1. Give three functional reasons why we have so many parallel processing pathways in the visual system.

   First reason is to get around the problem of anatomical bottleneck of optic nerve (as the space behind the eyes only allows certain amount of optic nerves to connect to the brain, thus the amount of information the optic nerves can deliver at once is limited) and limited bandwidth of ganglion cells (p. 361). Another function reason is that parallel processing allows the construction of new output channels when the streams of information are integrated (p. 366). Convergence of pathways may provide information that supports some unique computations and tasks (p. 368). The third functional reasons for having parallel processing is increased information transmission efficiency. Because in parallel processing several streams of information are processed simultaneously, the same amount of information is sent to the brain more quickly than in serial processing.

   It's parallel as opposed to distributed, not parallel as opposed to serial.

2. Dorsal and ventral visual pathways were originally thought to serve different functional purposes, what were they? Yet, certain visual properties are processed within both pathways, such as binocular disparity. Why is that?

   In a classic view, the dorsal pathway is the “where” (i.e. space related attributes) pathway and the ventral pathway is the “what” (i.e. object related attributes) pathway. Functionally, the dorsal stream was thought to be sensitive to “direction of motion and binocular
disparity” and the ventral stream was characterized by its selectivity of color and contour (p. 367). The reason that some properties are processed within both pathway could be that different pathways operate different computations on these attributes and serve different behavioral goals. Having both pathways processing the same information can promote efficiency in the sense that the desired goals can be achieved in a timely fashion. Also, if both pathways are capable of processing the same attributes, then there is no need to segregate the information before sending it to the parallel pathways as it will introduce computational loads and information lost.

What about binocular disparity?

3. When there are two stimuli within a visual neuron's receptive field, one preferred and one not preferred, how is neural response modulated by attention? What is the evidence that there is suppression induced by attending to the non-preferred stimulus (as opposed to a relatively smaller enhancement of response when compared to attending to the preferred stimulus)?

It seems that the response to preferred stimulus increases when attention is directed to it, but decreases to a level that's below neutral response when attention is directed elsewhere (p. 297). Therefore the overall responsiveness, due to attentional modulation, of preferred and non-preferred stimuli is enhanced (as the difference of response between preferred stimulus and non-preferred stimulus becomes larger) (p. 297). The observation that the response dropped below neutral level serves as evidence for suppression induced by the non-preferred stimulus.

4. In what sense does the attentional narrowing of tuning curves increase the neuron's selectivity? In what sense does the multiplicative increase of a neuron's response increase the amount of information communicated by the neuron?
Because it seems that the selectivity is indexed by the gradient or slope of the tuning curve, a narrower using curve will have higher selectivity (since the tangent of every point of the narrower curve would have a steeper slope than the corresponding point on the wider curve). The multiplicative increase of a neurons' response can increase the amount of information communicated by the neuron for several reasons. First of all, since the overall response is bigger and the size of random noise does not change, the signal-to-noise ratio will increase. Second, because the overall response is the result of the pooling of population of neurons, multiplicative increase in each neuron’s response will result in more overlapped turning curves of the population of neurons. In this sense, more noises will be averaged out, thus, more information is retained. Third, as mention above, selectivity is positively correlated with the slope of the turning curve, the multiplicative change that results in a bigger slope along the curve would also increase the selectivity of the neuron.

I give you a bonus .5 for going above and beyond in your response!

5. (Extra credit) Attentional modulation appears to increase higher up in the visual hierarchy.

Why is this (we discussed this in class)?

Because the visual processing has a hierarchical structure and though there is a feedforward information flow, lower processing also receives constant feedbacks from higher structures. The feedback information may modulate the information that is going to next level, and this modulation does not seem to be reversible. Therefore, the attentional modulations, in a sense, will build up along the visual processing and appears to increase as we go up to the visual hierarchy.
6. (Extra credit) How is featural attentional different from spatial attention? Why is the discovery of featural attention challenging for the "spotlight of attention" analogy?

The spatial attentional effect, with the metaphor of “spotlight,” suggests that attention operates on the basis of spatial location (p. 297). It seems to imply that attention is confined to a certain area, and it cannot be scattered in a visual scene. Features attentional effect does not assume such constraint on the focus of attention; rather it suggest that attentional effect can operate on the entire receptive field on the basis of stimulus features (p. 297). The spotlight of attention analogy is challenged because it implies that spatial attentional effect is the only attentional effect. Note that discovery of featural attentional effect will only challenge the spotlight analogy but not necessarily spatial attentional effect. Evidence suggests that two attentional effects are not mutually exclusive, and can be additive (p. 297).

7. (Extra credit) How can apparently nonlinear attentional modulation of neural response arise from multiplicative modulation in an earlier area?

Because downstream areas have larger receptive fields than the preceding areas, it is likely that not all neurons that converge to the downstream structure have gone through multiplicative modulation. This means, within the receptive field of the downstream neuron, some areas may be more responsive to certain features while the others are not as responsive. Attentional modulation would then become nonlinear for the downstream neuron, given the neurons in its receptive field have ununified responses to that particular feature.