

BIOLOGICAL RHYTHMS AND SLEEP



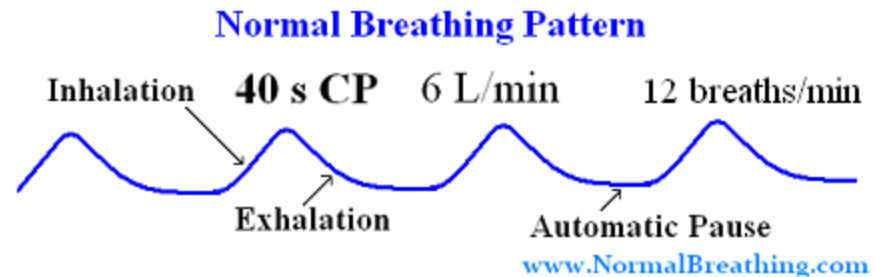
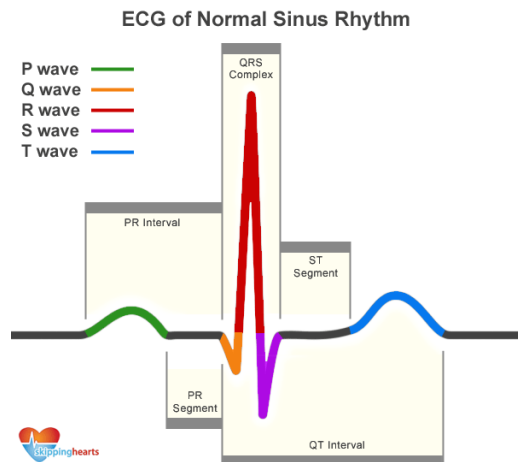
Time

- Do animals have a sense of time?



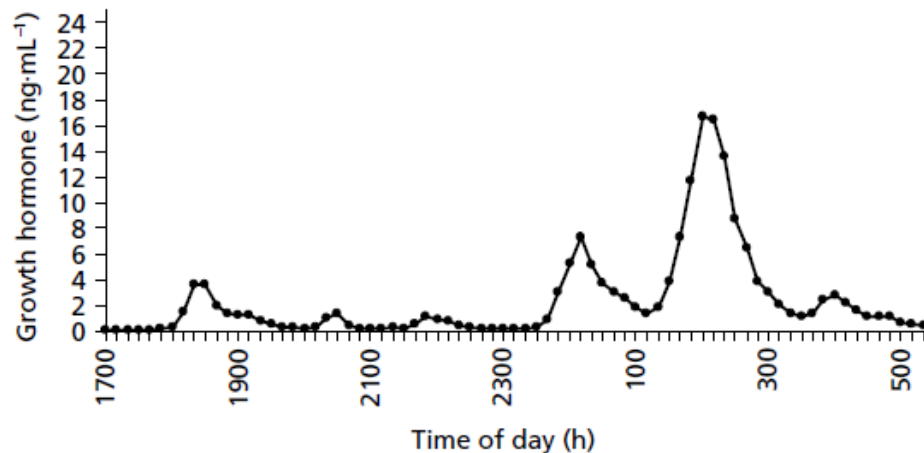
High-frequency rhythms

- 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).

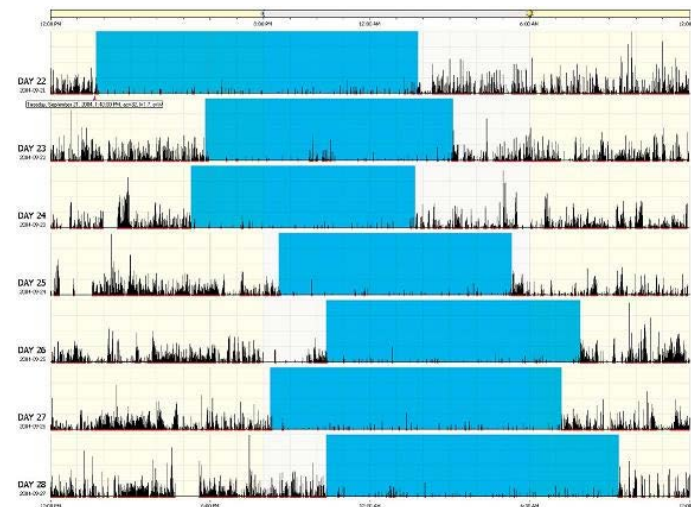
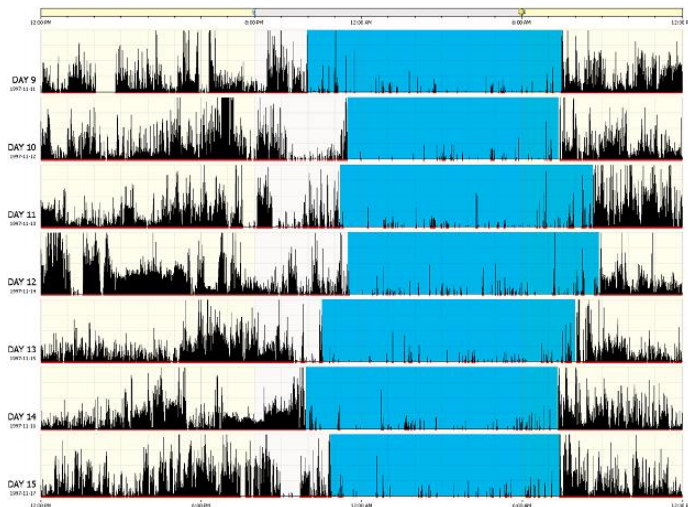


From: Resistance exercise: acute and chronic changes in growth hormone concentrations.
In: The endocrine system in sports and exercise.



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

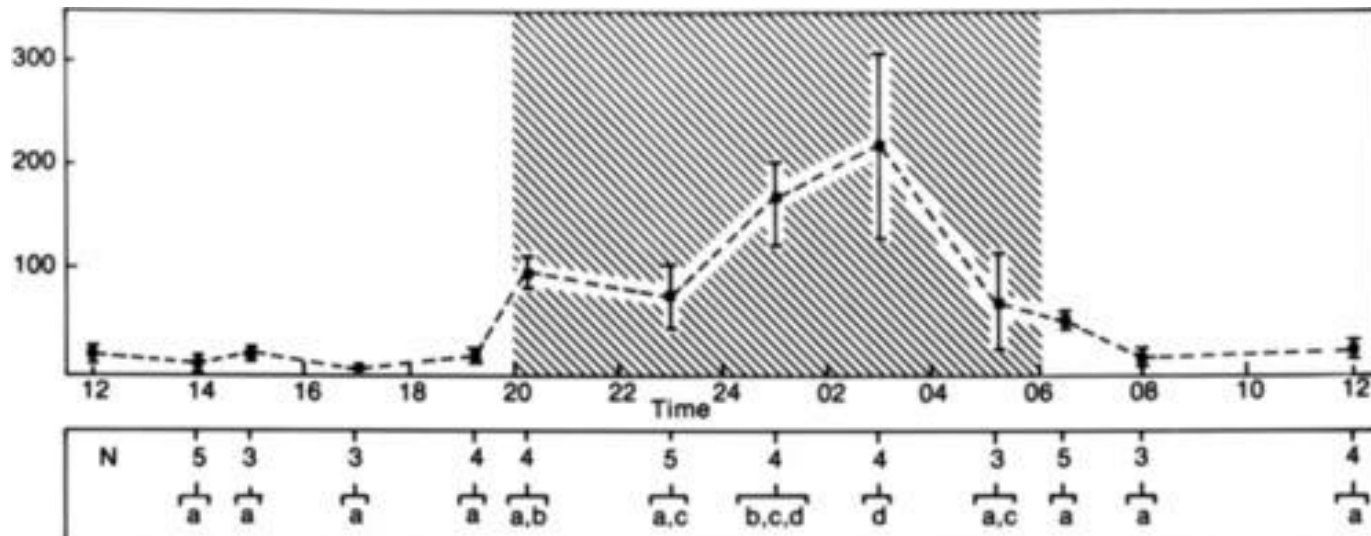


From: <http://www.bmedical.com.au/shop/sleep-diagnostics/actigraphy-products.htm>

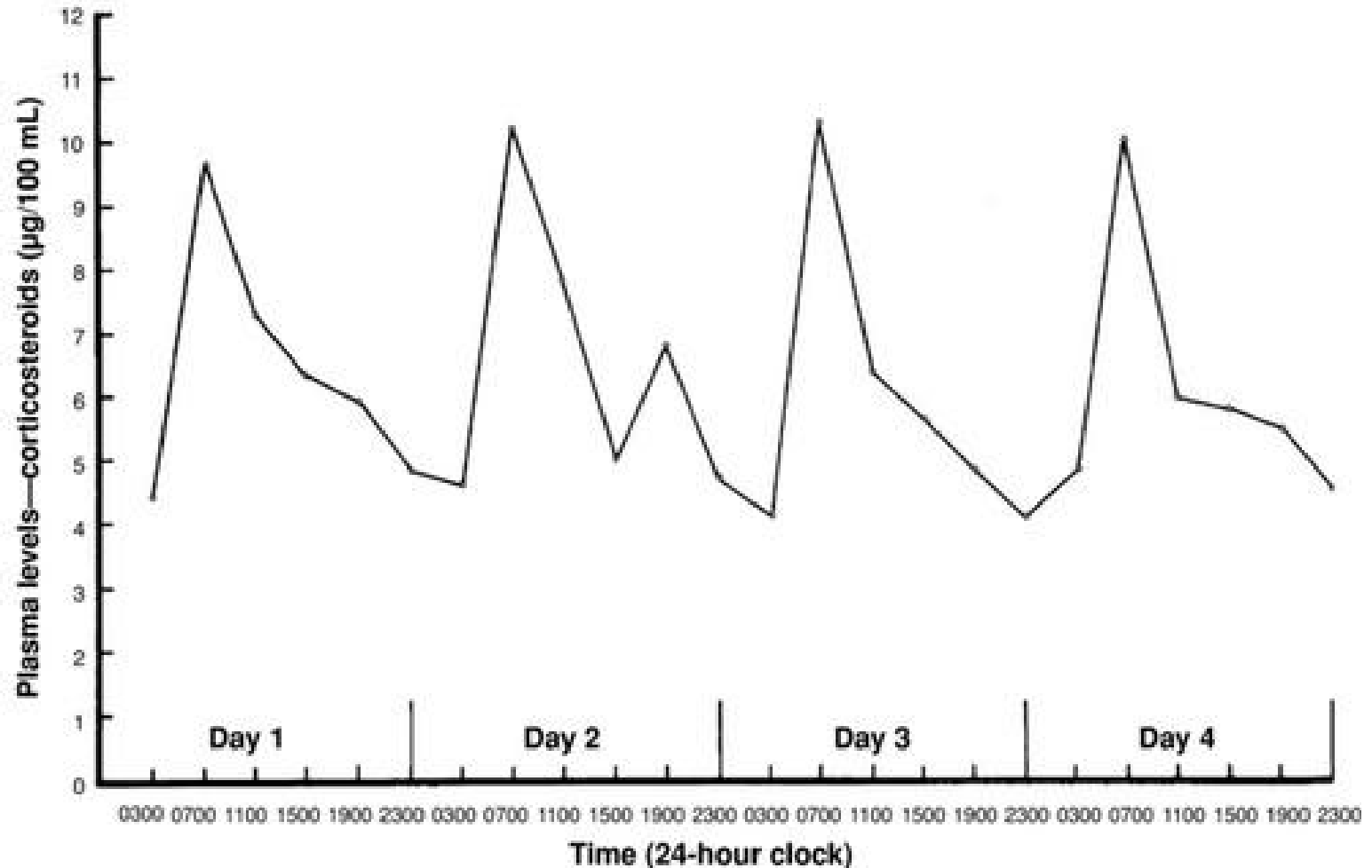


Pineal Gland

- Demonstrates rhythms of output of several hormones and neurotransmitters
- Melatonin-produced by pineal gland and present in higher quantities at night.

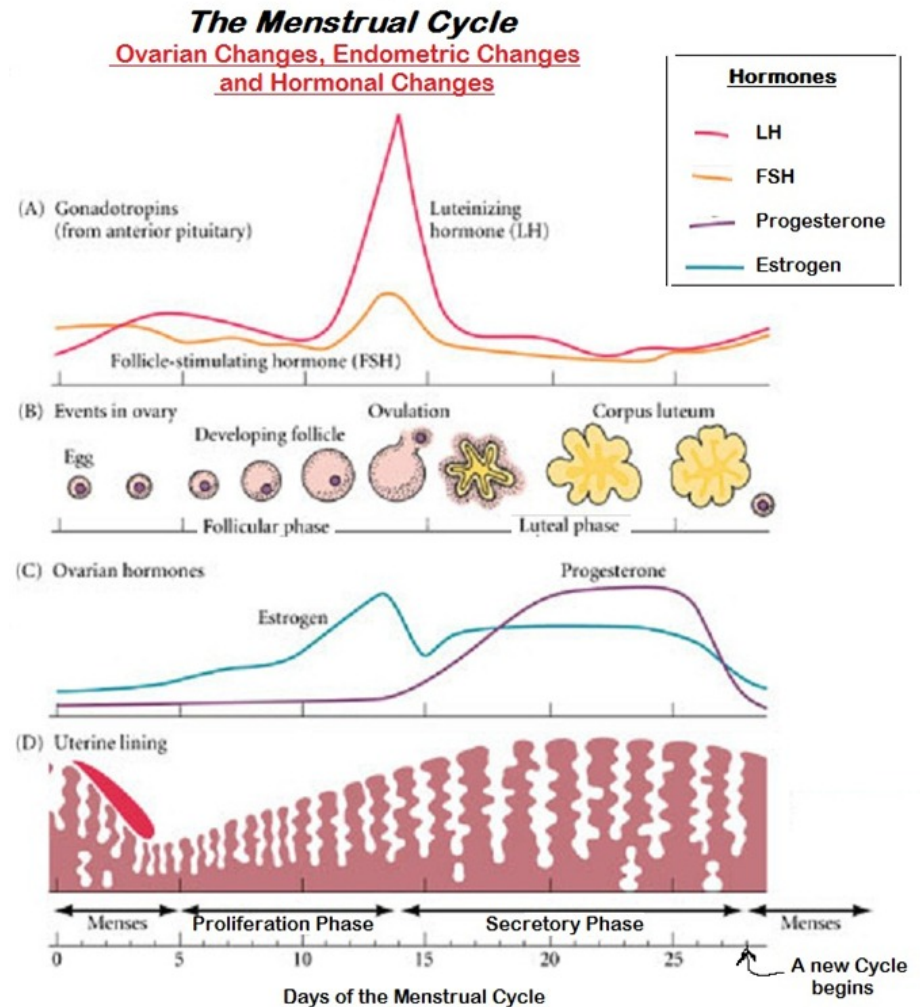


Circadian Rhythm Examples



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.

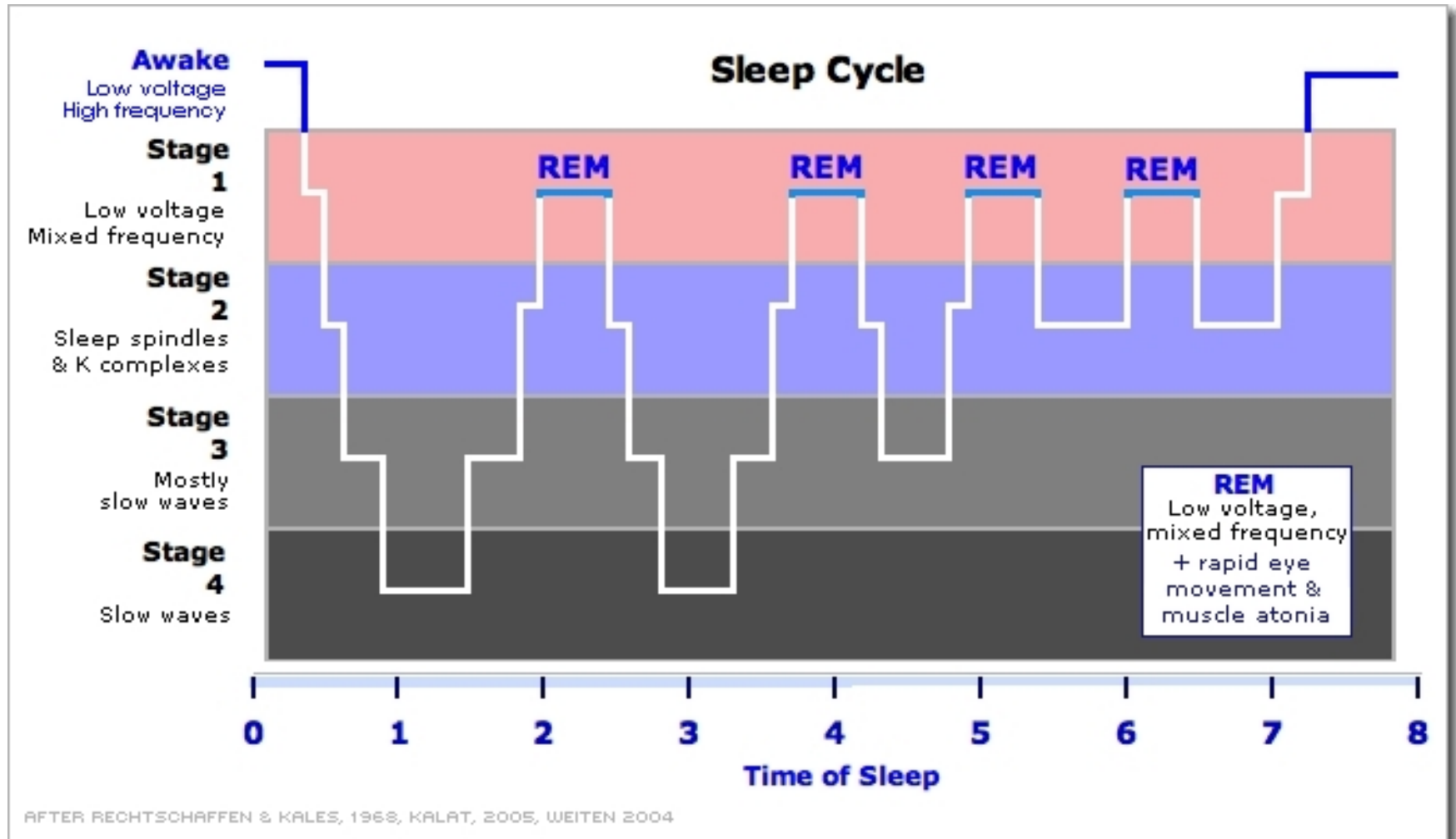


Sleep

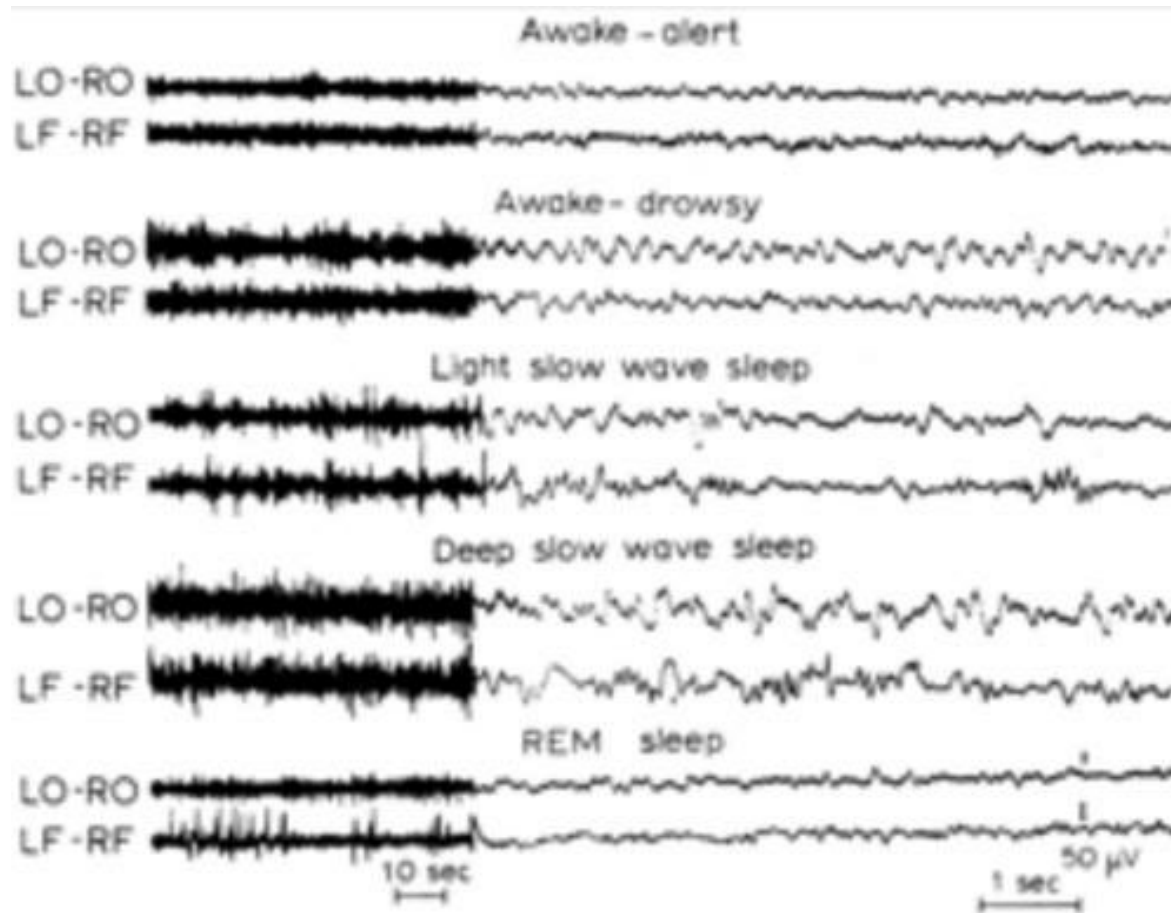
- $\frac{1}{4}$ of life for ruminants
- $\frac{1}{2}$ of life for dogs
- Function unknown?



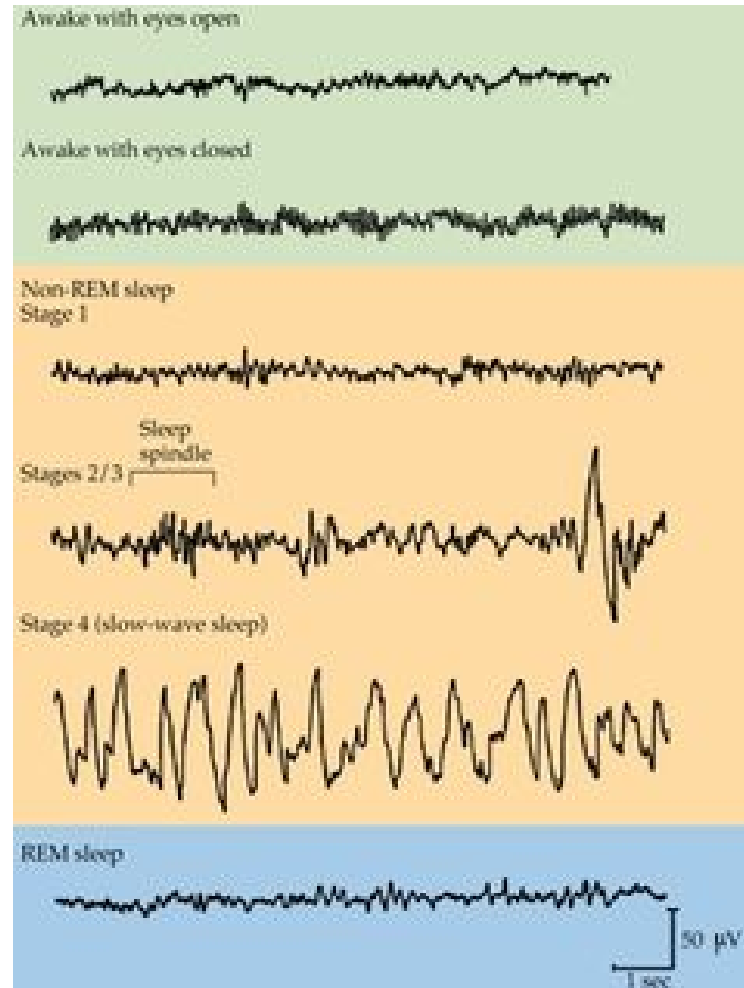
Types of Sleep



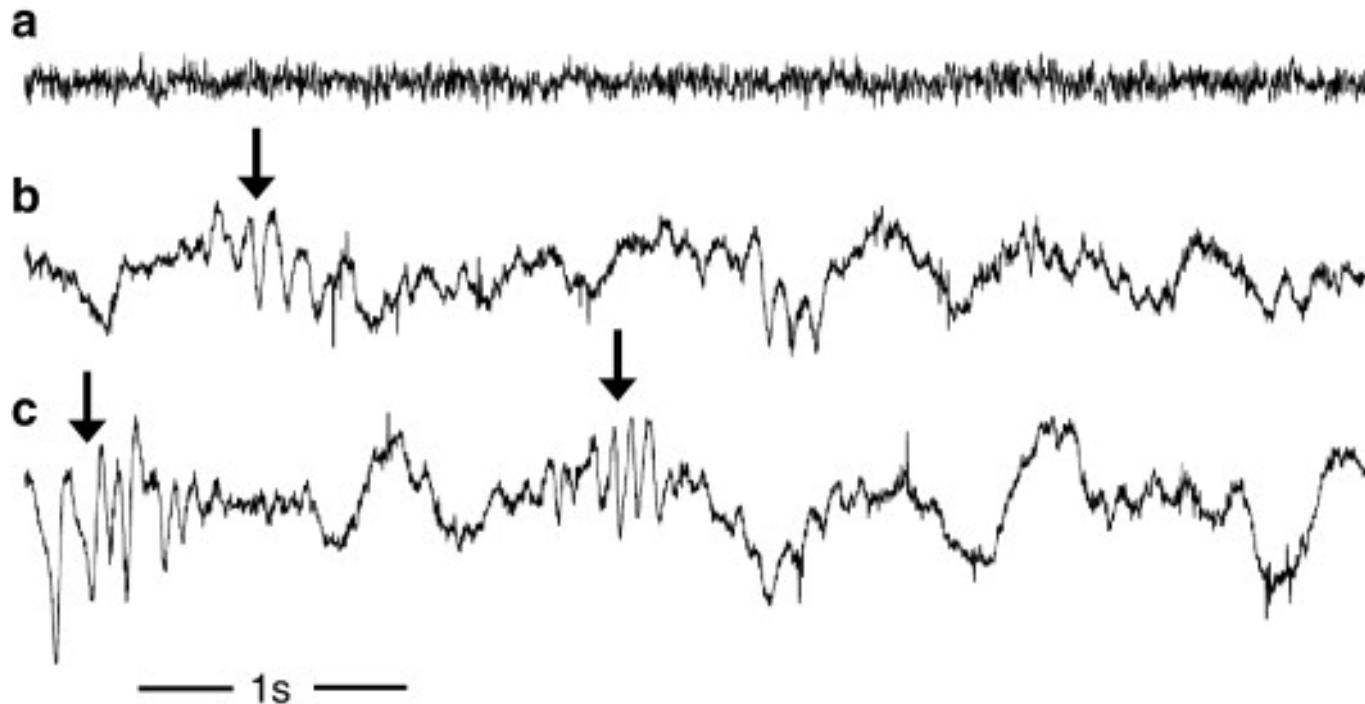
Cat EEG



Human EEG



Dog EEG (a=awake. b,c=SWS)

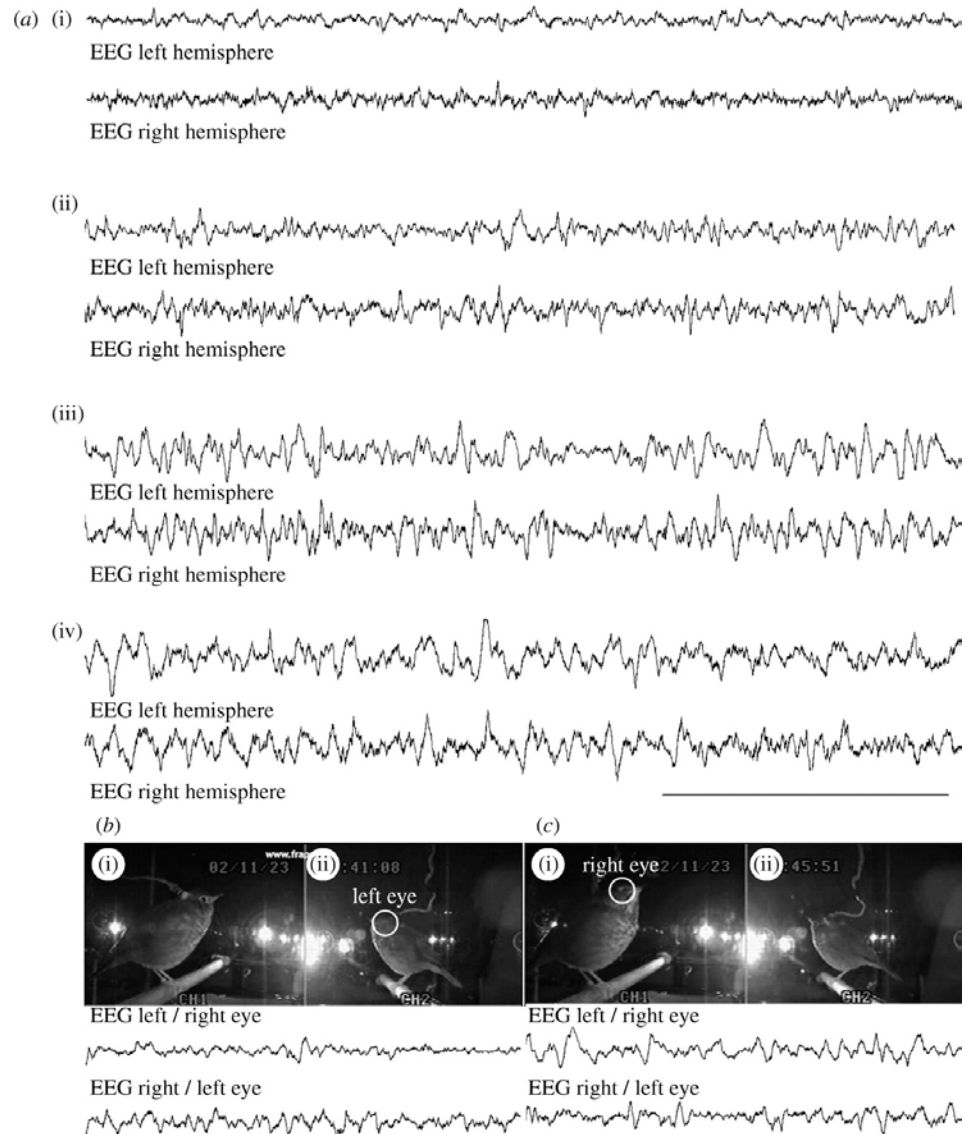


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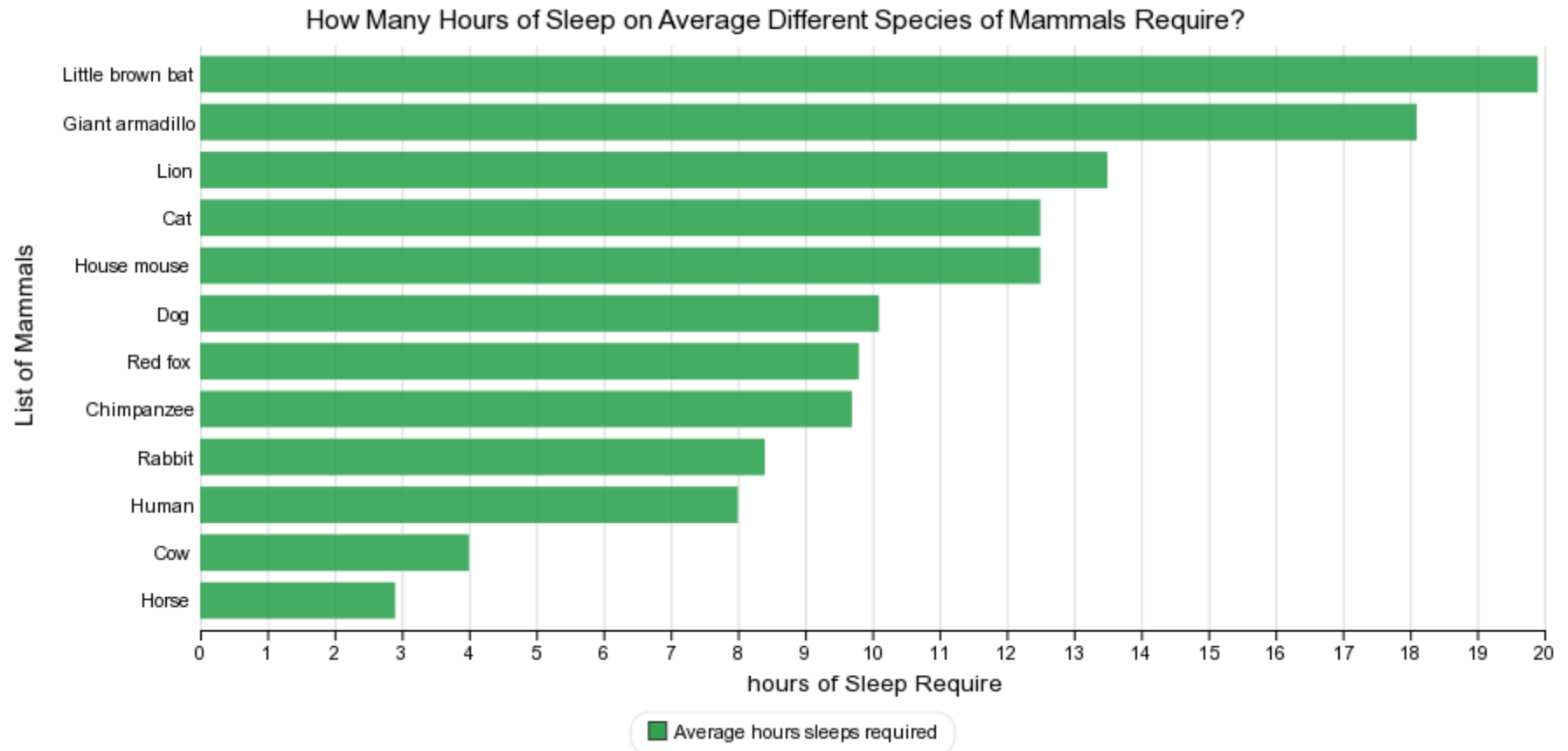


Bird EEG

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.

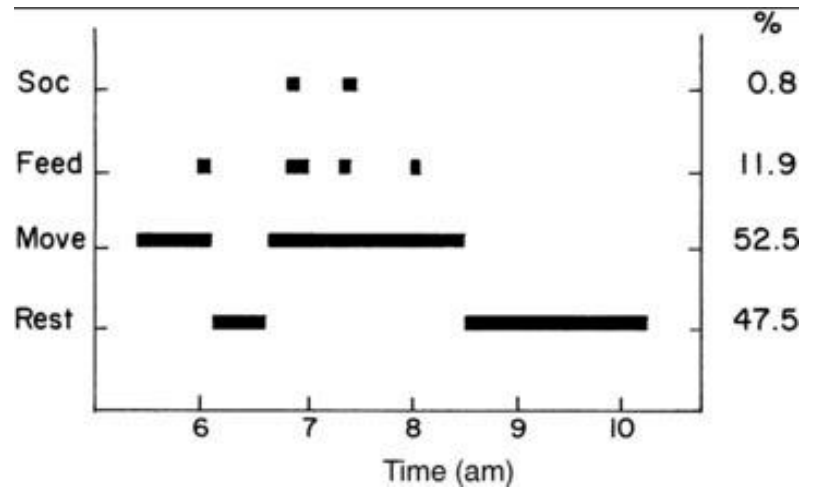
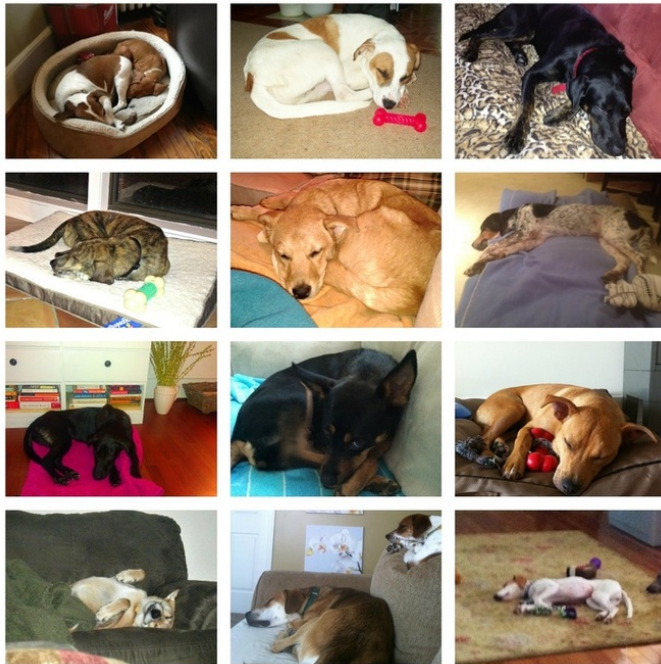


Patterns of sleep in animals



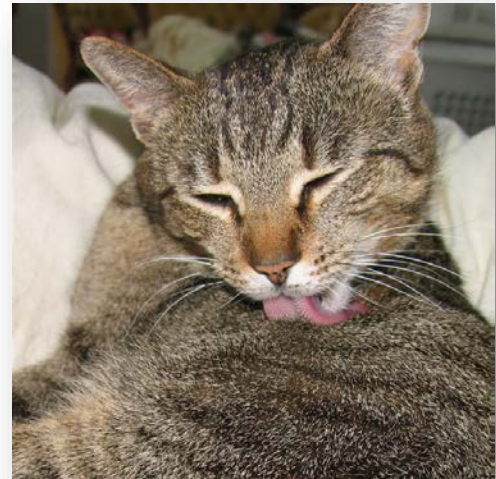
Dogs

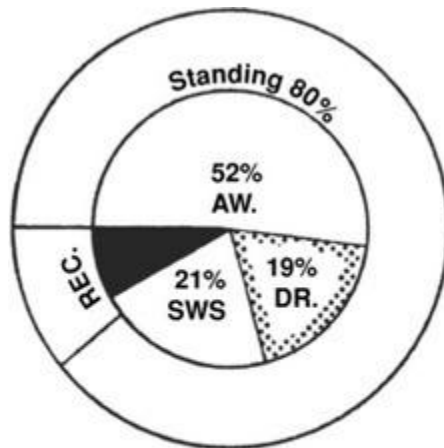
- Posture



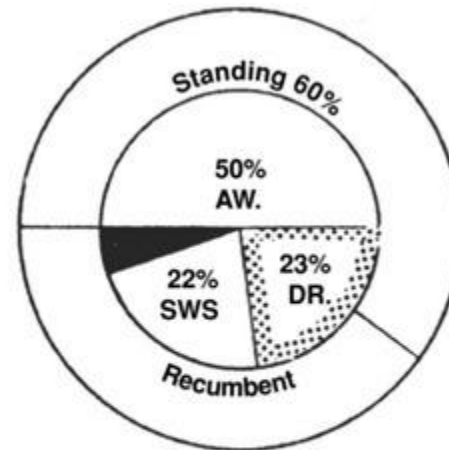
Cats

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

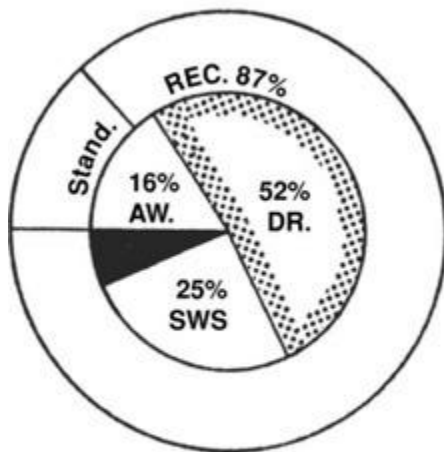




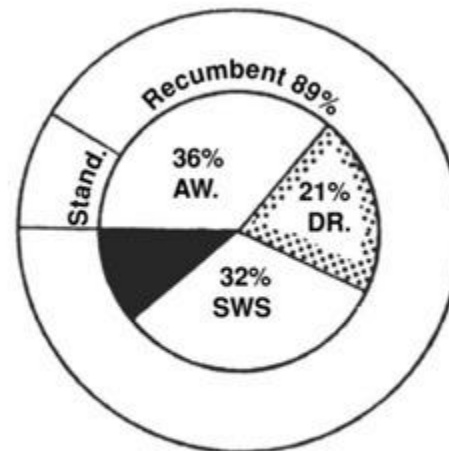
Horse



Sheep



Cow



Pig

(B)



Species and time period	Duration and Percentage					
	Wakefulness		Sleep		Attitude	
	AW	DR	SWS	PS	Standing	Recumbent
Horse						
24-h period	19 h 13 min 80.8%	1 h 55 min 8.0%	2 h 05 min 8.7%	47 min 3.3%	22 h 01 min 91.8%	1 h 59 min 8.2%
Nighttime (10 h)	5 h 14 min 52.4%	1 h 54 min 19.0%	2 h 05 min 20.8%	47 min 7.8%	8 h 01 min 80.1%	1 h 59 min 19.9%
Cow						
24-h period	12 h 33 min 52.3%	7 h 29 min 31.2%	3 h 13 min 13.3%	45 min 3.1%	9 h 50 min 40.9%	14 h 10 min 59.1%
Nighttime (12 h)	1 h 55 min 16.0%	6 h 14 min 51.9%	3 h 06 min 25.8%	45 min 6.3%	1 h 30 min 12.5%	10 h 30 min 87.5%
Sheep						
24-h period	15 h 57 min 66.5%	4 h 12 min 17.5%	3 h 17 min 13.6%	34 min 2.4%	16 h 50 min 70.1%	7 h 10 min 29.9%
Nighttime (12 h)	5 h 59 min 49.8%	2 h 45 min 22.9%	2 h 43 min 22.5%	34 min 4.8%	7 h 10 min 59.7%	4 h 50 min 40.3%
Pig						
24-h period	11 h 07 min 46.3%	5 h 04 min 21.1%	6 h 04 min 25.3%	1 h 45 min 7.3%	5 h 10 min 21.5%	18 h 50 min 78.5%
Nighttime (12 h)	4 h 23 min 36.5%	2 h 30 min 20.8%	3 h 52 min 32.9%	1 h 15 min 10.5%	1 h 20 min 11.1%	10 h 40 min 88.9%

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



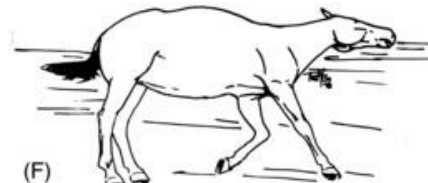
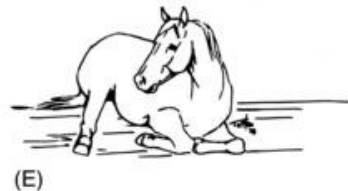
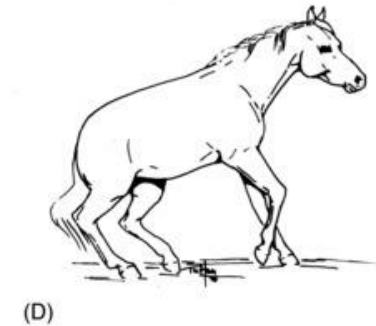
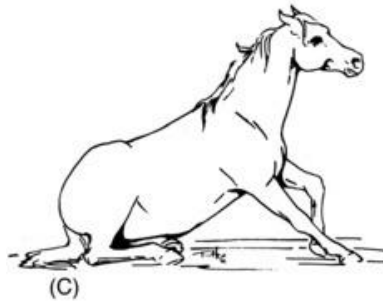
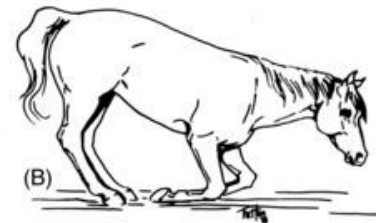
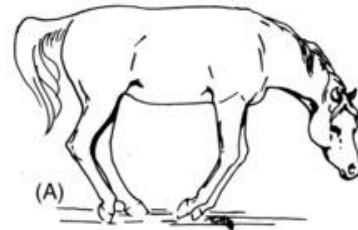
Pigs

- 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



Grazing (h)	Number of grazing bouts	Ruminating (h)	Lying (h)	Walking (h)	Standing (h)	Idling (h)	Type of cattle	Reference
5.5–7.5	6 (2 at night)	—	13	—	4	—	Dairy cows	Cattle on pasture 101
5.5–10	—	—	—	—	—	—	Beef steers (Hereford)	2096
6.5	—	5.5	9.25	—	—	8.25	Dairy cows (shorthorn)	2097
8	5–7 (1 at night)	5.5	9.25	—	—	3.50	Dairy cows (shorthorn)	386
7–9	2	—	—	—	—	—	Beef cattle	2098*
7.25–7.5	4–5	4	—	—	—	2	Dairy calves	425
6	3	—	8.25	—	—	9	Beef cows (Charolais)	671
10–12	6 (1 at night)	8	—	—	—	4	Dairy cows	751
9	4 (1 at night)	8.5	9	—	1.5	6	Dairy cows (Holstein)	2099
7–8	—	4.5	5	0.25	3.25	—	Zebu cattle	760
9 (8–11)	2	—	—	—	—	—	Steers	2100
9–10	4	8	2	2–3	2	—	Beef cows (Hereford, Santa Gertrudis)	830
11.50	—	8.50	—	—	4	—	Dairy cows	2101
8	5	8	—	—	—	9	Beef steers (Hereford)	899
7–8	—	7	12	—	—	—	Beef cattle (Hereford)	964
11.50	5	7	—	1.25	—	5	Beef and dairy heifers	2102
7	2	7	—	—	—	—	Zebu and grade steers	2103
	4	—	—	—	—	—	Dairy cows (Brown Swiss)	2104
6–8	4–8	—	—	—	—	7–12	Steers	2105
10–10.5	—	—	9–11	—	2–3.5	—	Beef cattle (Hereford)	2106
9.5–12	3	—	10–14	—	1.25–4	—	Nonlactating cattle	2107
8–9.5	4	—	—	—	—	—	Dairy cows	1720
10	2	—	—	1.5	—	—	Beef cattle	2108 ^a
—	3	—	—	—	—	—	Beef cattle	1964
7 (5.5–8)	5	6.25 (4.5–9.5)	—	—	—	—	Dairy cows (Ayrshire)	2109
9	6	7	5	1 ^a	6	—	Beef steers (Hereford)	2110
Cattle in confinement								
3–5	—	—	—	11	—	—	Dairy cows ^b (Holstein)	2111
4–5	—	—	—	8–11	—	—	Dairy cows ^c (Brown Swiss)	2112
3.5–5.25	9–12	—	—	—	—	—	Steers ^d	1562
3.5	4	7.5	9.5	6.5	14	1.25	Beef cows ^d (Hereford)	1693
3–4	—	—	—	12.25	—	6–7	Dairy cows ^c (Holstein)	2113
5	10	—	10.5	—	8.5	—	Dairy cows ^d (Ayrshire)	2114
6.25	18	—	—	—	—	—	Dairy cows ^e (Guernsey)	1985

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

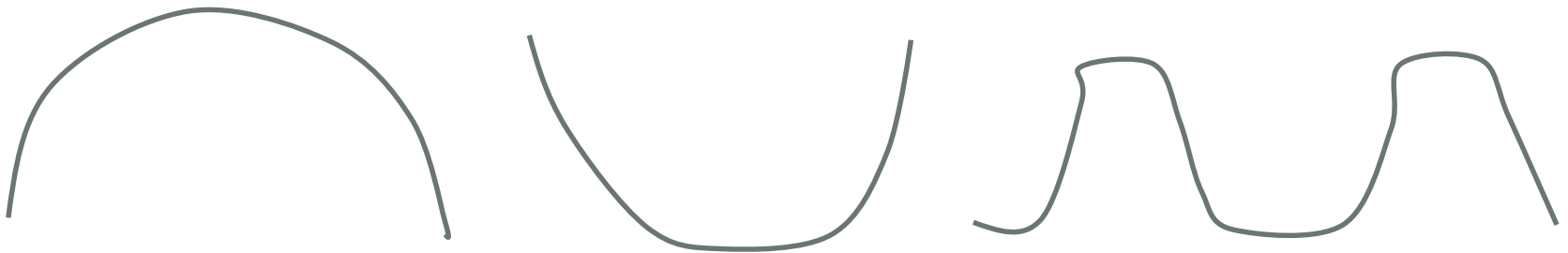


- **Ad libitum**-free feeding; meal-feeding tends to synchronize other behaviors
- Having a defined photoperiod entrains other behaviors
- Behavioral management can be used to entrain animals to change behaviors and impact animal welfare, environmental risks, and farm economics

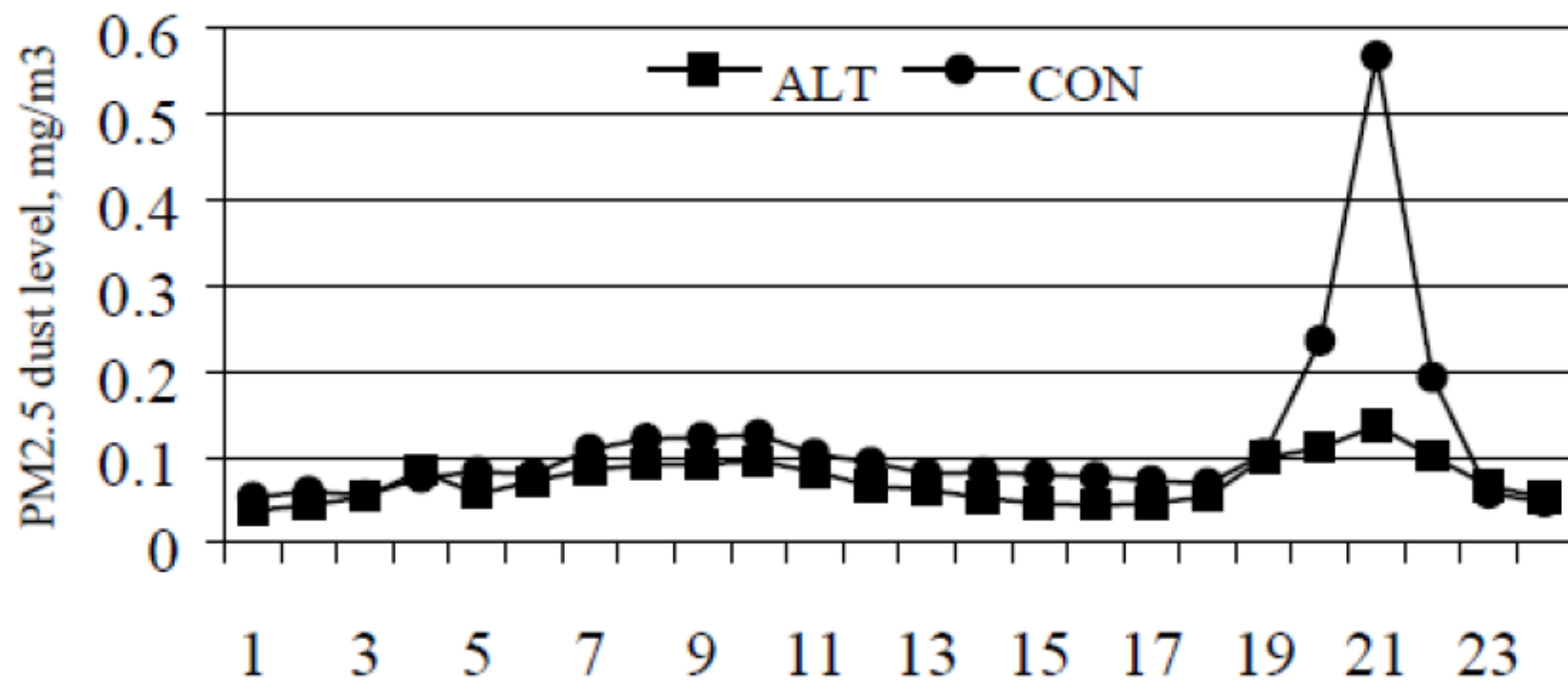


Nocturnal, Diurnal, Crepuscular daily activity patterns

- 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







Animals **2017**, *7*(3), 14; doi:10.3390/ani7030014

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Feature Paper

Article

Impact of Feed Delivery Pattern on Aerial Particulate Matter and Behavior of Feedlot Cattle †

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