QUIZ 3

NAME:

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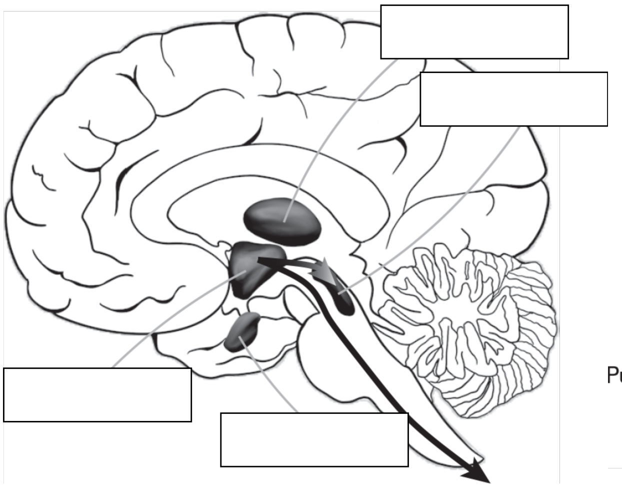
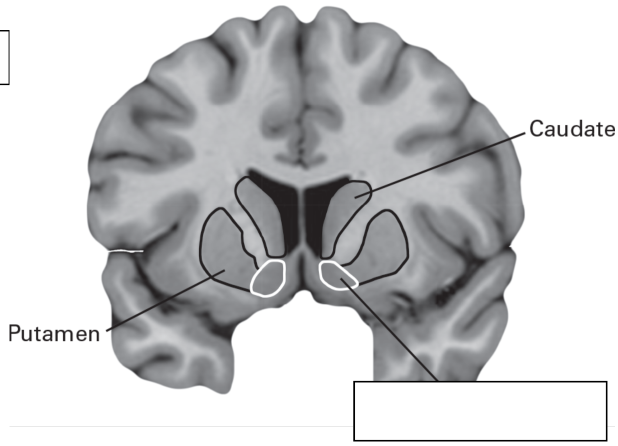
Problem 1. (Review) Here is a list of brain regions we discussed today: thalamus, hypothalamus, PAG, locus coeruleus ⊂ brainstem, anterior pituitary, amygdala (basolateral, central), occipital cortex, temporal cortex, nucleus accumbens, striatum, substantia nigra, midbrain





(1) Fill in the blanks above.
(2) Draw a diagram of the minimal brain. Are there any new areas or connections that need to be added to your “minimal brain”? (e.g., bidirectional connectivity, brainstem, etc.)
(3) Explain how the hypothalamus can provide internal context to the superior colliculus in the minimal brain.
(4) Explain why you may experience body aches when you relax after a stressful event.
(5) Explain using examples related to the amygdala why there is no 1-1 correspondence between function and area.
(6) Explain how you learn or unlearn the emotional significance of stimuli using the brain areas we covered today. Further explain how emotional significance is involved in selective information processing.
(7) One advice for anxiety is to focus on something challenging. Do you agree with this advice? Wouldn’t the new challenge induce another form of anxiety?
(8) Dopamine neurons in the striatum signal a reward prediction error, not the reward itself. How can we predict the total future reward without knowledge of the future?

Problem 2. (O/X) Label the following statements with **True** or **False**. If the statement is false, explain how you can revise it to be **True**.

(1) 19C thinking was that emotion was a function carried out by the subcortex.
(2) The hypothalamus has bidirectional connections to the cortex and brainstem.
(3) Our stress response is launched by neurons in the hypothalamus that distribute signals.
(4) Glucocorticoids are released from the Anterior pituitary.
(5) In operant conditioning, stimuli predict reward.
(6) The VTA is a band formed by dopamine containing neurons in the substantia nigra.

Problem 3. (작심삼일의 뇌과학적 이해) We make plans, act them out for three days, and that's usually it. In this problem we attempt to understand the underlying neurological mechanisms.

(1) Dopamine is synthesized in the VTA. It is then projected to the amygdala, hippocampus, and prefrontal cortex. Simply put, this circuit allows us to feel positive emotion, remember it, and make action-related decisions on it. What negative effects would an overly active "reward circuit" have on our lives?
(2) Because of such consequences you discussed above, the brain has another system - the **glutamate** network - that can suppress pleasure and delay gratification. When the prefrontal cortex decides that an action is harmful, it sends glutamate to the nucleus accumbens to inhibit the action. How does the prefrontal cortex decide? (Hint: it receives signals from the hippocampus and amygdala. What does this mean?)
(3) Ultimately, whether you can exercise self-control is determined by the competition between the dopamine circuit and the glutamate network. If you know that a behavior is harmful, but you cannot stop yourself from engaging in it, which system is the dominant one? What about when you stop yourself during an enjoyable activity? Discuss with **examples**.
(4) Dopamine induces learning. i.e., the more you play a game, the more "learned reward" you attribute to the game. How can we apply this learning effect to "unlearn" the reward? Or perhaps we can dominate (or replace) the current circuit by learning a new reward circuit. Discuss how brain plasticity enables us to acquire healthier habits and lose unhealthy ones.

Problem 4. (Predicting Total Future Reward) Now we will mathematically model the process of delaying gratification. Don't let the formulas scare you. Try to understand what it is saying using your own words.

The stimulus $u(t)$, the prediction $v(t)$, and the actual reward $r(t)$ are expressed as a function of $t \in [0, T]$. The prediction $v(t)$ is not just the predicted reward at time t, but the prediction of the total future reward expected from t onward.

$$v(t) = \mathbb{E}[\sum_{t \leq \tau \leq T} r(\tau)]$$

We approximate $v(t)$ by

$$v(t) = \sum_{0 \leq \tau \leq t} w(\tau) u(t - \tau)$$

Then, we find the appropriate weights by applying the stochastic gradient descent algorithm:

$$w(\tau) \to w(\tau) + \epsilon \delta(t) u(t - \tau)$$

with $\delta(t) = \sum_{t \leq \tau \leq T} r(\tau) - v(t)$ being the difference between the actual and predicted total future reward.

(1) What is the meaning of T? If a person is good at delaying gratification, can we say that he or she has a relatively large T? How would someone with $T = 3$days behave compared to someone with $T = 5$years or $T = 70$years?
(2) What is the meaning of $w(\tau)$? For example, what does a high value of $w(1)$ imply? What does it mean for $w(1)$ to have a negative value or 0? (1 can mean 1 day or 1 hour or 1 year - interpretation is up to you)
(3) Which variable $u, v, w, \epsilon, \delta$ do you think represents the amount of dopamine released?
(4) How do you predict the total future reward without knowledge of the future? (Re-interpret your experience with this framework: What timescale T do you usually use? How are your weights $w(\tau)$ distributed? etc.)