9.20 M.I.T. 2013

Lecture #7

More about

- Input and output sides of innate behavior
- Motivation

Special note: The "ethogram"

- Ethologists have done extensive studies of a number of species that have led to a detailed descriptive catalog of natural behavior patterns.
- These behaviors are considered to be FAPs because they are observed to be very similar in all members of a species. (They are seen even in animals reared in social isolation.)
- The ethogram contains no information on brain mechanisms.
- Example: a listing of behaviors at the end of a long descriptive study of the Syrian hamster by Fritz Dieterlen. (~135 distinct behavior patterns described)

Examples on web:
http://newguinea-singing-dog-conservation.org/Tidbits/Ethogram0405.pdf
http://www.ag.purdue.edu/ansc/mousebehavior/Wiki%20Pages/Species%20Ethogram.aspx

Ethograms

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Google Scholar searches: “Ethogram”

Homework #2, due Monday September 23 (by Noon):

Do Google Scholar searches for "ethogram," for any date, for articles since 2009, for articles from 2012. Find an article that interests you. Write a one-page description, giving the website, the animal's name (scientific and popular), a brief description of the ethogram (which may by partial or comprehensive). In a final paragraph, describe what you find most interesting about this animal.

Scott ch 3: **Motivation**

1. Define the term "homeostasis".
   - What are some quantities that the mammalian body maintains in homeostasis?
   - What is the role of behavior in accomplishing this?

   Give examples of automatic physiological mechanisms and behavior involved in maintaining homeostasis of a specific parameter.

"Homeostasis" = same or similar state

Maintenance of specific parameters within a certain range

Examples

- Temperature
  - Endothermic *vs* ectothermic control: different roles of behavior
  - Mammals & birds are endothermic; others are ectothermic (poikilothermic).
- Water balance
- Blood glucose
- Blood electrolytes (e.g., sodium, potassium, calcium)
- Body weight

➢ These parameters are each regulated by the autonomic nervous system (ANS)

➢ Behavior is also important in the regulation.

➢ For both behavior and the ANS, the hypothalamus of the caudal part of the forebrain—the diencephalon—is a major regulator.

Scott ch 3: Motivation

2. When an animal feels thirst, what does it do if there is no water nearby?

Scott ch 3: Motivation

2. When an animal feels thirst, what does it do if there is no water nearby?

   A good answer requires you to contrast **appetitive** and **consummatory** behaviors.

   These two kinds of behavior are critical for every Fixed Action Pattern.

Scott ch 3: Motivation

3. What changes in the brain cause thirst motivation?

   Why do you feel thirsty?

   If you have not had water for a long time, knowledge of this fact does not make you feel thirst. Something in your CNS causes the feeling of thirst.

Scott ch 3: Motivation

- Scott p 44: mentions osmoreceptors in hypothalamus. Their activity causes "**hypo-osmotic thirst**".
- There is also "**hypovolemic thirst**" detected by indicators of reduced blood volume:
  - Arterial, high-pressure baroreceptors
  - Venous, low-pressure baroreceptors –the most important.
- Species variations:
  - Adaptations to environmental extremes, e.g., in desert-living animals
  - Variations in drinking behavior across species

Scott ch 3: Motivation

4. Hunger intensity can be estimated behaviorally by the duration of food deprivation. The text mentions another possible measure, in terms of levels of certain hormones. From the text description, could these levels be an adequate explanation of hunger? Why or why not?

Correlates of hunger

- Two hormones: leptin and ghrelin, are found in humans and other mammals.
- **Leptin** is released by adipocytes, and can indicate the level of stored energy in fat. High levels suppress appetite (by influences on hypothalamus).
- Low levels of leptin cause stomach to secrete **ghrelin**, which stimulates appetite by action on hypothalamus.
- Explanation of hunger motivation?

Lasker Award, 2010: Jeffrey M. Friedman, M.D., has been awarded the prestigious Albert Lasker Award for Basic Medical Research. Dr. Friedman is head of the Laboratory of Molecular Genetics at Rockefeller University and a Howard Hughes Medical Institute Investigator.
Dr. Friedman shares the award with Douglas L. Coleman, emeritus scientist at The Jackson Laboratory, **for the pair's discovery of leptin**, a hormone that regulates food intake and body weight.

Does this explain hunger motivation?

- It is a means of long-term regulation, but the levels do not change rapidly enough to explain many aspects of feeding behavior.
- There are also various short-term regulators, *e.g.*, of meal size and timing.
  - Signals from throat, stomach and intestines reach the brain *via* the glossopharyngeal and vagus nerves (cranial nerves 9 and 10)
  - Experimental studies of the role of these signals in feeding behavior
    - Esophagus fistula: Food does not reach stomach but the animal still eats meals of a limited size.
    - Subdiaphragmatic vagotomy in rats made hyperphagic by lesions of the ventromedial hypothalamic nucleus can abolish the overeating (at least when the rats are fed on lab chow).

Research on leptin *(from HHMI 2003)*

- Many hoped that simple injections would control obesity, but this worked, to some degree at least, in only 15-20% of obese humans. Amgen gave up on it.
- However, it proved to be useful in treating rarer diseases:
  - Administration to very obese children who constantly crave food, and have a defective leptin gene: They respond dramatically, and become much more normal.
  - Effective in treating the insulin resistance that occurs in some type 2 diabetics.
- One speculation: The many, seemingly unrelated effects of leptin… may have evolved to provide a "link between the nutritional state and the physiology and behavior of an animal," enabling it to adapt to starvation.

- Thus, even though leptin did not live up to initial expectations that it would cure obesity, it has since proved to be an invaluable research and therapeutic tool. Peter J. Havel, a nutrition researcher at the University of California, Davis, says that by "demonstrating that body weight is a physiological parameter regulated by hormones, leptin opened up the whole field of obesity research." Leptin experiments, O'Rahilly adds, have debunked the notion that obesity results from people's "immorality, behavior and gluttony."
- There is a recently updated article on leptin in Wikipedia (2011)
- Recent scholarly review of research:
  - Berthoud H, Lenard NR, Shin AC (2011) Food reward, hyperphagia, and obesity**.** *Am J Physiol Regul Integr Comp Physiol 300: R1266-R1277. First published 16 March 2011;*

Note on addictions involving eating behavior:

Journal of Nutrition (2009), Vol. 139, No. 3, 629-632

Homeostatic and Hedonic Signals Interact in the Regulation of Food Intake[1–3,]

Michael Lutter[*] and Eric J. Nestler[4]

Department of Psychiatry, The University of Texas Southwestern Medical Center, Dallas, TX 75390

How the rewards of pleasure following ingestion could lead to the abnormalities of addiction.

Specific hungers: Sodium

- Do salt-deficient animals or humans acquire a specific hunger for sodium?
  - Early research resulted in some controversy: Some data indicated that hunger did change in sodium deficient rats, but the change was that they sought greater novelty in food intake. Their natural phobia for novel foods decreased.
  - However, many experiments have indicated that hunger for salt can be more specific, in humans as well as in animals.

Specific hungers: more findings

- Prenatal environment can influence postnatal food preferences:

Stylianos Nicolaïdis (2008)Prenatal imprinting of postnatal specific appetites and feeding behavior. *Metabolism, Clinical and Experimental,* 57 (Suppl 2) S22–S26.

  - Sodium preferences are greater in offspring of mothers who experienced vomiting during pregnancy
  - Alcohol consumption in pregnancy increases palatability of alcohol in offspring
  - "Both maternal under- and overnutrition during pregnancy predispose the offspring to later development of obesity and type 2 diabetes mellitus."

Scott ch 3: Motivation

5. Give examples of non-homeostatic motivations. Name several.

   These motivational states underlie cyclic and episodic behavior patterns.

Cyclic and **Episodic** Behavior:

- Cyclic behaviors/ motivational states:
  - Feeding *(We eat on a schedule even if we don't need to eat)*
  - Drinking
  - Sleeping, waking
  - Eliminating
  - Behaviors associated with feeding
    - Hoarding
    - Gnawing
    - Poking
    - *Et cetera*
  - *Others*
  - There are large variations among different species.

Cyclic and **Episodic** Behavior:

- Episodic behaviors/motivational states:
  - Agonistic:
    - Fight
    - Flee
    - Defend
  - Sexual: mating [both episodic and cyclic components]
  - Parental
  - Nesting
  - Digging, tunneling
  - *Etc.*

Scott ch 3: **Biological rhythms**

6. Define “circadian rhythm”, “infradian rhythm”, and “ultradian rhythm”. Give an example of each.

Scott ch 3: Biological rhythms

7. What is the role of endogenous and exogenous signals in control of the activity rhythm of a mammal, *e.g.*, a mouse?
8. What is a “free running rhythm”?
9. Describe the location of the “biological clock” in mammals, such as in the highly studied mouse, hamster or rat.

Proof of the endogenous nature of the body's clock mechanism: Behavioral studies

- "Free-running" rhythms of activity:
  - Hamsters with continuous monitoring of activity
    - Next two slides
  - Humans in underground bunkers

How Activity Rhythms are Measured

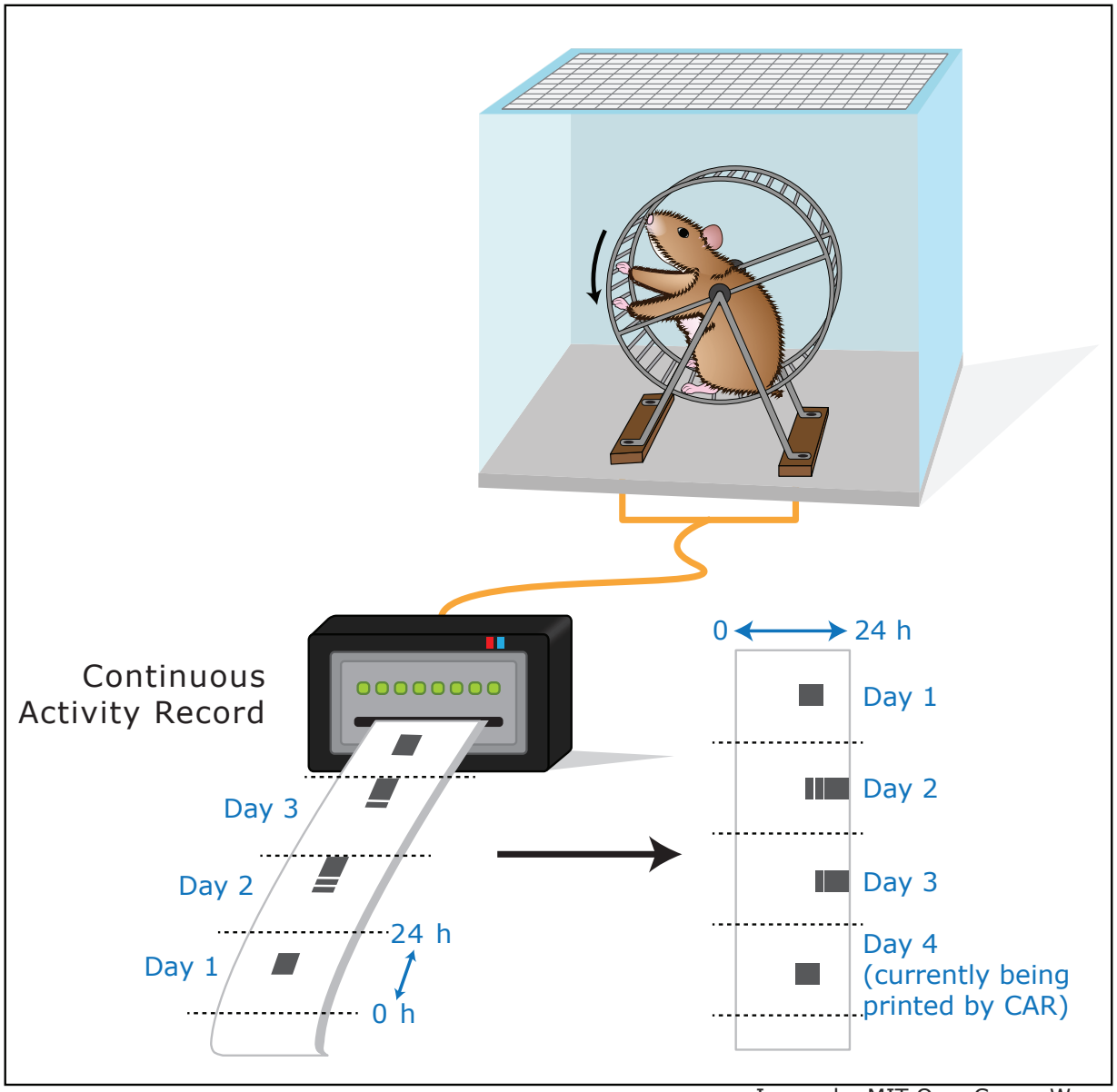

Image by MIT OpenCourseWare.

Activity Rhythms Measurement

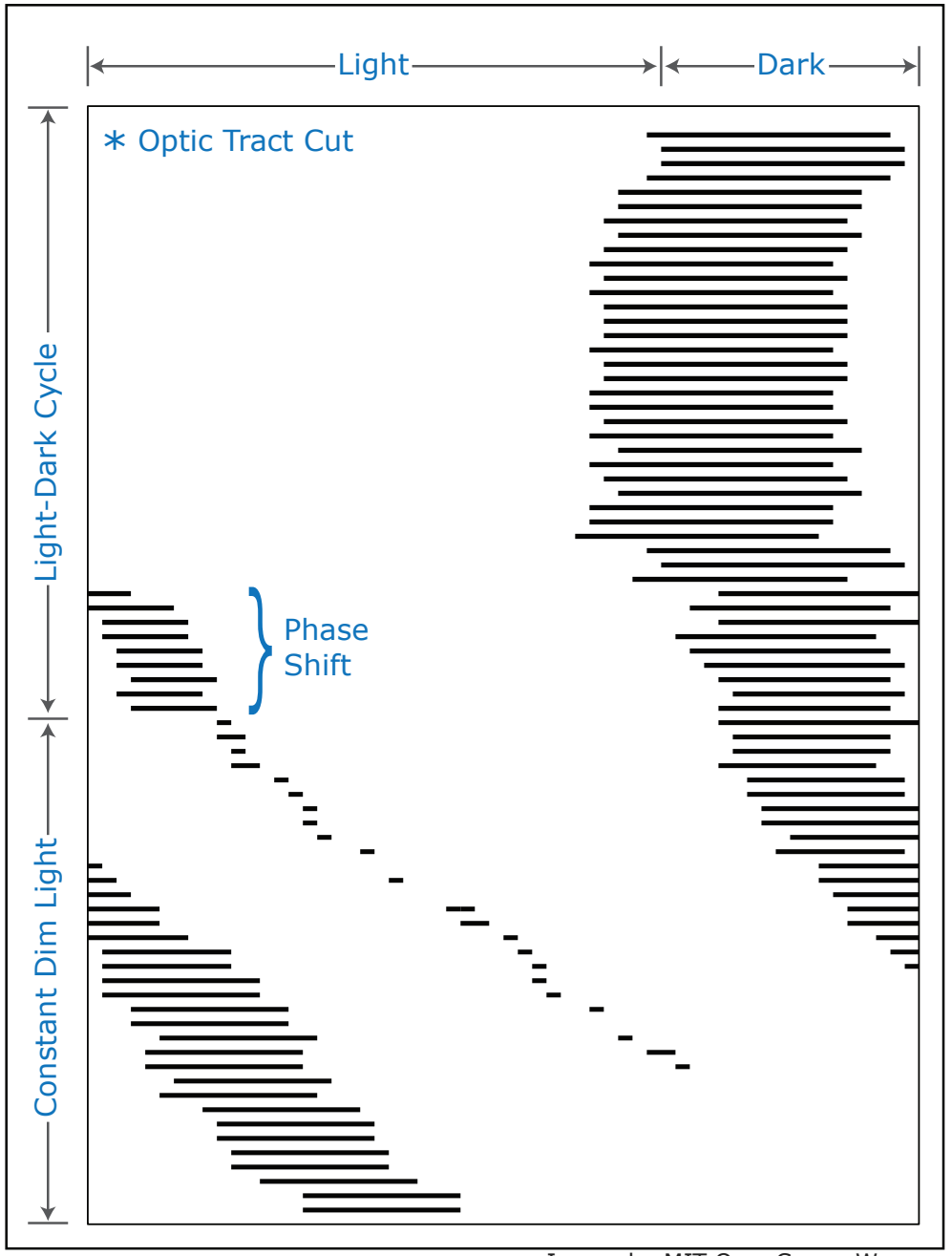

Image by MIT OpenCourseWare.

Proof of endogenous clock mechanism: brain-behavior studies

Search for the biological clock that can be entrained by the light-dark cycle:

- Ablation studies of optic-tract terminal areas: persistence of the circadian rhythm
- Discovery of retinal projection to hypothalamus: the Suprachiasmatic Nucleus (SCN)
- Without retina to SCN: a free-running circadian rhythm
- SCN cells: endogenous generation of circadian rhythms
  - There is good evidence for other biological clocks as well:
  - E.g., the daily feeding rhythm can be at least partially independent of the locomotor activity rhythm in animal studies.

Inheritance of the endogenous clock

- Dependent on the PER (period) gene
- The CLK (clock) gene also plays important roles

Adult optic tract (Hamster)

View of right side of brainstem, hemispheres removed

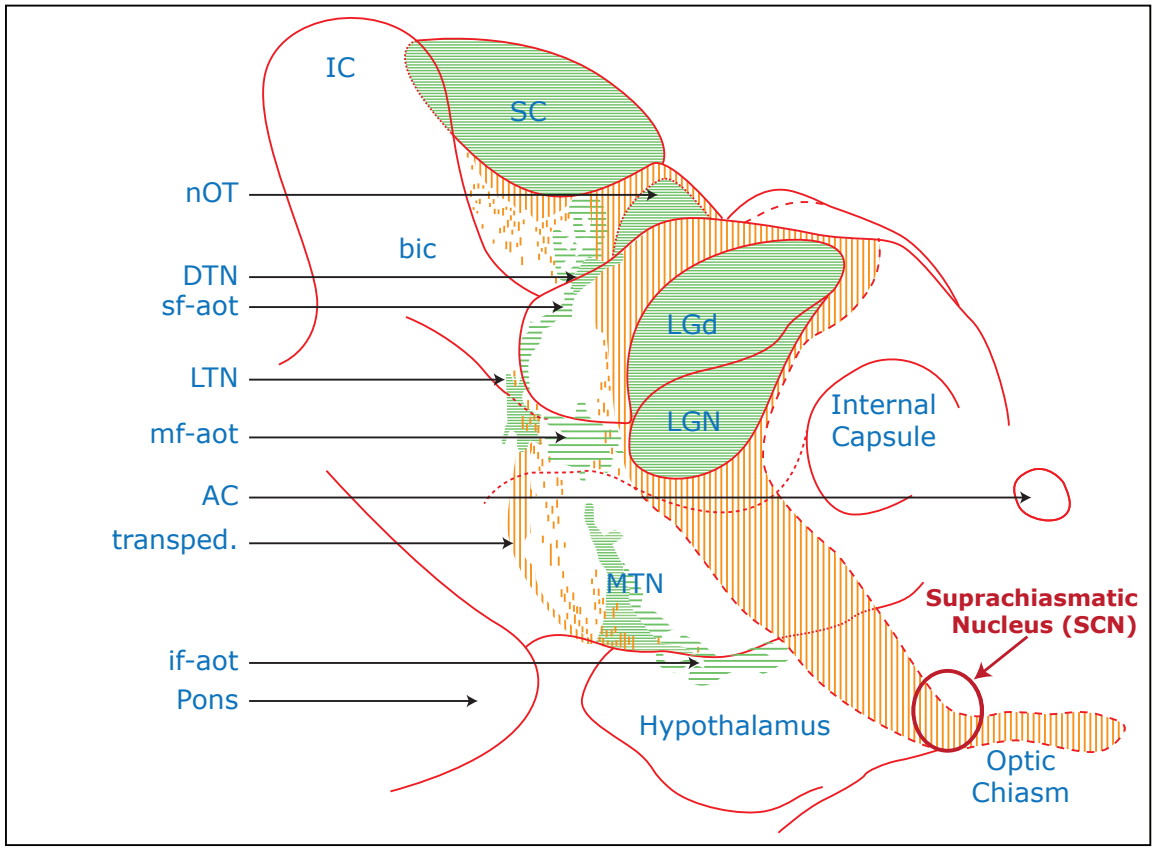

Image by MIT OpenCourseWare.

Reconstruction from serial, frontal sections. Retinal projections were marked by degeneration. Nauta method.

A. Suprachiasmatic nucleus (SCN) in the rat, Nissl stained coronal section of hypothal-amus at the level of the optic chiasm (OC).

B. Terminations of retino-hypothalamic tract (darkly stained): a bilateral projections

Images removed due to copyright restrictions.

C. Vasoactive intestinal peptide-containing neurons in ventro-lateral SCN.

D. Vasopressin-containing neurons in dorsomedial SCN.

R. Moore,
in Zigmond et al., 1999

Photos and chart of labeled axons from retina of one eye

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9.20 Animal Behavior
Fall 2013