**BIPN 194: Neurobiology of the Chemical Senses**
**Prof. Jing W. Wang**
**WI14, Wed 3:00-4:30 pm, York 3010**
**Office Hour: Monday 4:30-5:30 pm, Bonner Hall 2218**
**Phone: 858-534-5597**
**e-mail: jw800@ucsd.edu**

1. **1/8 Introduction**
   Course description
   Overview of recent advances in neurobiology of the chemical senses
2. **1/15 Odor map**.
   Background: The concept that spatial patterns of neural activity encode odor quality was first proposed by Adrian in 1950 (Adrian, 1950, Brit. Med. Bull., 6, 330-333). Since then, many imaging tools have been used to visualize the odor map in the mammalian olfactory bulb or the equivalent structure in invertebrates.
   **Research article: Rubin and Katz, 1999, *Neuron*, 23, 499-511.**
   Review article: Xu et al., 2000, *J. Comp. Neurol.*, 422, 489-495.
3. **1/22 Cloning of the mammalian odorant receptor gene family**.
   Background: Several findings pave the path for Buck and Axel to make the bold hypothesis that odorant receptors are encoded by a family of G-protein coupled receptor genes. Jones and Reed, Science, 1989, 244, 790-795; Nakamura and Gold, Nature, 1987, 325, 442-444; Pace et al., 1985, 316, 255-258.
   **Research article: Buck and Axel, 1991, *Cell*, 65, 175-187.**
   Review article: Julius and Katz, 2004, *Cell*, 119,747-752.
4. **1/29 Molecular mechanism for the odor map**.
   Background: Previous physiological experiments establish the notion that the odor map encodes the quality of an odor in the olfactory bulb. A given odor excites multiple glomeruli and each glomerulus responds to multiple odorants. However, physiological experiments cannot determine whether odorant receptor neurons expressing the same gene project their axons to single glomerulus or multiple glomeruli. Two papers provide an answer to this question (Vassar et al., 1994, Cell, 79, 981-991; Ressler et al., 1994, 79, 1245-1255). The paper by Mombaerts et al brings unprecedented resolution.
   **Research article: Mombaerts et al., 1996, *Cell*,. 87, 675-686.**
   Review article: Firestein, 2001, *Nature*, 413, 211-218.
5. **2/5 Olfactory system in *Drosophila***.
   Background: Most organisms have evolved olfactory mechanisms for locating foods, mates and predators. The discovery of an odor map in *Drosophila* suggests that odor map is a conservative mechanism. Several landmark papers provide support for this concept (Clyne et al., Neuron, 22, 327-338; Wong et al., Cell, 109,229-241; Marin et al., Cell, 109, 243-255; Wang et al., Cell, 112, 271-282).
   **Research article: Vosshall et al., 2000, *Cell*, 102, 147-159.**
   Review article: Bargmann, 2006, *Nature*, 444, 295-301.
6. **2/12 Olfactory behaviors**.
   Background: Genetic tools in make it easier to test in *Drosophila* whether the odor map is relevant to olfactory behaviors. Experiments increasingly point to an emerging theme that innate behaviors are controlled by hard-wired neural circuits whereas learned behaviors

require a flexible system. Stockinger et al., 2005, Cell, 121, 795-807.
**Research article: Suh et al., 2004, *Nature*, 431, 854-859.**
Review article: Bargmann, 2006, *Nature*, 444, 295-301.

7. **2/19 Theory I: spatial code**.
Background: Different odors elicit different, but often overlapping, glomerular patterns. The spatial coding hypothesis states that these glomerular patterns are important for odor detection and discrimination. Rubin and Katz, 1999, Neuron, 23, 499-511.
**Research article: Malnic et al., 1999, *Cell*, 96, 713-723.**
Review article: Axel, *2004 Nobel Lecture*, *Angew. Chem. Int. Ed.*, 2005, 44, 6110-6140.

8. **2/26 Theory II: temporal code**.
Background: Different odors elicit different temporal sequence of spike activity in the same cell. The temporal hypothesis argues that the temporal sequence of neural activity is informational and required for fine odor discrimination. Stopfer et al., 1997, Nature, 390, 70-74.
**Research article: Laurent et al., 1996, *J. Neurosci*., 16, 3837-3847.**
Review article: Laurent, 1999. *Science*, 286, 723-728.

9. **3/5 Mammalian sweet taste receptors**.
Background: Sweetness is NOT a physical property of sugar, instead it is a perception generated by our nervous system. Charles Zuker, Nicholas Ryba and colleagues discovered that the mammalian sweet taste is mediated by the heteromeric receptor T1R2+T1R3.
**Research articles: Nelson et al., 2001, *Cell*, 106:381-390. Koizumi et al., 2011, *PNAS*.**
Review article: Chandrashekar et al., 2006, *Nature*, 444:288-294.

10. **3/12 Coding of sweet, bitter and umami tastes**.
Background: There are two opposing views of how taste qualities are encoded in the periphery. In one model, taste receptor cells are tuned to respond to single taste modality–sweet, bitter, sour, salty or umami. In another model, individual receptor cells are tuned to respond to multiple modalities. The paper by Zhang and colleagues used elegant and rigorous tests to discriminate between the two opposing models.
**Research article: Zhang et al., 2003, *Cell*, 112:293-301.**
Review article: Chandrashekar et al., 2006, *Nature*, 444:288-294.

**Note: Articles in bold face are required readings before coming to class. Review articles usually provide background information, which you can read to gain a better understanding of the research articles.**

**Course Description**:
This course will examine the mechanisms of the chemical senses (taste and smell) from the receptors to the neural circuits. We will consider issues of detection, discrimination and perception. The class will meet once per week to discuss one or more key research articles. Our intent is to review the most important discoveries, evaluate current thinking in the field, and gain expertise in the critical analysis of scientific papers.

**Prerequisite Note**:
A course in neurobiology or neuroscience is strongly recommended.

**Teaching Philosophy**:
As you know already that a simple comprehension of a proposition is not sufficient for a student of science. One needs to know the evidence supporting that opposition, and what evidence is necessary to revise the proposition. A scientific investigation usually starts with an idea–a hypothesis. The hypothesis must then be tested by experiments. The testing of hypotheses distinguishes science from other forms of human activity. This course is designed to give you a taste of real world research in neurobiology of the chemical senses.

This is a course that requires you to spend time to think, to debate among yourself and in class. Understanding how the sensory system works requires that we integrate facts into coherent concepts. Neuroscience, unlike other matured disciplines such physics or chemistry, is a developing field. As we speak, neuroscientists all over the world are synthesizing different facts together to make hypotheses, and with hypotheses they make prediction about the brain. The cycles from facts to principle and from principle to more facts advance our understanding of the brain. It is impossible for us to cover all aspects of the chemical senses in such a short course. What I can do is to use some case studies to bring you a taste of neuroscience. My goal is to use the least amount of facts to get you a deep appreciation of neuroscience. Here is what I suggest that you can do to get an A in my course: read all the relevant papers, with a focus on the core concepts.

**Grade:**
Your special **presentation** in class, **summary writing** and class **participation** will contribute **50%, 30%** and **20%**, respectively, toward your final grade. Class participation will include attendance and activity in the classroom such as asking questions. Before class, everyone except the presenters of the week will hand in a summary on the scientific paper of that week. Immediately after class, all non-presenters will submit an evaluation of the presentation. Presenters should e-mail me a copy of their PowerPoint slides **at least two hours before class** (I need this to write up my comments).

In the **summary write up**, I am looking for the following information about the research article:
1) What is the question?
2) What is the hypothesis?
3) What kind of techniques do the authors use?
4) Do their results address their questions?
5) Do they prove or disprove their hypothesis?
6) What is the weakness of the paper?

I strongly encourage you to discuss about the paper among yourselves.

**For presenters**:
Each group will have 50 minutes for the presentation and 10-20 minutes for questions and discussion after the presentation. Group members should have equal time during presentation. Each member should be prepared to answer questions and engage in discussion of paper. Group members are encouraged to discuss the paper together and meet before their presentation, since substantial background information is required to understand each research article. Sophisticated techniques are common in contemporary biological papers. Each week after the group presentation, I sometimes give a short overview covering the minimum background for next week's research article.

You are encouraged to use PowerPoint for your presentation. Please talk to me for other presentation formats such overhead projector. You can either use my computer or bring your own computer. If you decide to use my computer, bring a memory chip or a CD of your slides to upload into my PC (not a Mac). In the case that you will use your computer, it is still a good idea to backup your presentation on a CD or memory chip. In general, a good presentation usually includes three sections:

1) **Background/Introduction**. In this section, you provide the necessary background to help your audience to understand the following questions. What are the authors trying to show? How does this work fit into the body of literature? What sort of techniques do they use? What is the hypothesis? What is the question?

2) **Discussion of results/data**. In this section, it is important to have a clear line of logic for the experimental results. In biological papers, control experiments are often important for the interpretation of results. Be prepared to discuss any reservation you may have about the authors' interpretation, and the reason for your opinion. In this section, clear figures are important.

3) **Conclusion and implication**. Discuss the conclusions of the paper. Where possible, include a model to provide an overview of the findings. Discuss the long-term implication of the work. Authors often speculate about the significance of their findings in the Discussion section. You can talk about your reservation and the reason.