within animals themselves, where associations are made and where complex behaviour and voluntary movement is initiated and controlled. Perception is the process whereby sensory stimulation is translated into organised and meaningful experience. Specific areas of the cerebral cortex receive inputs from different sensory systems such as hearing, vision, smell, the somatosensory system and so on. The somatosensory system is concerned with the tactile sensations of touch, pressure, and vibration), the sensations pf pain and temperature, which are highly relevant to animal welfare, and proprioception, which is

concerned with the position and relative motion of parts of the body.

Loss of consciousness can occur through failure of either the cerebral cortex or the reticular formation. Breakdown of the reticular formation means that the cerebral cortex will be switched off or cannot be switched on. Breakdown of the cerebral cortex removes the possibility of perception and subjective experience. A functioning brain stem and a non-functioning cerebral cortex produce the persistent vegetative state. In humans, cerebral function wanes rapidly when blood flow is interrupted and consciousness is lost within 6-10 seconds.

The indicators of consciousness and unconsciousness used for managing general anaesthesia and in the neurological examination of animals apply to the management of euthanasia and humane slaughter. These indicators are the signs of activity and behaviour that link to functions of the cerebral cortex. They can be supported in experimental studies by secondary aids such as electroencephalography (EEG) and electrocorticography (ECoG). Imaging methods for the nervous system such as PET (positron emission tomography) and fMRI (functional magnetic resonance imaging) may be useful for future research. It is emphasised that EEG etc do not replace the clinical assessment of unconsciousness.

The most important signs of consciousness relate to the motor responses of the body and the presence or absence of responses that concern the cranial nerves. Cranial nerves enter the brain directly and their loss of function during euthanasia or humane slaughter indicates general loss of function of the central nervous system. The absence of gross purposeful movement is considered the most fundamental of the measures for the adequacy of general anaesthesia. It has a reliable basis in neurophysiology and is the most fundamental of the measures used to assess unconsciousness.

Normal movement and control of posture in animals is a result of the integrated and coordinated function of the whole nervous system. The spinal cord functions in reflex responses such as the withdrawal of a limb from a noxious stimulus. It also acts as a pattern generator for the step cycle of the hindlimbs and for coordinating between the four limbs of a quadruped. However, the initiation and control of voluntary and purposeful movements in a way that maintains body posture and equilibrium requires a higher level of command over the more automated spinal mechanisms. The command centres involved are found in the cerebral cortex and the lack of command over voluntary and purposeful movement indicates the absence of general function in the

cerebral cortex. The cerebral cortex also contains centres for integrating information from the senses as described earlier.

Death and the process of dying

Animal welfare concerns cease absolutely at the death of an animal. “As opposed to pain and distress, death itself, or the ‘state of being dead’, is no longer harmful to the animal, which at that point has no physical existence” (World Association of Zoos and Aquaria, 2007) No harms are possible to an animal once it is dead. Accordingly, an understanding of the biological ideas applying to death either as the state of being dead or as the process of dying is prerequisite to an understanding of euthanasia and humane slaughter.

Death refers to the ending of an animal as an integrated whole and not to the death of every single cell in all tissues of an animal. Death is the total cessation of life processes or the irreversible loss of vital functions that eventually occurs in every living organism. These general statements enfold a mass of detail and the present outline will concentrate on aspects of death considered important for thinking about euthanasia and humane slaughter.

To start with, the concepts of brain stem death and brain death have wide medical acceptance as the end of life. In the United Kingdom, brain stem death is defined as irreversible loss of consciousness, irreversible loss of the capacity to breathe and irreversible loss of integrated functioning. From a biological perspective, “death of the brain is the necessary and sufficient condition for death of the individual and the physiological core of brain death is the death of the brain stem” (Christopher Pallis, 1982).

The process of dying involves “points of no return’, which can be identified. The irreversible cessation of circulation is a point of no return because it causes critical centres in the brain stem to die. “The brain stem is irreplaceable in a way the cardiac pump is not”. Death of the brain and the brainstem is inevitable when intracranial blood pressure exceeds arterial pressure and the brain is deprived of its source of oxygen and glucose. At the ultimate molecular level, death occurs when an absence of chemical energy ends the work involved in transporting substances across cell membranes and the transmission of signals by nerve cells is no longer possible.

As explained earlier, the brainstem is at the back of the brain and contains the ascending reticular activating system (ARAS), which plays a crucial role in maintaining alertness and in generating the capacity for consciousness. The brainstem also contains centres that initiate and control respiration. When cells in these centres cease to function and die, respiration ceases and life of the whole animal terminates. This stage is confirmed when brainstem function ceases as a whole and when consciousness has been lost.

Functions of the brainstem can be assessed clinically by observing signs of brainstem function. The most definitive signs of brainstem death are the cessation of rhythmic breathing and apnoea or respiratory paralysis, which cause the death of the rest of the body. Four specific regions in the brainstem control respiration in mammals. These trigger inspiration and expiration, generate the basic rhythm of breathing, and regulate inspiratory volume and respiratory rate.

Physical signs that add up to total brainstem destruction, and infer destruction of respiratory control centres, will adequately define death. The signs here relate to the activity of cranial nerves and include the absence of particular eye reflexes, the corneal reflex and the gag reflex.

The eye reflexes require a functional retina, optic nerve and optic pathways in the brain. Some require intact pathways for other cranial nerves. The gag reflex refers to pushing movements of the back of the tongue, which are stimulated by touching the back of the larynx. It requires that the pathways of cranial nerve IX (the glossopharyngeal nerve) and cranial nerve X (the vagus nerve) are intact.

The process of death has been likened to shutting down the machine and then wrecking the machinery. In summary, death can be regarded as a unified and interdependent process. When the brainstem ceases to function (brainstem death), respiration ceases. The heart, however, will continue to function until the stock of oxygen in the blood is consumed. When the heart and its inherent rhythmic contractions stop irreversibly (cardiac death), the brain receives no energy supplies and will rapidly cease to function. The result in all instances is death of an animal as a functional whole, which is followed inevitably by death of all parts of an animal. Some functions of parts of an animal persist after death as a “functional whole” For instance, viable skin grafts, bone grafts and arterial grafts may be obtained 24, 48 and 72 hours after the heart has stopped.