Either you repeat the same conventional doctrines everybody is saying, or else you say something true, and it will sound like it’s from Neptune.  -Noam Chomsky
Brain mechanisms for sleep and attention overlap extensively. For example, the cerebral cortex, where conscious perception is realized, undergoes radical changes in the patterning of synaptic potentials (as revealed by EEG/LFP recordings) between the lowest-attention state (stage ¾ non-REM sleep) and high attention states (waking, REM sleep).

Changes in sleep/wake state and attention are sometimes mediated by groups of neurons that are highly interconnected (brainstem reticular and thalamic reticular neurons).

The classroom can be very hot.

REM sleep appears to be associated with a maximal frequency of events associated with reorientation of attention (as in a startle response) while non-REM sleep is associated with a minimal frequency of such events. The frequency of such events in the waking state lies between the two sleep states. Oddly enough, a similar pattern is observed for brain metabolism.

Work attempting to uncover the function of sleep typically takes either a species-comparison approach, a sleep-deprivation approach, or an approach involving recording of specific neurobiological characteristics of sleep.

Theories as to the function of sleep nearly always suggest that the function pertains to the brain as opposed to the rest of the body.
Neurally, attention is associated with either changes in the overall patterns of firing across a group of neurons (increased action potentials in response to the attended stimulus, and fewer to the unattended stimuli) and/or changes in the temporal firing patterns of neurons (neurons responding to attended stimuli fire in tune with a gamma rhythm). Such changes may, in part, be brought about by changing the subset of synaptic inputs to which a neuron responds most strongly.

Overall, attention appears to involve changes in the neural dynamics of multiple brain regions. Does this reflect the fact that the brain is extremely complex and best studied by considering the system as a whole, or does it reflect the fact that attention is defined in so many different ways?

Normally, we think of attention as altering the responsiveness of the cerebral cortex to different types of sensory input. That is, we think of attention as a sub-cortical process that impacts what happens in the cortex or thalamus. In the case of the parietal cortex and prefrontal cortex, we seem to have two systems of the cortex itself that regulate attention. Each of these structures is nevertheless impacted by subcortical inputs (e.g., from basal forebrain or locus coeruleus) and, remarkably, appear to impact activity in the same subcortical structures. Thus, attention is a cyclical process (i.e., a chicken-and-egg type process) that is continuous where what has been attended will affect, to some extent, what is attended to subsequently.
what do we know so far (since midterm 1 material)?

Neural mechanisms for attention fall into 3 basic categories. 1) changes in signal-to-noise ratio. Here differences in the selectivity for firing responses of neurons are accentuated, in one or another form, by attention; 2) changes in the temporal coherence of neurons. Here, attention increases the degree to which neurons fire with temporal relation to a gamma frequency. 3) changes in the functional anatomy of neurons. Although neurons usually have thousands of synaptic inputs, they are not always ‘listening’ to all of them. Even synapses that are strong (more depolarizing when activated) can be depressed temporarily.

Acetylcholine and norepinephrine appear to be intimately involved in both altering the strength of responses of neurons to stimuli when they are attended and in altering, dynamically, the ‘strength’ of different synaptic inputs to a neuron.

The ‘hemineglect’ syndrome arises from damage to the right parietal cortex and impacts the left side of not just egocentric frames of reference (e.g., the left visual field or left side of the body), but also the left side of objects (i.e., in an object-centered frame of reference).

The ‘hemineglect’ syndrome could conceivably arise because the parietal cortex serves as that brain area where a ‘spatial representation of the world’ is laid out or because the parietal cortex serves to regulate spatial aspects of attention.
the divergent impact of the brain’s neuromodulatory systems:

neuromodulators may often exert the same effect on the neurons they target (e.g., increasing their signal-to-noise ratio in response to an appropriate stimulus)

nevertheless, they may exert different effects on the brain depending on differences in the areas of the brain that they innervate (compare, for example, DA and NE) and/or depending on whether individual neurons send axon terminals to a broad (e.g., NE) versus restricted (e.g., ACh) set of brain regions

they may also exert different effects by being activated by different types of stimuli – for example, DA is strongly activated by stimuli that are related to reward, NE neurons are activated by novelty, and 5-HT neurons are activated whenever total amount of movement is high
NE increases the signal-to-noise ratio of somatosensory cortex neurons and auditory cortex neurons.

Foote et al., Brain Res., 1975

NE may alter the timing of responses of somatosensory cortex neurons

Lecas, Eur. J. Neuroscience, 2004
NE can affect the functional anatomy of target neurons (i.e., the subset of synapses to which they are sensitive at any given time).

ACh and NE depress responses of ventrobasal thalamic neurons (which relay input from vibrissae) to the inputs they receive from the cortical area (barrel field) to which they project.

But..., this depression is specific to low-frequency inputs...responses to high frequency inputs are actually enhanced.

NE responses I: locus coeruleus neurons discharge in response to presentation of target stimuli – prior work has identified robust responses to surprise and/or novel stimuli and when stimuli are suddenly given importance (by virtue of association with reward)
the ‘type’ of NE activity may matter as well – high NE activity can increase the ‘false alarm’ rate and correlated firing among LC neurons is associated with stronger ‘hit’ versus ‘false alarm’ performance.
Increasing the release of NE in orbitofrontal cortex through the drug yohimbine impairs performance on a simple five-choice serial reaction time test. The animal’s task is to detect a brief flash of light and then to make a ‘nosepoke’ into the hole from which the light came.

High NE release results in a greater incidence of ‘premature’ nosepokes (i.e., nosepokes prior to a light flash). At the same time, accuracy (hole-choice) is unaffected, but the likelihood of missing a flash is increased.

Interpretation – high NE heightens the probability that sensory neurons will respond too strongly to irrelevant stimuli (resulting in premature responses / impulsivity) – because of this, relevant stimuli will be missed some portion of the time (yielding higher omissions).
when high NE levels might be good – NE depletion in PFC impacts the ability of animals to make ‘extra-dimentional’ shifts of attention

circles = cups full of digging medium, some with reward at base   color of outer ring = digging medium (e.g., sand)
color of fill = odor (e.g., cinnamon)   star = correct choice (i.e., reward beneath digging medium)

intra-dimensional shift (i.e., odor still matters)

extra-dimensional shift (i.e., digging medium matters)

circles = cups full of digging medium, some with reward at base   color of outer ring = digging medium (e.g., sand)
color of fill = odor (e.g., cinnamon)   star = correct choice (i.e., reward beneath digging medium)