



## Russell D. Fernald

Benjamin Scott Crocker Professor of Human Biology, Emeritus

 Curriculum Vitae available Online     Resume available Online

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### Bio

#### ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Biology
- Member, Bio-X
- Member, Stanford Cancer Institute
- Member, Wu Tsai Neurosciences Institute

#### HONORS AND AWARDS

- Bing Prize for Excellence & Innovation in Undergraduate Teaching, Stanford University (1996-99)
- Cox Medal for Excellence in Fostering Undergraduate Research, Stanford University (1998)
- Dinkelspiel Prize for Outstanding Contributions to Undergraduate Education, Stanford University (2000)
- Benjamin Scott Crocker Professor of Human Biology, Stanford University (1994-)
- NIH Fogarty Senior International Fellowship, NIH (1985-86)
- Javits Neuroscience Investigator Award, National Institute of Neurological Disorders and Stroke (1999-2006)
- Fellow-American Association for Advancement of Science, AAAS (2003)
- Rank Prize in Vision/Opto-electronics, Rank Foundation (February 2004)
- Elected Fellow, American Academy of Arts and Sciences (2011)

#### PROFESSIONAL EDUCATION

- PhD, University of Pennsylvania , Biophysics (1969)
- B.S., Swarthmore College , Electrical Engineering/Physics (1963)

#### LINKS

- Lab Website: <https://web.stanford.edu/group/fernaldlab/>

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### Research & Scholarship

#### CURRENT RESEARCH AND SCHOLARLY INTERESTS

How does social experience influence the brain?

Our research is focused on understanding the mechanisms through which social change is transduced into cellular and molecular change. Sex is the most potent selective force acting on animal behavior, shaping many aspects of animals' behavior and physiology. How is vertebrate sexual maturation and behavior controlled? Ultimately, males regulate reproductive opportunity and success through their behavior and social interactions, selecting a mate

from among males on offer. Males use a variety of competitive strategies, evolved to impress females, intending to become the chosen one. Amongst males, there is typically a status hierarchy in which males compete for highest rank that brings with it a higher chance of being chosen because high status leads to reproductive opportunity and competence as well as access to females and food. Lower ranking animals often have limited access to food and reproduction and are reproductively incompetent. To understand the circuitry responsible for male reproduction, we study the neural mechanisms of social ascent, assessing the changes in males as they ascend from low to high status. We use a uniquely appropriate fish model system dominance is reflected in maintaining a territory so when a vacated territory becomes available, a low-ranking male must quickly detect his absence, seize the opportunity to acquire this valuable resource, and initiate a dramatic transformation that spans from whole-organism behavior and coloration changes, to hormonal, cellular, and transcriptional-level changes throughout the body. In fact, within a matter of minutes, his appearance and physiology has changed radically as he prepares for a new lifestyle as a dominant and reproductively active territory holder. But social ascent happens over two timescales. Following the rapid changes described above that occur in minutes, the reproductive system also needs to ramp up so the male has sperm for mating. Though both of these systems are triggered by the recognition of social opportunity, we can show that they comprise distinct circuits in which different neural peptides are activated to achieve the changes needed.

## Teaching

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### GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Biology (School of Humanities and Sciences) (Phd Program)
- Neurosciences (Phd Program)

## Publications

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### PUBLICATIONS

- **Rhythmic expressed clock regulates the transcription of proliferating cellular nuclear antigen in teleost retina.** *Experimental eye research*  
Song, H., Wang, D., De Jesus Perez, F., Xie, R., Liu, Z., Chen, C., Yu, M., Yuan, L., Fernald, R. D., Zhao, S.  
2017; 160: 21-30
- **Differential activation of vasotocin neurons in contexts that elicit aggression and courtship** *BEHAVIOURAL BRAIN RESEARCH*  
Loveland, J. L., Fernald, R. D.  
2017; 317: 188-203
- **Cognitive skills and the evolution of social systems** *JOURNAL OF EXPERIMENTAL BIOLOGY*  
Fernald, R. D.  
2017; 220 (1): 103-113
- **Polygenic sex determination in the cichlid fish *Astatotilapia burtoni*.** *BMC genomics*  
Roberts, N. B., Juntti, S. A., Coyle, K. P., Dumont, B. L., Stanley, M. K., Ryan, A. Q., Fernald, R. D., Roberts, R. B.  
2016; 17 (1): 835-?
- **Dopaminergic inhibition of gonadotropin-releasing hormone neurons in the cichlid fish, *Astatotilapia burtoni*.** *journal of experimental biology*  
Bryant, A. S., Greenwood, A. K., Juntti, S. A., Byrne, A. E., Fernald, R. D.  
2016
- **Differential activation of vasotocin neurons in contexts that elicit aggression and courtship.** *Behavioural brain research*  
Loveland, J. L., Fernald, R. D.  
2016; 317: 188-203
- **Timing reproduction in teleost fish: cues and mechanisms** *CURRENT OPINION IN NEUROBIOLOGY*  
Juntti, S. A., Fernald, R. D.  
2016; 38: 57-62
- **A Neural Basis for Control of Cichlid Female Reproductive Behavior by Prostaglandin F-2 alpha** *CURRENT BIOLOGY*  
Juntti, S. A., Hilliard, A. T., Kent, K. R., Kumar, A., Andrew Nguyen, A., Jimenez, M. A., Loveland, J. L., Mourrain, P., Fernald, R. D.

2016; 26 (7): 943-949

- **A Neural Basis for Control of Cichlid Female Reproductive Behavior by Prostaglandin F2a.** *Current biology*  
Juntti, S. A., Hilliard, A. T., Kent, K. R., Kumar, A., Nguyen, A., Jimenez, M. A., Loveland, J. L., Mourrain, P., Fernald, R. D.  
2016; 26 (7): 943-949
- **Two types of dominant male cichlid fish: behavioral and hormonal characteristics.** *Biology open*  
Alcazar, R. M., Becker, L., Hilliard, A. T., Kent, K. R., Fernald, R. D.  
2016; 5 (8): 1061-1071
- **Identification of prohormones and pituitary neuropeptides in the African cichlid, *Astatotilapia burtoni*.** *BMC genomics*  
Hu, C. K., Southey, B. R., Romanova, E. V., Maruska, K. P., Sweedler, J. V., Fernald, R. D.  
2016; 17 (1): 660-?
- **Epigenetic DNA Methylation Linked to Social Dominance** *PLOS ONE*  
Lenkov, K., Lee, M. H., Lenkov, O. D., Swafford, A., Fernald, R. D.  
2015; 10 (12)
- **Social Crowding during Development Causes Changes in GnRH1 DNA Methylation** *PLOS ONE*  
Alvarado, S. G., Lenkov, K., Williams, B., Fernald, R. D.  
2015; 10 (10)
- **The effect of observers on behavior and the brain during aggressive encounters.** *Behavioural brain research*  
Desjardins, J. K., Becker, L., Fernald, R. D.  
2015; 292: 174-183
- **Social behaviour: can it change the brain?** *ANIMAL BEHAVIOUR*  
Fernald, R. D.  
2015; 103: 259-265
- **Electrical synapses connect a network of gonadotropin releasing hormone neurons in a cichlid fish** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*  
Ma, Y., Juntti, S. A., Hu, C. K., Huguenard, J. R., Fernald, R. D.  
2015; 112 (12): 3805-3810
- **Communication about social status** *CURRENT OPINION IN NEUROBIOLOGY*  
Fernald, R. D.  
2014; 28: 1-4
- **The genomic substrate for adaptive radiation in African cichlid fish** *NATURE*  
Brawand, D., Wagner, C. E., Li, Y. I., Malinsky, M., Keller, I., Fan, S., Simakov, O., Ng, A. Y., Lim, Z. W., Bezault, E., Turner-Maier, J., Johnson, J., Alcazar, et al  
2014; 513 (7518): 375-?
- **The genomic substrate for adaptive radiation in African cichlid fish.** *Nature*  
Brawand, D., Wagner, C. E., Li, Y. I., Malinsky, M., Keller, I., Fan, S., Simakov, O., Ng, A. Y., Lim, Z. W., Bezault, E., Turner-Maier, J., Johnson, J., Alcazar, et al  
2014; 513 (7518): 375-381
- **Social regulation of cortisol receptor gene expression.** *journal of experimental biology*  
Korzan, W. J., Grone, B. P., Fernald, R. D.  
2014; 217: 3221-3228
- **Social regulation of cortisol receptor gene expression** *JOURNAL OF EXPERIMENTAL BIOLOGY*  
Korzan, W. J., Grone, B. P., Fernald, R. D.  
2014; 217 (18): 3221-3228
- **Social status differences regulate the serotonergic system of a cichlid fish, *Astatotilapia burtoni*.** *journal of experimental biology*  
Loveland, J. L., Uy, N., Maruska, K. P., Carpenter, R. E., Fernald, R. D.  
2014; 217: 2680-2690

- **The dynamic nature of DNA methylation: a role in response to social and seasonal variation.** *Integrative and comparative biology*  
Alvarado, S., Fernald, R. D., Storey, K. B., Szyf, M.  
2014; 54 (1): 68-76
- **Brains over brawn: experience overcomes a size disadvantage in fish social hierarchies** *JOURNAL OF EXPERIMENTAL BIOLOGY*  
Alcazar, R. M., Hilliard, A. T., Becker, L., Bernaba, M., Fernald, R. D.  
2014; 217 (9): 1462-1468
- **Social opportunity rapidly regulates expression of CRF and CRF receptors in the brain during social ascent of a teleost fish, *Astatotilapia burtoni*.** *PloS one*  
Carpenter, R. E., Maruska, K. P., Becker, L., Fernald, R. D.  
2014; 9 (5)
- **Cognitive Skills Needed for Social Hierarchies.** *Cold Spring Harbor symposia on quantitative biology*  
Fernald, R. D.  
2014; 79: 229-236
- **Social Opportunity Rapidly Regulates Expression of CRF and CRF Receptors in the Brain during Social Ascent of a Teleost Fish, *Astatotilapia burtoni*.** *PloS one*  
Carpenter, R. E., Maruska, K. P., Becker, L., Fernald, R. D.  
2014; 9 (5): e96632
- **Social regulation of male reproductive plasticity in an african cichlid fish.** *Integrative and comparative biology*  
Maruska, K. P., Fernald, R. D.  
2013; 53 (6): 938-950
- **Tol2-Mediated Generation of a Transgenic Haplochromine Cichlid, *Astatotilapia burtoni*** *PLOS ONE*  
Juntti, S. A., Hu, C. K., Fernald, R. D.  
2013; 8 (10)
- **Social descent with territory loss causes rapid behavioral, endocrine and transcriptional changes in the brain.** *journal of experimental biology*  
Maruska, K. P., Becker, L., Neboori, A., Fernald, R. D.  
2013; 216: 3656-3666
- **Social Opportunity Causes Rapid Transcriptional Changes in the Social Behaviour Network of the Brain in an African Cichlid Fish** *JOURNAL OF NEUROENDOCRINOLOGY*  
Maruska, K. P., Zhang, A., Neboori, A., Fernald, R. D.  
2013; 25 (2): 145-157
- **Social information changes the brain** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*  
Fernald, R. D., Maruska, K. P.  
2012; 109: 17194-17199
- **Characterization of cell proliferation throughout the brain of the African cichlid fish *Astatotilapia burtoni* and its regulation by social status** *JOURNAL OF COMPARATIVE NEUROLOGY*  
Maruska, K. P., Carpenter, R. E., Fernald, R. D.  
2012; 520 (15): 3471-3491
- **Social Context Influences Aggressive and Courtship Behavior in a Cichlid Fish** *PLOS ONE*  
Desjardins, J. K., Hofmann, H. A., Fernald, R. D.  
2012; 7 (7)
- **Food deprivation explains effects of mouthbrooding on ovaries and steroid hormones, but not brain neuropeptide and receptor mRNAs, in an African cichlid fish** *HORMONES AND BEHAVIOR*  
Grone, B. P., Carpenter, R. E., Lee, M., Maruska, K. P., Fernald, R. D.  
2012; 62 (1): 18-26
- **The African Cichlid Fish *Astatotilapia burtoni* Uses Acoustic Communication for Reproduction: Sound Production, Hearing, and Behavioral Significance** *PLOS ONE*  
Maruska, K. P., Ung, U. S., Fernald, R. D.

2012; 7 (5)

- **Subordinate male cichlids retain reproductive competence during social suppression** *PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES*  
Kustan, J. M., Maruska, K. P., Fernald, R. D.  
2012; 279 (1728): 434-443
- **Social Control of the Brain** *ANNUAL REVIEW OF NEUROSCIENCE, VOL 35*  
Fernald, R. D.  
2012; 35: 133-151
- **Contextual chemosensory urine signaling in an African cichlid fish** *JOURNAL OF EXPERIMENTAL BIOLOGY*  
Maruska, K. P., Fernald, R. D.  
2012; 215 (1): 68-74
- **Social Regulation of Gene Expression in the Hypothalamic-Pituitary-Gonadal Axis** *PHYSIOLOGY*  
Maruska, K. P., Fernald, R. D.  
2011; 26 (6): 412-423
- **Systems biology meets behavior** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*  
Fernald, R. D.  
2011; 108 (44): 17861-17862
- **Animal Cooperation: Keeping a Clean(ing) Reputation** *CURRENT BIOLOGY*  
Fernald, R. D.  
2011; 21 (13): R508-R510
- **Visual Information Alone Changes Behavior and Physiology during Social Interactions in a Cichlid Fish (*Astatotilapia burtoni*)** *PLOS ONE*  
Chen, C., Fernald, R. D.  
2011; 6 (5)
- **Effects of stress and motivation on performing a spatial task** *NEUROBIOLOGY OF LEARNING AND MEMORY*  
Wood, L. S., Desjardins, J. K., Fernald, R. D.  
2011; 95 (3): 277-285
- **Acute Light Exposure Suppresses Circadian Rhythms in Clock Gene Expression** *JOURNAL OF BIOLOGICAL RHYTHMS*  
Grone, B. P., Chang, D., Bourgin, P., Cao, V., Fernald, R. D., Heller, H. C., Ruby, N. F.  
2011; 26 (1): 78-81
- **Plasticity of the Reproductive Axis Caused by Social Status Change in an African Cichlid Fish: I. Pituitary Gonadotropins** *ENDOCRINOLOGY*  
Maruska, K. P., Levavi-Sivan, B., Biran, J., Fernald, R. D.  
2011; 152 (1): 281-290
- **Plasticity of the Reproductive Axis Caused by Social Status Change in an African Cichlid Fish: II. Testicular Gene Expression and Spermatogenesis** *ENDOCRINOLOGY*  
Maruska, K. P., Fernald, R. D.  
2011; 152 (1): 291-302
- **What do fish make of mirror images?** *BIOLOGY LETTERS*  
Desjardins, J. K., Fernald, R. D.  
2010; 6 (6): 744-747
- **Female genomic response to mate information** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*  
Desjardins, J. K., Klausner, J. Q., Fernald, R. D.  
2010; 107 (49): 21176-21180
- **Neurobiology of behavior** *CURRENT OPINION IN NEUROBIOLOGY*  
Fernald, R. D., Scharff, C.  
2010; 20 (6): 746-747

- **Reproductive status regulates expression of sex steroid and GnRH receptors in the olfactory bulb** *BEHAVIOURAL BRAIN RESEARCH*  
Maruska, K. P., Fernald, R. D.  
2010; 213 (2): 208-217
- **Social status regulates kisspeptin receptor mRNA in the brain of *Astatotilapia burtoni*** *GENERAL AND COMPARATIVE ENDOCRINOLOGY*  
Grone, B. P., Maruska, K. P., Korzan, W. J., Fernald, R. D.  
2010; 169 (1): 98-107
- **Behavioral and physiological plasticity: Rapid changes during social ascent in an African cichlid fish** *HORMONES AND BEHAVIOR*  
Maruska, K. P., Fernald, R. D.  
2010; 58 (2): 230-240
- **NPY and GnRH Systems Respond to Food Deprivation in a Mouthbrooding Cichlid** *Annual Meeting of the Society-for-Integrative-and-Comparative-Biology*  
Grone, B. P., Lee, M., Fernald, R. D.  
OXFORD UNIV PRESS INC.2010: E64–E64
- **Steroid receptor expression in the fish inner ear varies with sex, social status, and reproductive state** *BMC NEUROSCIENCE*  
Maruska, K. P., Fernald, R. D.  
2010; 11
- **Regulation of gonadotropin-releasing hormone-1 gene transcription by members of the purine-rich element-binding protein family** *AMERICAN JOURNAL OF PHYSIOLOGY-ENDOCRINOLOGY AND METABOLISM*  
Zhao, S., Kelm, R. J., Fernald, R. D.  
2010; 298 (3): E524-E533
- **Fish sex: why so diverse?** *CURRENT OPINION IN NEUROBIOLOGY*  
Desjardins, J. K., Fernald, R. D.  
2009; 19 (6): 648-653
- **Gonadotropin-Releasing Hormone Receptors: Where Did They Come From?** *ENDOCRINOLOGY*  
Fernald, R. D.  
2009; 150 (6): 2507-2508
- **Cytoarchitecture of a Cichlid Fish Telencephalon** *BRAIN BEHAVIOR AND EVOLUTION*  
Burmeister, S. S., Munshi, R. G., Fernald, R. D.  
2009; 74 (2): 110-120
- **Genes and Social Behavior** *SCIENCE*  
Robinson, G. E., Fernald, R. D., Clayton, D. F.  
2008; 322 (5903): 896-900
- **How do social dominance and social information influence reproduction and the brain ?** *Annual Meeting of the Society-for-Integrative-and-Comparative-Biology*  
Desjardins, J. K., Fernald, R. D.  
OXFORD UNIV PRESS INC.2008: 596–603
- **Expression of arginine vasotocin in distinct preoptic regions is associated with dominant and subordinate behaviour in an African cichlid fish** *PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES*  
Greenwood, A. K., Wark, A. R., Fernald, R. D., Hofmann, H. A.  
2008; 275 (1649): 2393-2402
- **GnRH and GnRH receptors: distribution, function and evolution** *JOURNAL OF FISH BIOLOGY*  
Chen, C., Fernald, R. D.  
2008; 73 (5): 1099-1120
- **Color change as a potential behavioral strategy** *HORMONES AND BEHAVIOR*  
Korzan, W. J., Robison, R. R., Zhao, S., Fernald, R. D.  
2008; 54 (3): 463-470

- **Sequences, expression patterns and regulation of the corticotropin-releasing factor system in a teleost** *GENERAL AND COMPARATIVE ENDOCRINOLOGY*  
Chen, C., Fernald, R. D.  
2008; 157 (2): 148-155
- **Heterogeneous nuclear ribonucleoprotein A/B and G inhibits the transcription of gonadotropin-releasing-hormone 1** *MOLECULAR AND CELLULAR NEUROSCIENCE*  
Zhao, S., Korzan, W. J., Chen, C., Fernald, R. D.  
2008; 37 (1): 69-84
- **Localization and diurnal expression of melanopsin, vertebrate ancient opsin, and pituitary adenylate cyclase-activating peptide mRNA in a teleost retina** *JOURNAL OF BIOLOGICAL RHYTHMS*  
Grone, B. P., Zhao, S., Chen, C., Fernald, R. D.  
2007; 22 (6): 558-561
- **Expression, structure, function, and evolution of gonadotropin-releasing hormone (GnRH) receptors GnRH-R1(SHS) and GnRH-R2(PEY) in the teleost, *Astatotilapia burtoni*** *ENDOCRINOLOGY*  
Flanagan, C. A., Chen, C., Coetsee, M., Mamputha, S., Whitlock, K. E., Bredenkamp, N., Grosenick, L., Fernald, R. D., Illing, N.  
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- **Androgen receptors in a cichlid fish, *Astatotilapia burtoni*: Structure, localization, and expression levels** *JOURNAL OF COMPARATIVE NEUROLOGY*  
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- **Territorial male color predicts agonistic behavior of conspecifics in a color polymorphic species** *BEHAVIORAL ECOLOGY*  
Korzan, W. J., Fernald, R. D.  
2007; 18 (2): 318-323
- **Fish can infer social rank by observation alone** *NATURE*  
Grosenick, L., Clement, T. S., Fernald, R. D.  
2007; 445 (7126): 429-432
- **Social dominance regulates androgen and estrogen receptor gene expression** *HORMONES AND BEHAVIOR*  
Burmeister, S. S., Kailasanath, V., Fernald, R. D.  
2007; 51 (1): 164-170
- **Casting a genetic light on the evolution of eyes** *SCIENCE*  
Fernald, R. D.  
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- **Physiological consequences of social descent: studies in *Astatotilapia burtoni*** *JOURNAL OF ENDOCRINOLOGY*  
Parikh, V. N., Clement, T., Fernald, R. D.  
2006; 190 (1): 183-190
- **Differential social regulation of two pituitary gonadotropin-releasing hormone receptors** *BEHAVIOURAL BRAIN RESEARCH*  
Au, T. M., Greenwood, A. K., Fernald, R. D.  
2006; 170 (2): 342-346
- **Chronic valproic acid treatment triggers increased neuropeptide Y expression and signaling in rat nucleus reticularis thalami** *JOURNAL OF NEUROSCIENCE*  
Brill, J., Lee, M., Zhao, S., Fernald, R. D., Huguenard, J. R.  
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Chen, C. C., Fernald, R. D.  
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- **Androgen level and male social status in the African cichlid, *Astatotilapia burtoni*** *BEHAVIOURAL BRAIN RESEARCH*  
Parikh, V. N., Clement, T. S., Fernald, R. D.

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2006; 68 (4): 241-254
- **Investigator profile. An interview with Russell D. Fernald, Ph.D. Interview by Vicki Glaser.** *Zebrafish*  
Fernald, R. D.  
2006; 3 (2): 119-125
- **Rapid behavioral and genomic responses to social opportunity** *PLOS BIOLOGY*  
Burmeister, S. S., Jarvis, E. D., Fernald, R. D.  
2005; 3 (11): 1996-2004
- **Comprehensive algorithm for quantitative real-time polymerase chain reaction** *JOURNAL OF COMPUTATIONAL BIOLOGY*  
Zhao, S., Fernald, R. D.  
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- **Diurnal rhythm of cone opsin expression in the teleost fish *Haplochromis burtoni*** *VISUAL NEUROSCIENCE*  
Halstenberg, S., Lindgren, K. M., Samagh, S. P., Nadal-Vicens, M., Balt, S., Fernald, R. D.  
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- **Behavioral coping strategies in a cichlid fish: the role of social status and acute stress response in direct and displaced aggression** *HORMONES AND BEHAVIOR*  
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Burmeister, S. S., Fernald, R. D.  
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- **IGF-1 produced by cone photoreceptors regulates rod progenitor proliferation in the teleost retina** *DEVELOPMENTAL BRAIN RESEARCH*  
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- **Two visual processing pathways are targeted by gonadotropin-releasing hormone in the retina** *BRAIN BEHAVIOR AND EVOLUTION*  
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- **Functional mapping of the auditory midbrain during mate call reception** *JOURNAL OF NEUROSCIENCE*  
Hoke, K. L., Burmeister, S. S., Fernald, R. D., Rand, A. S., Ryan, M. J., Wilczynski, W.  
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- **Eyes: Variety, development and evolution** *15th Annual Karger Workshop*  
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2004; 27: 697-722
- **Evolving eyes** *INTERNATIONAL JOURNAL OF DEVELOPMENTAL BIOLOGY*  
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- **How does behavior change the brain? Multiple methods to answer old questions** *Annual Meeting of the Society-for-Integrative-and-Comparative-Biology*  
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- **The regulatory effects of cortisol on social status shift in *Haplochromis burtoni*** *Annual Meeting of the Society-for-Integrative-and-Comparative-Biology*  
Parikh, V. N., Schrupf, M., Clement, T., Fernald, R. D.  
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- **Social regulation of the brain: sex, size and status** *Symposium on the Genetics and Biology of Sex Determination*  
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