Larry Young - selected references

1 Rilling, J. K. & Young, L. J. (2014). The biology of mammalian parenting and its effect on offspring social development. *Science, 345,* 771-776.
Notes: Parents know the transformative nature of having and caring for a child. Among many mammals, giving birth leads from an aversion to infant stimuli to irresistible attraction. Here, we review the biological mechanisms governing this shift in parental motivation in mammals. Estrogen and progesterone prepare the uterus for embryo implantation and placental development. Prolactin stimulates milk production, whereas oxytocin initiates labor and triggers milk ejection during nursing. These same molecules, interacting with dopamine, also activate specific neural pathways to motivate parents to nurture, bond with, and protect their offspring. Parenting in turn shapes the neural development of the infant social brain. Recent work suggests that many of the principles governing parental behavior and its effect on infant development are conserved from rodent to humans

2 Young, L. J. (2013). When too much of a good thing is bad: chronic oxytocin, development, and social impairments. *Biological Psychiatry, 74,* 160-161.
Notes: Center for Translational Social Neuroscience, Department of Psychiatry and Behavioral Neuroscience, Yerkes National Primate Research Center, Emory University, Atlanta, Georgia, USA. lyoun03@emory.edu

3 Young, L. J. & Flanagan-Cato, L. M. (2012). Editorial comment: oxytocin, vasopressin and social behavior. *Hormones and Behavior, 61,* 227-229.

4 Modi, M. E. & Young, L. J. (2012). The oxytocin system in drug discovery for autism: animal models and novel therapeutic strategies. *Hormones and Behavior, 61,* 340-350.
Notes: Animal models and behavioral paradigms are critical for elucidating the neural mechanism involved in complex behaviors, including social cognition. Both genotype and phenotype based models have implicated the neuropeptide oxytocin (OT) in the regulation of social behavior. Based on the findings in animal models, alteration of the OT system has been hypothesized to play a role in the social deficits associated with autism and other neuropsychiatric disorders. While the evidence linking the peptide to the etiology of the disorder is not yet conclusive, evidence from multiple animal models suggest modulation of the OT system may be a viable strategy for the pharmacological treatment of social deficits. In this review, we will discuss how animal models have been utilized to understand the role of OT in social cognition and how those findings can be applied to the conceptualization and treatment of the social impairments in ASD. Animal models with genetic alterations of the OT system, like the OT, OT receptor and CD38 knock-out mice, and those with phenotypic variation in social behavior, like BTBR inbred mice and prairie voles, coupled with behavioral paradigms with face and construct validity may prove to have predictive validity for identifying the most

efficacious methods of stimulating the OT system to enhance social cognition in humans. The widespread use of strong animal models of social cognition has the potential yield pharmacological, interventions for the treatment social impairments psychiatric disorders. This article is part of a Special Issue entitled Oxytocin, Vasopressin, and Social Behavior

5 Burkett, J. P. & Young, L. J. (2012). The behavioral, anatomical and pharmacological parallels between social attachment, love and addiction. *Psychopharmacology (Berlin), 224,* 1-26.
Notes: RATIONALE: Love has long been referred to as an addiction in literature and poetry. Scientists have often made comparisons between social attachment processes and drug addiction, and it has been suggested that the two may share a common neurobiological mechanism. Brain systems that evolved to govern attachments between parents and children and between monogamous partners may be the targets of drugs of abuse and serve as the basis for addiction processes. OBJECTIVES: Here, we review research on drug addiction in parallel with research on social attachments, including parent-offspring attachments and social bonds between mating partners. This review focuses on the brain regions and neurochemicals with the greatest overlap between addiction and attachment and, in particular, the mesolimbic dopamine (DA) pathway. RESULTS: Significant overlap exists between these two behavioral processes. In addition to conceptual overlap in symptomatology, there is a strong commonality between the two domains regarding the roles and sites of action of DA, opioids, and corticotropin-releasing factor. The neuropeptides oxytocin and vasopressin are hypothesized to integrate social information into attachment processes that is not present in drug addiction. CONCLUSIONS: Social attachment may be understood as a behavioral addiction, whereby the subject becomes addicted to another individual and the cues that predict social reward. Understandings from both fields may enlighten future research on addiction and attachment processes

6 McGraw, L. A. & Young, L. J. (2010). The prairie vole: an emerging model organism for understanding the social brain. *Trends in Neurosciences, 33,* 103-109.
Notes: Unlike most mammalian species, the prairie vole is highly affiliative, forms enduring social bonds between mates and displays biparental behavior. Over two decades of research on this species has enhanced our understanding of the neurobiological basis not only of monogamy, social attachment and nurturing behaviors but also other aspects of social cognition. Because social cognitive deficits are hallmarks of many psychiatric disorders, discoveries made in prairie voles can direct novel treatment strategies for disorders such as autism spectrum disorder and schizophrenia. With the ongoing development of molecular, genetic and genomic tools for this species, prairie voles will likely maintain their current trajectory becoming an unprecedented model organism for basic and translational research focusing

on the biology of the social brain

7 Young, L. J., Owens, M. J., & Nemeroff, C. B. (2009). Neuropeptides: Biology, regulation, and role in neuropsychiatric disorders. In B.J.Sadock, V. A. Sadock, & P. Ruiz (Eds.), *Kaplan & Sadock's comprehensive textbook of psychiatry, Vol.1* (9 ed., pp. 84-96). Philadelphia,PA: Lippincott Williams & Wilkins.

8 Ross, H. E. & Young, L. J. (2009). Oxytocin and the neural mechanisms regulating social cognition and affiliative behavior. *Front Neuroendocrinol., 30,* 534-547.
Notes: Oxytocin is produced in the hypothalamus and released into the circulation through the neurohypophyseal system. Peripherally released oxytocin facilitates parturition and milk ejection during nursing. Centrally released oxytocin coordinates the onset of maternal nurturing behavior at parturition and plays a role in mother-infant bonding. More recent studies have revealed a more general role for oxytocin in modulating affiliative behavior in both sexes. Oxytocin regulates alloparental care and pair bonding in female monogamous prairie voles. Social recognition in male and female mice is also modulated by oxytocin. In humans, oxytocin increases gaze to the eye region of human faces and enhances interpersonal trust and the ability to infer the emotions of others from facial cues. While the neurohypopheseal oxytocin system has been well characterized, less is known regarding the nature of oxytocin release within the brain. Here we review the role of oxytocin in the regulation of prosocial interactions, and discuss the neuroanatomy of the central oxytocin system

9 Ross, H. E., Freeman, S. M., Spiegel, L. L., Ren, X., Terwilliger, E. F., & Young, L. J. (2009). Variation in oxytocin receptor density in the nucleus accumbens has differential effects on affiliative behaviors in monogamous and polygamous voles. *Journal of Neuroscience, 29,* 1312-1318.
Notes: Oxytocin receptors in the nucleus accumbens have been implicated in the regulation of alloparental behavior and pair bond formation in the socially monogamous prairie vole. Oxytocin receptor density in the nucleus accumbens is positively correlated with alloparenting in juvenile and adult female prairie voles, and oxytocin receptor antagonist infused into the nucleus accumbens blocks this behavior. Furthermore, prairie voles have higher densities of oxytocin receptors in the accumbens than nonmonogamous rodent species, and blocking accumbal oxytocin receptors prevents mating-induced partner preference formation. Here we used adeno-associated viral vector gene transfer to examine the functional relationship between accumbal oxytocin receptor density and social behavior in prairie and meadow voles. Adult female prairie voles that overexpress oxytocin receptor in the nucleus accumbens displayed accelerated partner preference formation after cohabitation with a male, but did not display enhanced alloparental behavior. However, partner preference was not

facilitated in nonmonogamous meadow voles by introducing oxytocin receptor into the nucleus accumbens. These data confirm a role for oxytocin receptor in the accumbens in the regulation of partner preferences in female prairie voles, and suggest that oxytocin receptor expression in the accumbens is not sufficient to promote partner preferences in nonmonogamous species. These data are the first to demonstrate a direct relationship between oxytocin receptor density in the nucleus accumbens and variation in social attachment behaviors. Thus, individual variation in oxytocin receptor expression in the striatum may contribute to natural diversity in social behaviors

10 Young, L. J. & Wang, Z. (2006). The neurobiology of pair bonding. Nature Neuroscience 7[10], 1048-1054.

11 Young, L. J., Wang, Z., & Insel, T. R. (2002). Neuroendocrine bases of monogamy. In J.T.Cacioppo, G. G. Berntson, R. Adolphs, C. S. Carter, R. J. Davidson, M. K. McClintock, B. S. McEwen, M. J. Meaney, D. L. Schacter, E. M. Sternberg, S. S. Suomi, & S. E. Taylor (Eds.), *Foundations in social neuroscience* (1 ed., pp. 809-816). Cambridge,MA: MIT Press.

12 Insel, T. R. & Young, L. J. (2001). The neurobiology of attachment. *Nature Reviews Neuroscience, 2,* 129-136.
Notes: Center for Behavioral Neuroscience, 954 Gatewood Road Northeast, Emory University, Atlanta, Georgia 30329, USA. insel@rmy.emory.edu
It is difficult to think of any behavioural process that is more intrinsically important to us than attachment. Feeding, sleeping and locomotion are all necessary for survival, but humans are, as Baruch Spinoza famously noted, "a social animal" and it is our social attachments that we live for. Over the past decade, studies in a range of vertebrates, including humans, have begun to address the neural basis of attachment at a molecular, cellular and systems level. This review describes some of the important insights from this work

13 Young, L. J., Wang, Z., & Insel, T. R. (1998). Neuroendocrine bases of monogamy. *Trends in Neurosciences, 21,* 71-75.
Notes: Dept of Psychiatry and Behavioral Sciences, Emory University School of Medicine, and the Yerkes Regional Primate Research Center, Atlanta, GA 30322, USA ; ABSTRACT: A number of studies have implicated the neurohypophyseal peptides oxytocin and vasopressin in the central mediation of complex social behaviors, including affiliation, parental care and territorial aggression. Research on a monogamous rodent, the prairie vole (Microtus ochrogaster), suggests that these neuropeptides are also involved in the control of several behaviors associated with monogamy, including pair bonding, paternal care and mate guarding. Comparative studies using several species of vole have identified species- specific patterns of oxytocin- and vasopressin-receptor expression in the brain that appear to be associated with a monogamous versus non-monogamous social structure. Molecular

studies suggest that changes in the regulation of oxytocin- and vasopressin-receptor gene expression underlie these species differences in receptor distribution and might provide a mechanism for the evolution of monogamy in voles