How altruism and prosocial behaviour can be explained from an evolutionary, psychological, and chemical perspective.

Altruism refers to the tendency of social organisms to display prosocial behaviour to other individuals at their own detriment, or without benefitting themselves. At first, it appears to be an evolutionary paradox. If anything, selfish behaviour – the opposite of prosocial behaviour - would appear to be the most certain path towards reproduction. Even so, across the human and natural world we see evidence of altruism occurring. Whether it be in insect colonies or human civilizations, altruism appears to be an integral part of the global ecosystem. This essay will attempt to explain the evolutionary, psychological, and chemical reasons why we see altruism so often in nature.

In some cases, altruism can be explained by Hamilton's equation. This states that if $r * b > c$ then altruism is, evolutionarily speaking, beneficial for an individual (Hamilton, 1964). In this equation, r refers to the relatedness of the benefactor to the recipient, b refers to the benefit of the altruistic action to the recipient and c refers to the cost of the altruistic action to the benefactor. An example of this equation in action comes from termite colonies. Termites are governed by a strict caste system. The 'King' and 'Queen' termites are solely responsible for reproduction, while all other members of the colony, soldiers, and workers, serve to feed and protect them (Rosin, 2000). The workers and soldiers, which are typically infertile, sacrifice their own potential offspring to ensure that the genetic code of the colony as a whole can be passed down to the next generation. By decreasing the competition for the King and Queen, termites increase the likelihood of the perpetuation of the colony, and the foundational genotypic sequences that exist within it. In some cases, Hamilton's equation is modified to change r to be the relatedness of the kin's offspring and c to be the product of the cost to the benefactor's offspring and the relatedness of this offspring to the benefactor. This is often a useful modification, since as with all aspects of evolutionary science, it is the likelihood of surviving to pass on genes that should be considered. Therefore, from an evolutionary perspective, altruism is almost always a beneficial path for individuals who cannot or will not reproduce themselves. Of course, this manner of thinking does not consider the individual lives of those organisms making this a pertinent example of how altruism cannot be simplified into a merely evolutionary issue, there must also be other factors, perhaps nullified artefacts of evolution, driving the altruism we see. Even from a purely evolutionary perspective, Hamilton's equation has its limitations - in general, it can only be applied to kin selection. Dawkins' "selfish gene" theory explains this well. Even if we cannot pass on our genes directly, assisting our close relatives - children, siblings, cousins – in successfully reproducing means that portions of the genes present in our genome will inevitably be passed on (Dawkins, 1976). This means that alleles coding for altruistic behaviour will have a higher chance of being passed on, and so will increase in frequency (Boehnke, 1991). However, when considering all types of altruism,

the selfish gene, being selfish in nature, would surely select away from actions such as the kindness a person may show towards a stray cat. Therefore, it would be shortsighted to propose that altruism was solely a result of genetic evolution.

The presence of factors beyond pure genetics may also be seen by the simple fact that how we feel affects our actions. We are typically more inclined to help those with whom we have a close friendship, irrespective of their genetic similarity. This, however, is possibly explained by the idea of reciprocal altruism (Trivers, 1971). People have a predisposal to help others if they suspect that the favour will be repaid (Speilman et al., 2020). Of course, there is the chance that acts of prosocial behaviour will be betrayed, however, particularly in human society, this has historically been discouraged by punishment systems. More generally in nature, failure to reciprocate altruistic actions may result in social exclusion (Buss, 2004). The chances of a benefactor committing to reciprocal altruism occurring relies on a cost-benefit-analysis (Dovidio et al., 2006). If the required cost of the altruistic act is relatively low, then the benefactor is more likely to commit it. Conversely, if the potential reward is high then the benefactor will also be more likely to display prosocial behaviour. Arguably the idea of reciprocal altruism somewhat betrays the core definition of altruism – namely that the act should be detrimental to the benefactor. Upon first examination the idea of being 'repaid' goes against this principle. However, the cases in which reciprocal altruism can occur are such that the return act is not guaranteed. For example, giving a shopkeeper money cannot be considered altruism when there is the guarantee that goods of some form are given to the buyer in return. The initial payment is not an act of kindness, but the initiation of trade. If reciprocation of prosocial behaviour is present in nature, as it is, then it follows that individuals who display altruism (and are therefore more likely to benefit from another's altruism in return) have a greater likelihood of surviving to reproduce, passing on the alleles that prompted them towards prosocial behaviour in the first place. This results in altruism being selected for by evolution.

Reciprocal altruism is not the only example of where rewards can drive prosocial behaviour. The human body, it would appear, is hard-coded to reward kindness – and punish cruelty. Oxytocin, the so-called love hormone, primarily plays a role in childbirth. It stimulates contractions of the endometrium and the cervix during childbirth (Nagwa, 2025) as well as triggering the 'let down' reflex in breastfeeding to release the mother's milk (Baron-Cohen, 2025). However, oxytocin is also linked to making us more trusting, generous and friendly. Oxytocin is a nonapeptide, consisting of a ring of six amino acids with a tail of a further three amino acids. The oxytocin receptor (OXTR), found on the cell surface membrane, is a G protein-coupled receptor (GPCR). GPCRs are the largest group of membrane receptors in eukaryotes. GPCRs can bind with a vast host of signalling molecules, however in the case of OXTR, the relatively small protein oxytocin will bind, causing an interaction between the OXTR and a nearby heterotrimeric G protein (Alberts, 2023). When activated by OXTRs, G proteins will bind to guanosine

triphosphate (GTP) in favour of guanosine diphosphate (GDP). The association of GTP causes the G protein's alpha subunit (which the GTP binds to) to dissociate from the beta and gamma subunits. The subunits remain anchored in the cell membrane, but do not remain associated with the OXTR. This dissociation allows them to move laterally through the membrane to interact with other membrane bound proteins. Inactive OXTRs (which are not associated with OXT) will hydrolyse the GTP group associated with the G protein to GDP, allowing the G protein to bind with the OXTR again, effectively deactivating it. When activated, G proteins coupled with OXTR will activate the enzyme phospholipase C. This enzyme hydrolyses intracellular phospholipids to inositol triphosphate and diacylglycerol (Roby, 2019). These molecules will stimulate the intracellular release of calcium ions which, in hypothalamic neurons, will stimulate the release of neurotransmitters (Südhof, 2012). The ultimate effect of oxytocin, when targeting OXTRs in the hypothalamus, is to cause feelings of intimacy, friendship and comfort. A study by psychologists Pederson and Prange (1979) found that injection of oxytocin into rats brought on full maternal affection from foster parents towards adopted pups. Interestingly, studies also suggest that benefitting from prosocial behaviour will also cause an increase in oxytocin levels. Parker and Nemeroff (2021) reported that lower concentrations of oxytocin were found in breastfeeding women with an experience of childhood abuse. This suggests that as well as being passed on genetically, the environments we grow up in also have a long term impact on our oxytocin levels, and possibly therefore our inclination towards altruistic behaviour. Oxytocin is but one example of many hormones which stimulate feelings of happiness, love, or comfort. The secretion of these hormones is one of the chemical factors with which our bodies encourage altruistic behaviour. This encouragement will be a derivative of evolution, since altruism, to a certain extent, is beneficial when considering the chances of reproduction.

While helping someone may release 'rewarding' hormones such as oxytocin, this is not the only chemical driver of prosocial behaviour. Seeing someone in pain or discomfort can release hormones such as cortisol to activate a stress response, causing an unpleasant arousal for the observer. Cortisol is a glucocorticoid secreted from the adrenal gland (Burkitt, 2009). Cortisol, or it's medical equivalent hydrocortisone, is detected by two distinct types of receptors, glucocorticoid receptors (GR) and mineralocorticoid receptors (MR). The effect of cortisol on the brain is to increase cognition (Hedayat et al., 2019). Cortisol favours a more extroverted state, which can lead to feelings of stress and discomfort, giving cortisol its reputation as the "stress hormone". When in a stressful situation, the adrenal gland will secrete increased amounts of cortisol. When associated with cortisol, GRs will shuttle from the cytoplasm to the nucleus of their cell. At the nucleus, it will up- or down-regulate the transcription rate of glucocorticoid responsive genes (Nicolaides et al., 2020). Glucocorticoid responsive genes include PERIOD genes. These genes are found in the

X-chromosome and play a crucial role in regulating the molecular circadian rhythm (Kwak et al., 2024). The circadian rhythm defines our sleep cycle, body temperature, mood and metabolism (Fagiani, 2022). As a result, molecular changes to it can have widespread impacts. In general, cortisone will increase our drive to be active, which, in a situation where altruism is an option, may drive us towards prosocial actions. Of course, in triggering a "stressful" emotional response, the release of cortisol also discourages letting someone else remain in pain.

While there are plenty of chemical and evolutionary factors driving prosocial behaviour from social organisms, we still see examples of antisocial, selfish behaviour across nature. While actively selfish acts, for example male bears killing cubs for food, and to promote oestrus in their mother (Frederick, 2010), can be explained by an inherent evolutionary drive of all life for self-preservation at least as far as reproduction. However, in some cases a lack of prosocial behaviour is shown through a lack of action. One of the explanations for this lack of altruism is the bystander affect. Following a case in which Kitty Genovese was brutally attacked and killed in front of thirty-eight innocent bystanders, who were free to help but didn't, the idea of the bystander affect was born (Darley, 1968). One explanation for this phenomenon has been explained already. The principles of reciprocal altruism suggest that if the potential cost were higher than the perceived reward no one would help. But in this case, without other factors, each of the 38 people would be right to assume that the other 37 bystanders would help to overcome the attacker, making it a relatively low risk option to help, particularly considering that a life would certainly be lost if they didn't. The main factor inhibiting prosocial behaviour in this scenario is pluralistic ignorance. This phenomenon is grounded on the assumption of individuals that one of the other bystanders is more qualified to firstly identify that the situation at hand requires response, and secondly to action the necessary response. A consequence of this is that, strangely, the more people present at a situation, the less likely any of them are to display prosocial behaviour, since the likelihood of someone else present being better qualified to approach the situation are increased. Another driver of pluralistic ignorance is the human tendency to try to fit in. The social nature of humans means that, where possible, people will copy the actions of those around them. This means that, in the example of Kitty Genovese, the bystanders would wait for someone else to act first. If all thirty-eight bystanders do this, it of course results in no one displaying altruistic behaviour, with each individual waiting for someone else to act first. The case of Kitty Genovese shows how, despite the presence of multiple factors driving individuals towards altruistic behaviour, the nature of humans as social organisms sometimes prompts antisocial behaviour over prosocial behaviour, occasionally to tragic ends.

To conclude, altruism, despite in theory being detrimental to the benefactor, can be beneficial to their genetic lineage in the long run. This is since, while the individual benefactor may suffer, their offspring, or the offspring of their kin, can still benefit.

Alternatively, altruism can be beneficial to the benefactor themselves due to prosocial behaviour being reciprocated by its recipients. This has led to chemical drivers such as oxytocin and cortisol being selected for through evolution. While in some cases the nature of social organisms may inhibit the expression of prosocial behaviour, social behaviour will often manifest as prosocial behaviour rather than antisocial behaviour.

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