1. For the LGN, which structures supply (a) feedforward, (b) feedback, and (c) recurrent input? Why is it categorized this way?

Retinal input to the LGN is categorized as feedforward because the direction of information flow is one way (P. 138-139). That is, signals originating in the retina feed into the LGN, but signals in LGN do not feed into the retina. Cortical input to LGN is categorized as feedback because it is composed of signals originating in a structure (cortex) that itself receives input from the LGN; information leaves LGN and is processed in cortex, producing output that then affects LGN (P. 145). Thalamic reticular nucleus (TRN) supplies input to LGN that is categorized as recurrent, since both LGN and TRN are part of the same structure (thalamus). As with feedback, LGN signals effect TRN which in turn effect LGN (P. 136).

2. How is the efficacy of the retinogeniculate drive defined? How does it depend on the animal’s sleep/arousal state? Why does it almost never reach 100% in awake behaving animals?

Efficacy of the retinogeniculate drive is defined as the ratio of an LGN cell’s response to the firing of its input retina. The example LGN cell from the paper had 50% efficacy because it only fired half as often as its input retinal cell. Increasing states of arousal has the effect of increasing retinogeniculate efficacy: as an animal goes from deep sleep, to wakeful, to attentive cells in LGN are more likely to respond to their retinal input (P. 136). The animal’s retinogeniculate drive never reaches 100%, because that would essentially render the LGN computationally useless. Every signal produced by a retinal ganglion cell would arrive in cortex unchanged. If that were the case, then LGN would be a waste of space and energy.

3. Can LGN provide more visual information than the retina? Why or why not?

The answer to this question depends on how we interpret several things, including what exactly the LGN and the retina are providing visual information to, and what we mean by visual information itself. Here’s one interpretation: suppose what we mean by “visual information” is something like, the information that is contained in the pattern of light that falls on the retina. Suppose also that when we talk about “the thing” that this information is being provided to, that we are then talking about the visual cortex. Then the question becomes, can LGN provide more of the information that is contained in the pattern of light that falls on the retina, to the visual cortex, than the retina could? In this case the answer is simply no. If that pattern of light, as encoded by the retina, was passed directly to V1, it would contain more information then what is in fact transmitted to V1 by LGN. This is true because LGN actually does work on that information, specifying and amplifying relevant features while filtering out noise. This work has the effect of compressing the information content of the message it received from retina, before passing it on to visual cortex. However, consider a different starting definition for visual information, say something like, neurally encoded information that is used to specify the structure and content of the environment as it is visually perceived. Then an argument can be made that the LGN might provide more visual information than the retina. At the very least, an
argument can be made that the LGN provides visual information that never existed in the retina. In any case, I’m pretty sure that it was in the spirit of the first set of definitions that the question was asked.

4. Why is it useful for LGN to provide “efficient access... to selective populations of retinal groups? Give one example.

Retinal projections that carry information about specific colors, center polarity, or other functionally relevant information segregate when they reach LGN so that non retinal inputs to LGN, originating in cortex or TRN, can access them efficiently (P. 136-137). Studies have shown that neurons in different areas of VI selectively target the segregated regions of LGN, yielding differences in tissue density between those regions. This segregation is what gives LGN its laminated appearance (P. 137). Presumably, the computational advantage of this arrangement is that information originating in one cortical region can feed into a specific population of LGN neurons, all performing the same function, and for which that information is behaviorally relevant. Because that LGN region is functionally segregated, there is no risk that the cortical input will influence the activity of neurons performing different functions, for which the information it carries is behaviorally irrelevant.

5. What does it mean that the LGN cells have higher gain at low contrast, and lower gain at higher contrast? What function does it serve?

What it means for LGN cells have higher gain at low contrast levels is that the cells amplify low contrast signals more than when there is high contrast in the visual image, in which case they have lower gain and so amplify the contrast less. In other words, when the visual scene contains small differences in luminance, cells in LGN amplify those differences, accentuating them. When there are large differences in luminance levels, then LGN cells don’t have to accentuate the differences, since they are already stark. This ability, to shift the scale of output for different contrast levels, allows cells in LGN to use a relatively small set of values to represent a much larger range of variation in an image.

6. Why might there be interspecies differences in how much multiplexing or integration there is in LGN (as opposed to downstream in the visual pathway)?

The differences between species might depend on the amount of real estate available in the cortex, compared with the LGN. The example from the paper is the distinction between the amount of multiplexing and integration observed in cat LGN compared with monkey LGN (P. 139-140). Integration appears to be common in cat LGN, while cells in monkey LGN seem to be primarily driven by one retinal cell. It’s possible that in monkey the retinal signal is passed to visual cortex, having undergone less processing then it does in cats, because the cortex is more developed in that specie. Therefore, it might be advantageous for it to receive a rawer signal in
order to process it using more complex machinery than can be implemented in LGN. Another possibility is that cat’s need to be able to respond to their visual environment more quickly, and that putting the processing closer to the information source (eyes) shortens the delay between stimulus and response.