1. Do specificity of neural computation and information loss always go hand in hand? Describe 3 examples in the retina to support your answer.

   Yes, neural computation and information loss always go hand in hand, because at each level of the computation process, some received information will be extracted and sent to the next step for process, whereas some other information will be discarded -- this is information loss. For example: The process of detecting light: temporal filtering process discard signals at high frequencies; then rectification only allows signals pass threshold to move on (p151). The process of detecting object motion: Object-motion-sensitive (OMS) ganglion cells are silent under global motion due to cancelation of the inhibitory and excitatory input, and only active under local motion (p152). The process of detecting approaching motion: there are RGC selective for approaching motion only, but not lateral motion. When the object moves laterally, the excitatory and inhibitory signals cancel out, and cells remain silent (p154).

2. Describe 3 general strategies that retinal neurons employ to reduce noise in processing

   Band-pass filtering by rod bipolar cells. This step reduces chemical noise that are at a higher frequency (p153). Rob bipolar pools information over many photoreceptors. The pooling is a nonlinear summation process that reduces the noise input (p151). Rectification presynaptically before the signal reaches the bipolar cells also reduces noise in rods. Signals below the threshold are ignored, and only the ones pass the threshold counts (p152-p153).

3. What’s rectification? What’s it computational function? Give 2 specific examples in which it performs important function in the retina.

   Rectification: rectification is basically a threshold held at each subunit of the receptive field. It’s performed pre-synaptically before the signal reaches the bipolar cells. Computational function: helps to reduce noise going to the next process. only the ones pass the threshold get through, information that’s below the threshold is ignore. Examples: In sensing the approaching motion of an object, rectification is important for ignoring global brightening. In detecting texture motion, nonlinear rectification is important for allowing only the depolarized bipolar cells communicate to the RGC

4. Give 3 examples of RGC that would appear to have ordinary center-surround responses for static point stimuli, but in fact encode more specific information when richer stimuli are used.

   The OMS ganglion cells have ordinary center-surround response for white-noise flicker (p159), but they encode more specific information like local motion when fed with richer stimuli. They remain silent under global motion due to cancelation of the incoming information. In salamander retina, the ON bipolar cells respond with slower kinetics than OFF bipolars, which makes latency coding possible. There are also RGC that are selective for approaching motion, but not lateral motion.
5. What’s the evidence that the retina computations contribute to making predictions about future sensory states based on past observations?

The retina computation contribute to making prediction about future state by relying on objects moving in a smooth motion, and allows motion extrapolation. RGCs have extended spatialtemporal receptive field, and the their gain-control system allows the nonlinear modulation. Each ganglion cell’s firing rate is weighted by a vector representing its receptive field center (p155). Then the motion extrapolation is computed following the trajectory based on the delayed data. We can see the evidence of this underlying computation when the object makes a sharp turn: there’s a few tens of milliseconds delay when the RGC neural image continues straight, then it catches up. If the object reverse its trajectory completely, not only there’s even more synchronized firing near the reversal point, identifying an error in the retina’s prediction. The “omitted stimulus response” also suggests build-up of an anticipation for the next stimuli when the visual system is exposed to a periodic stimulus (p155).

6. How do presynaptic and postsynaptic inhibition differ physiologically? Functionally? Give one example of each in retinal circuits.

Post synaptic inhibition is essential for combining the signals from different part of the object. Functionally it suppresses response to the non-preferred signal. Presynaptic inhibition is essential for rectification. Functionally it helps to selects the preferred signal to get through, and ignores the non-preferred one (p154). Examples: Object motion: OMS inhibition happens presynaptically. Approaching motion: Inhibition of ganglion cells that detect Approaching motion act postsynaptically.

7. Hypothesize why certain visual computations are done as early as in the retina, and others are done in the rest of the brain.

Visual computation done at the retina level probably has evolutionary advantage. Because the visual system can generate a much faster response than sending everything downstream to the rest of the brain. But there’s only a certain amount of neurons that can fit in the retina, so the rest of the brain is required for processing other information.