Vertebrate Physiology 437 EXAM I NAME KEY **, Section (circle): am pm**
21 September 2006. Exam is worth 100 points. You have 75 minutes.

True or False **(write 'true' or 'false'; 10 points total; 1 point each)**

1. False Proteins contain more metabolizable energy per gram than do fats or carbohydrates.
2. False Quantal packets were first deduced using the patch-clamp technique. → used for ion channels
3. false When an ion species moves passively across the membrane through open channels and changes the membrane potential, the concentration gradient for that ion is abolished and needs to be reestablished later using ATP.
4. false The ~~2nd~~ 1st Law of Thermodynamics states that energy is neither created nor destroyed.
5. False Joe Slowinski's death in Myanmar (Burma) on 12 September 2001 was caused by the activity of a nicotinic acetylcholine ~~agonist~~ antagonist.
6. false ~~Transcription~~ Translation usually takes place in the ribosome.
7. True If extracellular fluid is hypoosmotic with respect to nearby cells, water will tend to move in to the cells.
8. True Enkephalin is an endogenous opiate with analgesic effects.
9. True Increased strength of incoming sensory information is coded to the central nervous system via a higher frequency of action potentials.
10. True The Fick equation allows you to calculate the net rate of diffusion (J).

Really Short Answer **(a few words or a sentence; 35 points total; 2.5 points each)**

1. How does the role of a kinase differ from that of a phosphatase?

   adds a phosphate — cleaves a phosphate

2. How is Haeckel's statement that "ontogeny recapitulates phylogeny" useful in a class on vertebrate physiology?

   - comparative
   - allows predictions
   - other?

3. Zeitgeber, entrainment, photoperiod, and suprachiasmatic nucleus are all associated with what phenomenon discussed in the last few pages of chapter 10 of your text book?

   biological clocks (circadian rhythms)

4. Explain how fish olfactory systems are able to "learn" odors through processes that do not necessarily occur in the brain.

   upregulate certain olfactory receptor proteins in the nose

Key /20

5. How does the mechanism of activity of nicotinic acetylcholine receptors differ from that of muscarinic acetylcholine receptors?

ionotropic / fast
ligand opens that channel

metabotropic
2nd messenger cascade

6. Explain how and why receptor-field size varies on the skin surface of the human body.

(has to do w/ # receptors/unit area and w/ # of CNS neurons devoted to that part of body
why could include the inability to make everything a "fovea"

7. Calcium, IP_3, and cAMP all play what common role in the context of cellular physiology?

2nd messengers in cells

8. What are two differences in physiology and/or anatomy that would allow you to differentiate between the sympathetic and the parasympathetic nervous systems?

1 CNS Origin
2 Location postganglionic
3 NT
4 Receptors

see lecture 5, 05 Sept 06

9. Give an example of a mechanoreceptive hair cell and briefly explain how sensory transduction works in that cell.

lateral lines, equilibrium/balance organs, hearing transduction

deflection of stereocilia/kinocilia causes mechanical Δ to membrane which changes ion permeability (channels)

10. Explain how nodes of ranvier and the length constant, lambda, are related.

(the gaps in the myelin insulation allow for regeneration of the action potential
the myelin allows the Δ charge to travel farther before dissipating, but the nodes are required to allow for another set of voltage-gated Na^+ channels to contribute to the AP

11. During smolting, increased tolerance to seawater in Atlantic Salmon is correlated with increased levels of which two proteins? Why?

NKCC
NKATPase
} allow for increased osmoregulatory activity

12. Explain how saturation of membrane lipids affects membrane fluidity at a given temperature.

unsaturated (still some double bonds) lipid tails contribute to fluidity, saturation reduces fluidity

13. What is the equilibrium potential (E_{Cl}) for chloride ion (Cl^-) given the following information: $[Cl^-]_{outside}$= 120 mM and $[Cl^-]_{inside}$ = 5 mM (please show your work).

$$E_{Cl} = \frac{58}{-1} \log\left(\frac{120}{5}\right) = -58 \log 24 = -80\,mV$$

14. Which way will chloride (from question 13 above) tend to move (in or out of the cell) if V_m = -90 mV? Given your answer, explain how chloride can play an important role in IPSPs.

Chloride will tend to move out (-90 → -80)
Important for IPSP b/c "clamps" Vm at E_{Cl}

Key

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Distaste for sprouts in the genes, by Helen Pearson; News@Nature.com, 18 September 2006

In the name of science (and for a small fee), 35 brave individuals volunteered to take part in an extensive taste test of raw broccoli, cauliflower, Brussels sprouts and 25 other bitter vegetables. The results help to explain why some people have a natural aversion to these veggies.

Researchers previously knew that the tongue carries a receptor called TAS2R, which comes in several different forms. Only those people carrying a 'sensitive' form of this receptor have been found to be able to taste bitter chemicals such as phenylthiocarbamide (PTC), and researchers had suspected that these same people may be turned off vegetables that contain chemically similar compounds called glucosinolates. But this conclusion was uncertain: in vegetables, the taste of these compounds may be masked by other chemicals.

Sandell and Breslin of Monell Chemical Senses Center in Philadelphia wanted to test the theory. They gave the willing victims 17 raw vegetables known to be rich in glucosinolates — a shopping list that includes some vegetables that have nauseated generations of school kids, such as broccoli, cauliflower, Brussels sprouts, radish and turnips. The volunteers also swallowed 11 vegetables that are bitter but lack glucosinolates, including aubergine, bitter melon and spinach. The veggies were served raw because cooking can alter their taste. Each person chewed the vegetable ten times to the tick of a metronome; then they spat and cleaned their mouth with water and crackers.

Genes for greens

Swabs were also taken of the volunteers' cheek cells so that researchers could determine whether they carried none, one, or two 'sensitive' copies of the taste receptor gene that allows taste of PTC. People carrying two 'sensitive' copies of the gene rated the glucosinolate-carrying vegetables as around 60% more bitter than the group carrying two 'insensitive' copies of the gene. The two groups ranked the vegetables lacking glucosinolates as equally bitter. The findings support the idea that a person's genes (and particularly this gene) help to explain whether they nudge some vegetables to the side of their plate, or gobble them up.

Bitter pill

Our ability to taste bitter compounds is of particular interest to some researchers because such chemicals are often medicinally active — for better or for worse. Researchers have wondered whether being able to taste certain chemicals puts us at an evolutionary advantage.

Glucosinolates can interfere with uptake of iodine by the thyroid, for example. Iodine, found in some salts and seafood, is essential for the synthesis of thyroid hormones, which in turn can affect mental and reproductive growth or development. According to one long-standing hypothesis, in geographic regions where iodine is naturally low, those carrying the 'sensitive' form of the taste receptor may be at an advantage; avoiding foods containing glucosinolates would allow their thyroids to be healthier.

On the other hand, vegetables such as broccoli also carry an assortment of other nutrients thought to be good for health. So in areas where iodine is plentiful, those carrying the 'insensitive' form of the taste receptor gene might eat more of them and benefit. These two opposing selective pressures could be keeping the two forms of the gene in circulation.

Breslin points out that taste alone does not determine whether we eat bitter foods; culture also plays a part in our liking of coffee, beer or liquorice. So taste genes will only make up part of the reason for an individual's vegetable loves or hates. It is also possible that the types or quantities of receptors on our tongues change over time, perhaps explaining why children turn up their noses more than adults at bitter foods.

Question: Choose one aspect of this short article that you would like to expand upon in the context of vertebrate physiology. You could, for example, relate this news piece to other readings you did for this class, further explain the mechanisms underlying the findings, or discuss other examples of adaptive physiology that shed light on this phenomenon. Please use complete sentences. [6 points]

open, but show us you know something
+ can write intelligently

Key 6

***Short Answer* (~ 2 or 3 sentence answers; 36 points total; 4 points each)**

1. Explain the difference between relative and absolute refractory periods at the level of the membrane potential and ion channels.

voltage-gated Na^+ channels inactive briefly after they open. No amt of depolarization will cause them to open

voltage-gated K^+ channels open ∴ Vm further from threshold so takes larger stimulus to get to Vm where voltage-gated Na^+ channels will open

2. Several animals that live in areas with lots of wide open space, but minimal topography, have evolved **visual streaks**. Examples include cheetahs and gazelles. Explain, from the following two perspectives, how visual streaks came to be: 1) natural selection and evolution acting on the whole organism, and 2) natural selection and evolution acting on the physiological mechanisms that underlie the animals' sensory processing.

1) one could argue that selection favored those animals able to integrate a lot of information about the horizon in order to avoid predators or find potential prey

2) in the retina, small receptor fields for photoreceptors that "see" the horizon would allow for these areas to be more greatly represented in the CNS; larger sensory homunculus component for the "horizon".

3. Explain how the sodium and potassium gradients in cells are generated and why they are important.

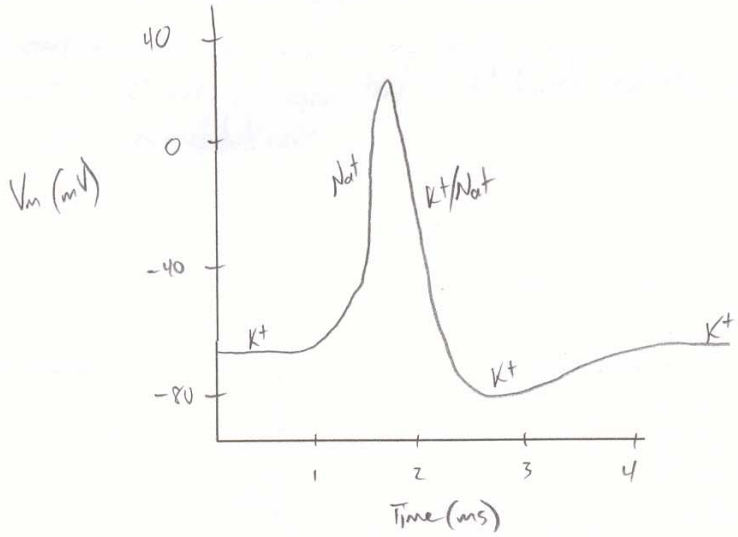
Na^+/K^+ ATPase pump expends a lot of energy maintaining gradients that allow for work to be done like a) moving Glucose against its [ ] gradient via a cotransporter with Na^+ or b) facilitating action potential propagation. Also important for work of osmotic regulation and maintaining cell and organism homeostasis.

4. In the context of body temperature, explain how maintaining homeostasis takes a different amount of energy than anhomeostasis.

Trying to maintain a physiological variable (e.g. temperature, pH, osmolarity, [Glu]) at a certain set point requires the activity of negative feedback systems. This activity requires ATP (see question 3). It is much less energetically costly to allow interior variables to fluctuate w/ environmental variables; the drawback to anhomeostasis include less-than-ideal conditions for enzyme + cell function and perhaps exclusion from certain environmental conditions.

Key 16

5. Using the axes (which you should label) below, draw an action potential in a typical vertebrate neuron. Choose three portions of the action potential to label and describe which ion plays the largest immediate role in the value represented by the curve at that point in time.



6. Use glucose to define and explain the difference between facilitated diffusion and active transport. What other molecules are directly involved?

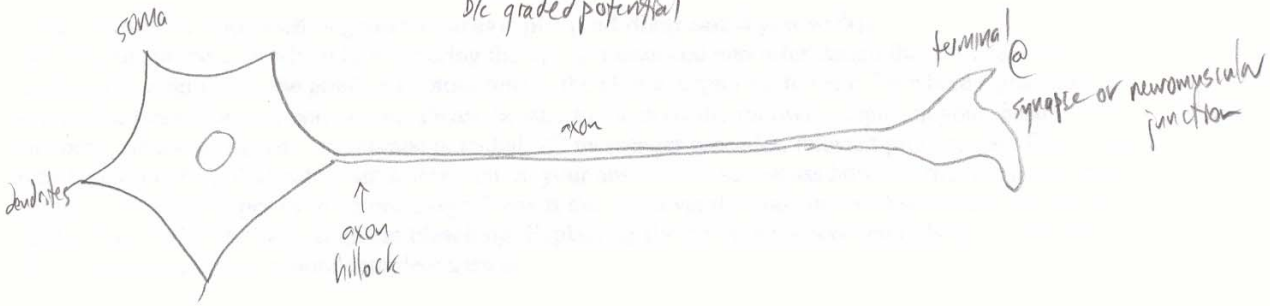
GluT proteins
Na^+
(K^+, ATPase)

down C] gradient
(blood → muscle)
needs carrier protein

against C] gradient
(gut → blood)
symporter w/ Na^+

7. Draw and label a typical neuron. Indicate how two different EPSPs of the same magnitude acting on the soma of this neuron can have different effects on the likelihood that the neuron will fire an action potential.

location relative to hillock b/c graded potential

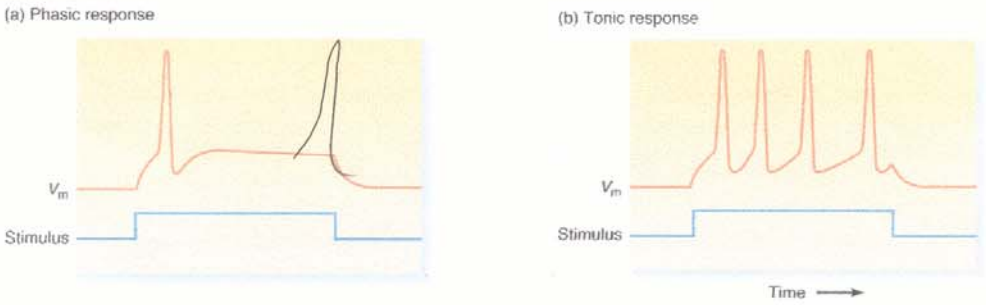


Key 12

Key

8. How could you use two of the five qualities within the taste modality to explain the concept of *ionotropic vs. metabotropic receptors*.

salty – Na+ channel; even faster than ionotropic b/c no receptor
bitter – IP_3 2nd messenger ~ metabotropic
sweet – cAMP 2nd messenger ~ metabotropic
sour – H^+ binds to receptor that is K^+ channel that then closes
umami – ~metabotropic



9. Neither of the above figures is a good depiction of the response of a Pacinian Corpuscle. How would you modify (a) or (b) to make the response more accurate for a Pacinian Corpuscle? Why?

b/c records Δ in stimulus

***Essay Answer* (13 pts; well-organized paragraphs [and diagrams if you wish]).**
Describe the process by which light entering the eye is transduced into information that the brain can understand. Begin from the point of photons hitting the photoreceptor up to the point where signals are sent toward the brain from the optic nerve. Please be sure to touch on the following topics in your discussion: anatomy, acuity, sensitivity, membrane potential, 2nd messenger cascades, relevant proteins, etc. Diagrams may be used to help illustrate your description. In your answer please discuss how information is processed among several cell types even before a signal leaves the retina via the optic nerve. Also be sure to explain the mechanism behind photopigment bleaching. Explaining the differences between rods and cones will likely help you provide a more complete answer.

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6
1
1
1

3 for writing per se.

Key 21