BIOLOGICAL RHYTHMS AND SLEEP
Time

• Do animals have a sense of time?
High-frequency rhythms

- Less than 30 minutes

- Examples include heart and respiration rates
Ultradian Rhythms

• More frequent than 24 hours

• Examples include growth hormone output from pituitary (~every 3.5 hours) and body temperature in cats (~every hour).

From: Resistance exercise: acute and chronic changes in growth hormone concentrations. In: The endocrine system in sports and exercise.
Circadian Rhythms

• Self-sustaining cycle of approximately 24 hours.

• Zeitgebers—temperature, barometric pressure, drugs, hormones, pineal gland and light

• Disruption of circadian rhythms leads to memory deficits

**Pineal Gland**

- Demonstrates rhythms of output of several hormones and neurotransmitters

- Melatonin-produced by pineal gland and present in higher quantities at night.
Circadian Rhythm Examples
Other rhythms

- Feeding and Drinking
- Infradian Rhythms (< 24 h)
- Circatrigintan rhythms (~ 30 d)
- Sexual cycles (ex., 21 d)
Examples of annual cycles

- Horse and sheep are seasonal breeders.
- Dogs have sexual cycles every 6 months.
- Cats show cycles for GCs, thyroxine, and Epi.
- Ewes vary heart rate by season.
- Horses show seasonal rhythms in carbohydrate metabolism.
Sleep

- ¼ of life for ruminants
- ½ of life for dogs
- Function unknown?
Types of Sleep

- **Awake**: Low voltage, high frequency
- **Stage 1**: Low voltage, mixed frequency
- **Stage 2**: Sleep spindles & K complexes
- **Stage 3**: Mostly slow waves
- **Stage 4**: Slow waves

REM: Low voltage, mixed frequency + rapid eye movement & muscle atonia

*Source: Rechtschaffen & Kales, 1968, Kalat, 2005, Weiten 2004*
Cat EEG

Awake - alert
LO-RO
LF-RF

Awake - drowsy
LO-RO
LF-RF

Light slow wave sleep
LO-RO
LF-RF

Deep slow wave sleep
LO-RO
LF-RF

REM sleep
LO-RO
LF-RF

10 sec
50 μV
1 sec
Human EEG
Dog EEG (a=awake. b,c=SWS)

Bird EEG

Representative samples of EEG activity. (a) EEG-amplitude progressively increases from (i) alert wakefulness to (ii) drowsiness and sleep due to an increase in low-frequency high-amplitude brain activity (slow-wave or Δ-activity). Episodes of unilateral eye closure are accompanied by interhemispheric EEG asymmetries. (b) Closure of the (ii) left eye with sleep-like EEG activity in the contralateral right brain hemisphere (EEG R). (c) Closure of the (i) right eye with increased slow-wave activity in the left hemisphere.
Patterns of sleep in animals

How Many Hours of Sleep on Average Different Species of Mammals Require?

- Little brown bat: 19 hours
- Giant armadillo: 18 hours
- Lion: 13 hours
- Cat: 12 hours
- House mouse: 11 hours
- Dog: 10 hours
- Red fox: 9 hours
- Chimpanzee: 8 hours
- Rabbit: 7 hours
- Human: 6 hours
- Cow: 4 hours
- Horse: 3 hours

(hours of Sleep Require)
Dogs

- Posture
Cats

- General Activity
  - Although active at night cats are not nocturnal

- Sleep

- Elimination
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<th>Species and time period</th>
<th>Duration and Percentage</th>
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<td>Wakefulness (AW)</td>
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<td>Horse 24-h period</td>
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<td>Horse Nighttime (10 h)</td>
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<td>Cow 24-h period</td>
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<td>Cow Nighttime (12 h)</td>
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<td>Sheep 24-h period</td>
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<td>Pig 24-h period</td>
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<tr>
<td>Pig Nighttime (12 h)</td>
<td>4 h 23 min 36.5%</td>
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Source: 1653
Pigs

• Activity
  • Optimal Foraging—gaining the most from a food source while minimizing the cost.
  • Increased hunger leads to more time rooting and more time lying down.

• Elimination
Pigs

- **Sleep**
  - Spend more time resting than any other domestic animal.
  - 19 hours per day.
  - Drowse 5 hours per day.
Horses

• SWS vs. REM sleep

• Posture
Horses

• Activity
  • Horses are awake 88% of the time and is alert most of this time.

  • Main activity is feeding, grazing varies from 50% to 80% of every 24 hour interval.

  • Traveling depends on availability of nutrients and horse’s social status.

  • Standing occurs when there is no feeding, usually when a horse is satiated.
Cattle

• Alternating periods of eating and ruminating interspersed with resting or loafing and short periods of sleep.

• Activity
  • Diurnal (day active)
  • Found either grazing, ruminating, and resting.
  • Cattle lie down to sleep, ruminate, or to drowse.
  • Lying occupies nearly half the cow’s day (13 hours in loose housing).
Cattle

- Grazing

- Distance Traveled
  - ~0.19-5.6 miles a day

- Elimination

- Sleep
  - Rem and SWS
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Clinical Problems

- Hyperactivity

- **Narcolepsy**
  
  Narcolepsy - chronic neurological disorder involving the loss of the brain's ability to regulate sleep-wake cycles normally.

- Nocturnal Wakefulness
Glossary of Terms

- **Suprachiasmatic nucleus (SCN)** - a tiny region located in the hypothalamus, situated directly above the optic chiasm. It is responsible for controlling circadian rhythms.
- **High-frequency rhythms** - rhythms lasting less than 30 minutes.
- **Ultradian rhythms** - rhythms lasting more frequent than 24 hours.
- **Circadian rhythms** - rhythms lasting approximately 24 hours.
- **Infradian rhythms** - rhythms lasting less frequent than 24 hours.
- **Circatrigintan rhythms** - rhythms lasting 30 days.
• **Zeitgebers** - events that keep circadian rhythms regulated.
• **Slow wave sleep (SWS)** - deep sleep, stage three of non-rapid eye movement sleep. EEG activity is synchronized, producing slow waves with a frequency of less than 1 Hz and a relatively high amplitude.
• **Rapid Eye Movement sleep** - a stage of sleep characterized by the rapid and random movement of the eyes.
• **Optimal Foraging** - a model that helps predict how an animal behaves when it's searching for food. The animal wants to gain the most energy for the lowest cost during foraging, so that it can maximize its fitness.
• **Nocturnal** - active during the night
• **Diurnal** - active during the day
• **Ad libitum**-free feeding; meal-feeding tends to synchronize other behaviors

• Having a defined photoperiod entrains other behaviors

• Behavioral management can be used to entrain animals to change behaviors and impact animal welfare, environmental risks, and farm economics
Nocturnal, Diurnal, Crepuscular daily activity patterns

- Nocturnal vs. diurnal
- Crepuscular:
  
  “Because of the timing of these grazing events, ruminants seem to be crepuscular animals, and light provides an environmental cue as to when to seek food. Certainly, the preference for twilight grazing plays a role in shaping the daily grazing pattern…” Gregorini et al., 2006. PAS 22:201-209.
Field application of behavioral management: Feeding confined cattle according in a crepuscular pattern reduced dust generation in feedlots.