Ch 7. How can the brain be so fast?
Q1. In what sense are brains fast? And how is it possible in spite of limitations from neuronal time constants and coding scheme. (Hint: experiments of RT shows the brains are fast; population coding scheme defines firing rate as population average rather than temporal average so that the information transmission can be reasonably fast)
Q2. How does the spontaneous cortical activity help the brain can be fast? (Hint: spontaneous cortical activity (dubbed as noises)
- shifts the mean membrane potential close to threshold
- induces voltage fluctuations
- increases the conductance
- so, the effective membrane time constant can be below 10ms.)

Ch 22. Synesthesia: What does it tell us about the emergence of qualia, metaphor, abstract thought, and language?
Q1. Is synesthesia a genuine sensory effect? (Hint: Yes, synesthesia is sensory Subjective report & Psychophysical measurements are provide clear evidence)
** Psychophysical measurements : Pop out, apparent motion, symmetry detection.)
Q2. What are the underlying mechanism? (Hint: Defective gene ? --> Cross activation --> synesthesia !
Synesthesia is caused by a cross-activation of sensory brain maps. And a Faulty gene(or faulty genes) cause cross activation.)
Q3. What are the implications of synesthesia? (Hint: Unconscious early sensory processing stage is confirmed Something either conscious or unconscious in Qualia [Certainty of sensory signal - type of representation? emergency of Qualia ]
Metaphor, abstract thought, language : Based on Cross-activation mechanism possibility)

Ch 11. Which computation runs in visual cortical columns?
Q1. Is the set of models in this paper plausible? (Hint: Resulting networks are quite plausible, but it seems implausible that all of the abstract functions would have been inferred.)
Q2. How did he try to model a function of a brain(orientation, curvature) at an information processing level? (Hint: N-person Game
- Player: Each columnar position
- Pure strategy: Each orientation
- Probability distribution of Strategies: Orientation Preference
- Payoff: Cocircularity
Derivation of equations is explained in presentation pdf.)
Q3. Why did he have to find different model(Cliques Computation) of this system? (Hint: N-person game is solved via gradient descent classically, but it can be extremely delicate numerically. We cannot imagine how they can be applied to neurons over short time period. Therefore, he sought different ways that permits a proper reduction to biophysical approximations of neurons. The previous model is transformed into cliques computation model via Kuhn-Tucker theorem. Derivation of equations is explained in presentation pdf.)

Ch 10. What is the other 85 percent of V1 doing?
Q1. That despite for decades of research characterizing the response properties of V1 neurons, why we still do not have a decent picture of how V1 really operates?
A working model of V1 function in previous research assumed that neurons are linear. But cortical neurons are highly nonlinear. And there is no general method for characterizing non-linear systems.

- Using biased sampling, biased stimuli, biased theories
- Interdependence & context problems (influence of intra-cortical input, context in natural scenes.
- Ecological deviance (Responses to natural scenes deviate from predictions of standard models)

Q2. Describe a new theory that can overcome the limitations of previous research (The answers of (Hint:
- Neurons ad Dynamical systems and the limits of prediction
- Sparse, overcomplete representations
- Contour integration (V1 neurons have an orientation- and position-specific connectivity structure. This connectivity helps resolve the ambiguity of contours)
- Surface representation (V1 is involved in computing three-dimensional surface representations.)
- Top-down feedback and disambiguation (Low-level shape features can be inferred based on global context and higher-level knowledge.)
- Dynamic routing (ex. Two distinct classes of neurons - Invariant / Variant neurons) )

Ch12. Are Neurons Adapted for Specific Computations?
Q1. What properties of the neurons in the auditory system are different from any others? (Hint: Phase-lock, detect coincidences, and encode temporal patterns all exhibit a suite of physiological and morphological adaptations that suit them for their task.)

Q2. Why does dendritic structure have an advantage in the detection of inter-aural time differences? (Hint: The segregation of the inputs on the dendrites allowing non-linear integration [Agmon-Snir et al., 1998]. Each dendrite acts as a current sink for inputs on the other dendrite consequently increasing the voltage change needed to trigger a spike at the soma when inputs arrive only on one side [C. E. Carr et al. 2005].)

Ch13. How Is Time Represented in the Brain?
Q1. How is time represented in the brain? 
- no simple answer
- instead, we will find the following question.
  "which types of representations best support flexible and robust computations of temporal relations?"

Q2. How to interpret temporal sequence? 
- find neural representation == find neural coding (rate coding & temporal coding)
- in this paper, author mentioned temporal coding related to spike interval
- time warp algorithm is needed for time varying sequence
- suggested neural representations are shown in the following table.
Ch 14. How general are neural codes in sensory systems?

(Answers)

1. There are three important methods to investigate generality: 1) cross-modal studies 2) interspecies studies and 3) developmental studies. When checking the answer, it would be great if one can give specific examples.

2. In sound localization, we can start based on ‘Duplex Theory’.

<table>
<thead>
<tr>
<th>Types</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaural Level Difference</td>
<td>Within the high frequency sound source, there will be acoustic shadows at different side of the ear since the organism’s heads work as low pass filter. From those phenomenon, there will be difference in sound amplitude and will be utilized in sound source localization.</td>
</tr>
<tr>
<td>Interaural Time Difference</td>
<td>When the sound sources are not located at exactly balanced position, the sound source localization will be based on time difference.</td>
</tr>
</tbody>
</table>
on, there will be time delay reaching to ipsilateral and contralateral ear. Within this temporal difference, spatial location of sound is decoded at the brain.

**Interaural Phase Difference**

Brief concept of this start from phase ambiguity. If ITD+T of pure tone stays within physiological range (which is head width, then it will cause confusion in localization of the sound source). From here, complexity of sound (bandwidth concept) is imported and phase difference between largest peaks is considered.

**Inhibitory Mechanism**

Within empirical data of mammal, there are some physiological mechanisms which causes inhibition of the sound signal decoded in brain. This is also temporally phase-locked and results time window shift or gain control.

3. Coincidence detection is the key mechanism. Attached slide of presentation will clearly give explanation.

4. Since the primary (frequency map) and secondary (ITD map) tonotopic map of the avian is orthogonal, thus every iso-frequency map has representation of ITD map. Within this aspect, avian uses the peak of ITD and it is revealed with characteristic delay shown in the graph. On the other hand, tonotopic map of mammal is parallel which means only certain portion of ITD map is represented in certain iso-frequency line. (see the graph). Thus, at certain frequency range, ITD peak gets off-physiological range. Thus, they adopt new mechanism using the steepest slope. If they adopt steepest slope, they will all lie in physiological range of the mammal.

5. Different pattern of inhibition between mammal and avian.

<table>
<thead>
<tr>
<th>Mammal</th>
<th>Avian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycinergic pathways are used</td>
<td>GABAergic pathways are used</td>
</tr>
<tr>
<td>This induces mammal to imply hyper-polarizing</td>
<td>This induces mammal to imply de-polarizing</td>
</tr>
<tr>
<td>Feed-forward inhibition</td>
<td>Feed-backward inhibition</td>
</tr>
<tr>
<td>ITD time-window shift</td>
<td>De-correlation based on gain control</td>
</tr>
</tbody>
</table>

**Ch 15. How Does the Hearing System Perform Auditory Scene Analysis?**

Q1. How does the auditory scene analysis be encoded?

Hint) Distributed population coding is able to combine multiple dimension information of auditory scene

Q2. Which processes are suggested for top-down and bottom-up processing of auditory scene analysis?

Hint)

**Top-down:**

- Perceptual restoration of interrupted speech

**Bottom-up:**

- Segregation of sequential tone pulses
- Object formation by common modulation (CMR, MDI)
- Object formation by spatial processing

Q3. What is most important mechanism for bottom-up processing of auditory scene analysis?

Hint) Auditory hair cells in cochlea work as the Fourier transformer and the frequency filters