Animal Models: Themes and Examples

Sue Carter
Research Triangle Institute, RTP, NC

THEMES that run through the selection of ANIMAL MODELS IN BEHAVIOR – A personal perspective

And SOURCES OF KNOWLEDGE AND APPROACHES TO BEHAVIORAL SCIENCES AS THESE HAVE IMPACTED THE SELECTION OF ANIMAL MODELS:

INVESTIGATOR DRIVEN or CURIOSITY BASED:

Research – Me Search? – perhaps more common than we care to admit
Anthropomorphism, introspection and attempts to understand human "nature."
Answering "why" and "how" questions?
Searching for "organizing principles"
Searching for "patterns" (across or within taxa)

DISEASE or PROBLEM DRIVEN, or FUNDING BASED (beyond the scope of this talk)

EMPIRICALLY OR DESCRIPTIVELY BASED

DOMAIN or SCIENTIFIC DISCIPLINE BASED:

ECOLOGY

EVOLUTION, including PHYLOGENY

ETHOLOGY

PSYCHOLOGY

NEUROSCIENCE

MOLECULAR BIOLOGY

DEVELOPMENT (incl. DEVELOPMENTAL PSYCHOBIOLOGY)

REPRODUCTION BASED PROCESSES

SOCIAL ORGANIZATION AND MATING SYSTEMS:

PROCESSES OR MECHANISMS.

DISCIPLINE or DOMAIN DRIVEN (Constantly in flux)

Psychology – Biological, Social, Health, Cognitive/Learning, etc

Ethology, Neuroethology and Sociobiology Neuroscience

Social Neuroscience

Affective Neuroscience

Cognitive Neuroscience

Sensory systems (vision, olfaction, somatosensory, etc)

Molecular Biology and Genetics

DOMAIN or SCIENTIFIC DISCIPLINE BASED

1. ECOLOGY –

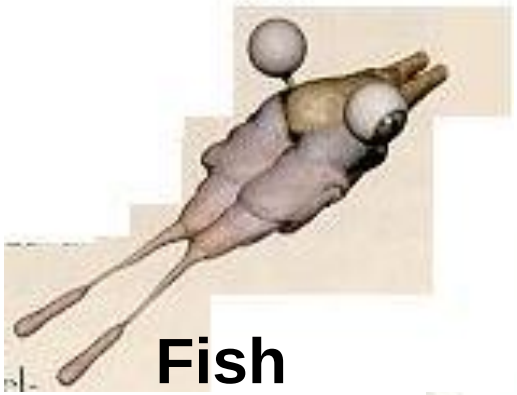
DRIVING FORCES FOR EVOLUTION? (The chicken and the egg)

KNOWLEDGE OF NATURAL HISTORY AND THE PRESUMED "NORMAL ENVIRONMENT" OF A SPECIES MAY BE NECESSARY TO INTERPRET THE EXPRESSION OF BEHAVIOR

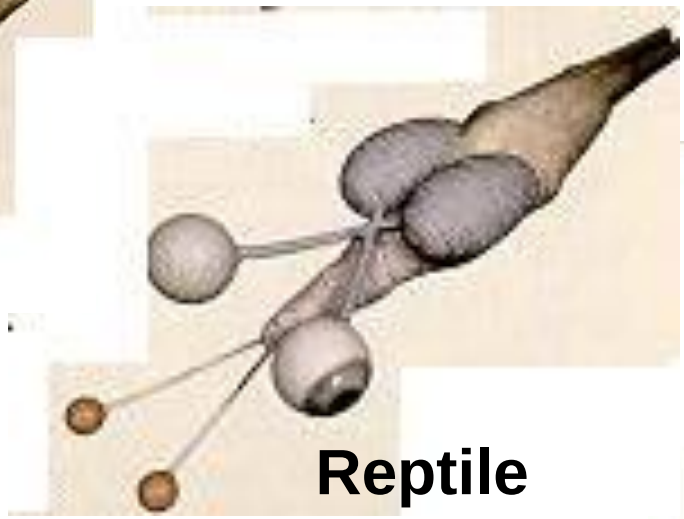
2. EVOLUTION – Search for the

ORIGINS OF SPECIES
ORIGINS OF BEHAVIORAL SYSTEMS
ORIGINS OF PROCESSES THAT REGULATE BEHAVIOR

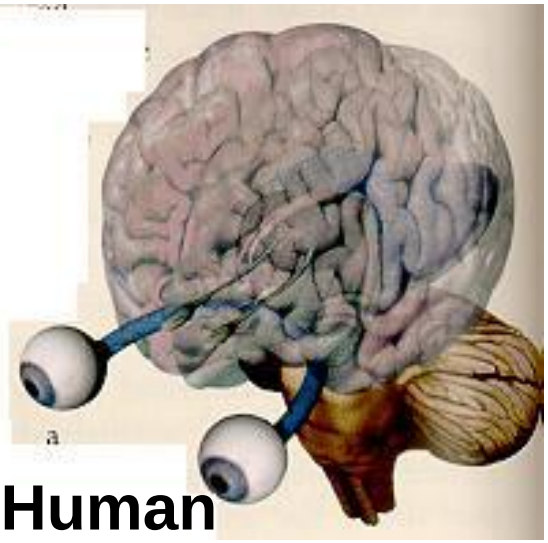
The human nervous system is a consequence of evolution, with a massive increase in the cerebral cortex



Fish



Reptile



Human

But, the old parts of the nervous system are still present, and can influence the actions of more modern components.

Much of the wiring comes UP from these more primitive brain regions, with fewer pathways that come down.

Thus, comparative approaches have much to teach us about basic processes, such as emotion.

EMPIRICALLY OR DESCRIPTIVELY BASED

Experiments of Nature have provide the substrates for behavioral variations. The first step in the experimental method is DESCRIPTION. Astute observers historically extracted themes and developed theories based on their own observations, and providing the building blocks for contemporary behavioral sciences. (Examples: Lorenz, Tinbergen, MacLean, Harlow, Bowlby, Beach)

As new technologies and methodologies have developed, variations across and within species have become increasingly useful.

INDIVIDUAL DIFFERENCES have become more apparent and dominant in our understanding of behavior.

GENOMIC AND EPIGENOMIC REVOLUTION have been esp. important to the study of INDIVIDUAL DIFFERENCES

DEVELOPMENT & the ORIGINS OF INDIVIDUAL DIFFERENCES–

EXPRESSIONS OF EVOLUTIONARY PROCESSES (phylogeny, ontology)

EARLY LIFE EXPERIENCES

CRITICAL LIFE EVENTS – birth, stress, trauma

EPIGENETIC/EXPERIENTIAL PROGRAMMING

LIFE-SPAN PERSPECTIVES and AGE-SPECIFIC APPROACHES

- Embryonic and early development (including gestation)
- Birth/hatching
- Early postnatal life
- Adolescence
- Maturity and adulthood
- Aging

SEX DIFFERENCES and REPRODUCTIVE BASED PROCESSES

- Sexual differentiation
- Puberty
- Reproductive cycles
- Maturity – including menopause

Requirements for a laboratory animal model:

1. **Accessibility**
   - Commercial vendors may have great influence
   - Cost – benefit ratios

2. **Suitability for laboratory work (including economics)**
   - Successful and rapid reproduction (short generations)
   - Size (relatively small may be preferred)
   - Simple nutritional requirements (commercial foods)
     - Ex: guinea pigs need Vit C (fresh foods)
   - Genome availability
     - Mice, rats, zebrafish, fruitflies, worms, etc
     - And prairie voles (in progress)

3. **"Normal" behaviors and physiology under laboratory conditions**

4. **Modeling human traits, questions or problems**

Shared features of mammalian species that have been selected as laboratory animals:

1. **Commensal with or co-evolving with humans**

   May eat "human food"
   Tolerate human parameters of temperature, humidity, etc
   Share selected traits with humans?
   Examples: rats, mice, cats, dogs, pigs, rhesus monkeys

2. **"Domestic species" (artificial selection):**

   FOOD (ex. Cows, pigs, goats, guinea pigs)
   PROTECTION (ex. Dogs)
   COMPANION ANIMALS (ex. Dogs)
   WORK (ex. Horses)
   RODENT CONTROL (ex. Cats)

3. **Comparability or similarities to humans:**
   HIGH SOCIALITY OR COMMUNAL LIVING
   Examples: dogs, prairie voles,
   GENETIC SIMILARITIES; NEURONAL SIMILARITIES
   Examples: primates

SOCIAL ORGANIZATION AND MATING SYSTEMS –

HIGH SOCIALITY to SOLITARY LIFESTYLES

COMMUNAL OR COOPERATIVE BREEDING to ISOLATION

Example: Taking into account social organization has been shown to have predictive power. For example, data from voles and other highly social mammals suggest that patterns of behavior and also of the use of hormones may be predicted by social systems.

The behavior of highly social mammals such as prairie voles, may rely on quickly responding NEUROPEPIDES systems, such as oxytocin and vasopressin.

Species that are less social, but more dependent on the biophysical environment, such as golden hamsters, may be more dependent on STEROID HORMONES. For example, in female golden hamsters cyclic reproductive hormones, such as estrogen and progesterone, regulate reproduction. "Asocial" species may be less reliant on social interactions and the "social peptides", and more dependent on steroids.

PROCESSES OR MECHANISMS – PERSPECTIVES

TOP DOWN vs BOTTOM UP

REDUCTIONISM vs SYSTEMS APPROACHES

DESCRIPTIONS vs EXPERIMENTATION/INTERVENTION

NEURAL SYSTEMS APPROACHES: for example,
The search for the "engram of memory or instinct"
The search for the "centers" for sexual or maternal behavior
The "social nervous system"
"Neural pathways" for specific emotions, such as rage or anger
"Genetic pathways" associated with a given behavior

INDIVIDUAL DIFFERENCES (nature vs nurture)
- **Genetics**
- **Epigenetics**
- **Experience based**

INDIVIDUAL and GENETIC DIFFERENCES

Behavioral – working backward to mechanisms

Genetic – Population, Strain, Selective Breeding

Genetic manipulations

Breeding experiments

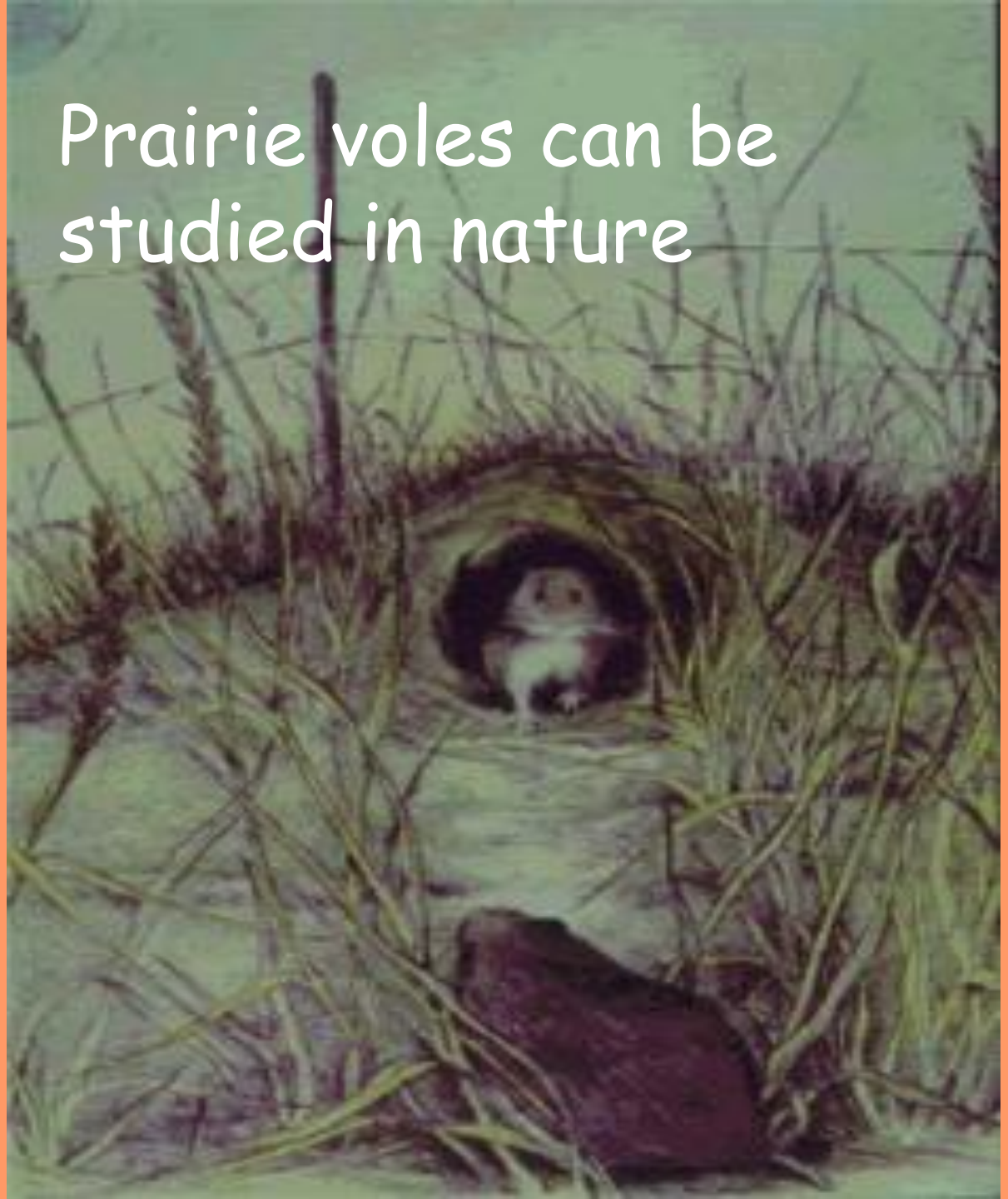
Knock-out (genetic ablation)

Conditional knock-outs and other temporary genetic lesions

Epigenetic – known or unidentified changes in response to experience.

Particularly helpful to our understanding of social behavior and the social nervous system have been SOCIALLY MONOGAMOUS RODENTS including -

PRAIRIE VOLES,
Microtus ochrogaster


Prairie voles can be
studied in nature

PRAIRIE VOLES exhibit selective, and in nature, life-long SOCIAL BONDS:

The future of animal models -

Comparative approaches grounded in ethology, ecology, evolution and development.

New perspectives and theories
New paradigms and technologies
Multidisciplinary and integrative approaches
Collaborations and recognition that no one person can do everything
A search for patterns, but
Recognition of individual differences and processes including epigenetics that allow these

And especially critical supporting -
New scientists and new energies

"Science is a wonderful thing if one does not have to earn one's living at it."

- Albert Einstein

Paraphrased on a practical note for this occasion:

"The study of animal models is a wonderful thing if one does not have earn one's living at it."

Animal models come in many forms, and may have many purposes.

Needed:
Ideas, techniques, and resources…