Synaptic Transmission II: Postsynaptic Mechanisms
Problem Set

Metabotropic receptors typically have 4 or 5 subunits.
True
False

Receptors with non-selective cation conductance have a reversal potential of ~ 0mV.
True
False

Activating a $GABA_A$ receptor can depolarize or hyperpolarize a cell.
True
False

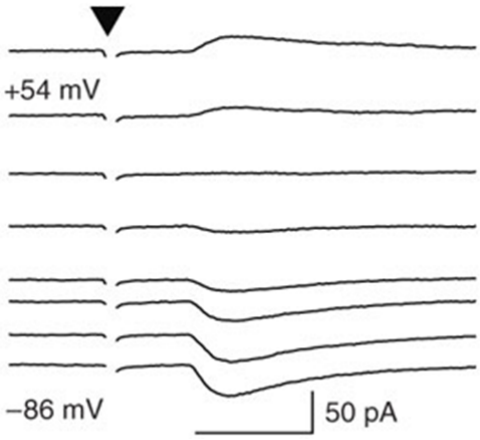
NMDA receptors have similar ion permeability as AMPA receptors, except they are also permeable to chloride.
True
False

NMDA receptors bind which of the following (circle all that apply):
A. AMPA
B. Ca^{2+}
C. GABA
D. Glutamate
E. Glycine
F. Kainate
G. NMDA

Typically, glutamatergic synapses express either AMPA or NMDA receptors, but not both.
True
False

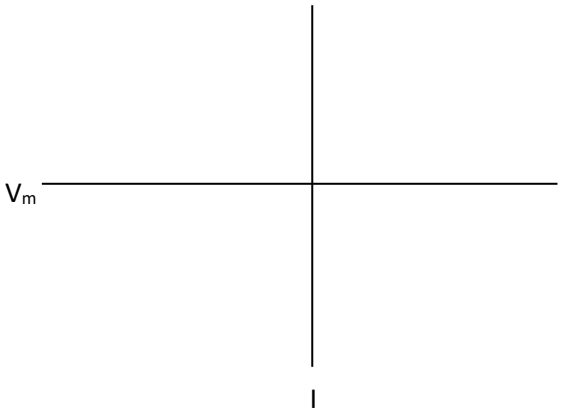
The native neurotransmitter for a receptor composed of GluAs1-4 is (circle all that apply):
A. AMPA
B. GABA
C. Glutamate
D. Kainate
E. NMDA

You are making whole cell patch clamp recordings on cells in cerebellum slice preparation. While recording from a cell, you are able to stimulate a bundle of axons (presynaptic to your cells) and cause those axons to generate action potentials. Your internal solutions and extracellular solutions are typical, meaning that ion reversal potentials are typical. The set of sweeps below shows the responses you observed while holding the postsynaptic cell at different membrane potentials (ranging from -86mV to +54 mV in steps of ~20mV). Timing of the axon stimulation is denoted by the arrow head.



X ms

Construct a current/voltage (I/V) plot of the results:



Based on this information, is this synapse most likely to be **excitatory** or **inhibitory**? In one sentence, explain your reasoning.

Excitatory because it led to an action potential

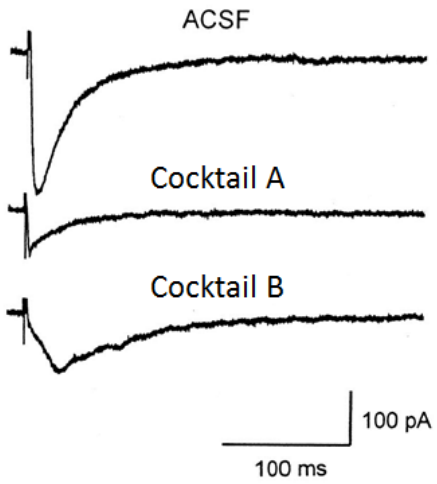
If the postsynaptic receptors are not metabotropic, what is the most likely value for X in the time scalebar: 0.5 ms 5 ms 50 ms 500 ms
In one sentence, explain why.

not metabotropic, most likely 5 ms as metabotrpic are generally slower

Like the problem above, you are once again making whole cell patch clamp recordings – only this time in the inferior colliculus. No sooner had you been able to see a nice postsynaptic response holding the cell at -60mV (which is E_{Cl} for your recording solutions) in control conditions (ACSF – artificial cerebrospinal fluid, top trace in recordings below) than a colleague, Pandora, rushes up to you with a box. "You know that freezer in the hallway that hasn't been opened since 1997?" she says. "Well, I was cleaning it out and found this!" She hands you the box, and after knocking off some of the thick frost that had accumulated, you see that the box is labeled "Receptor Drug Cocktails". Opening the box, you see only two different color tubes of drugs remaining. There are also some really old strips of tape that apparently used to label the tubes, but through time and the cold conditions had peeled off of the tubes. You find 4 different labels for the tubes:
Stry + Bic
ACET + CPPG
APV+ Stry + Bic
CNQX + Stry + Bic

You think these abbreviations are probably referring to the following drugs:
Strychnine – blocker of glycine receptors
Bicuculine – blocker of $GABA_A$ receptors
ACET –blocker of kainate receptors
CPPG – blocker of metabotropic glutamate receptors
APV – blocker of NMDA receptors
CNQX – blocker of AMPA/kainate receptors

In a new set of recordings, you apply the drugs from one of the tubes (A and B below), and see the following result:



After presenting these results at lab meeting, Pandora and another lab member, Prometheus, are discussing their thoughts in the breakroom. Pandora thinks the two tubes are "APV+ Stry + Bic" and "CNQX + Stry + Bic" while Prometheus thinks the two tubes are "Stry + Bic" and "ACET + CPPG".

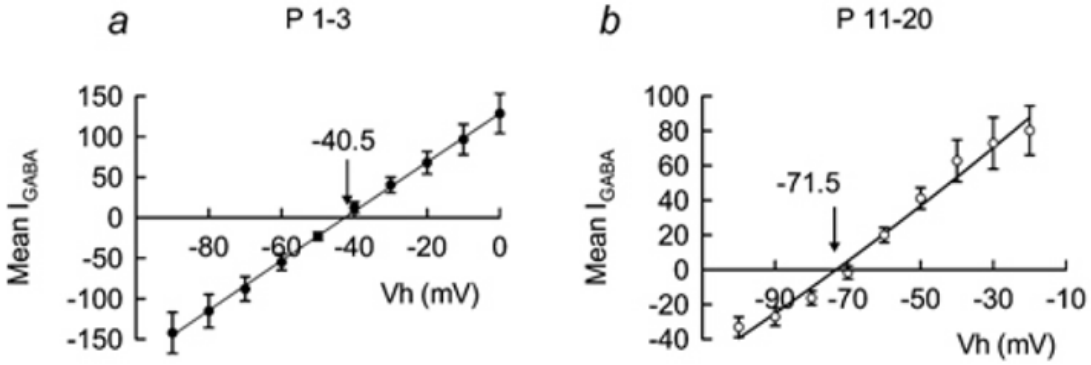
Who is most likely correct?

Using a few sentences, explain why the other person must be wrong. (Assume no other receptors are possible other than the ones blocked by the list of 6 drugs; e.g. don't worry about acetylcholine receptors, etc.)

Which label goes with Cocktail A?

Which label goes with Cocktail B?

Below, the current-voltage relationship for GABA receptors in rat neocortical neurons is plotted for different developmental times: 1-3 days after birth (left, a) and 11-20 days after birth (right, b).



Changes in the cytoplasmic concentration of which ion or ions might underlie the difference seen above?

Na^+ K^+ Cl^- Ca^{2+}

If the resting membrane potential of a neuron is -60 mV, and the action potential threshold of the cell is -45 mV, use one sentence to explain how GABAergic synaptic transmission influences the excitability of the neuron at these two developmental times.

If the resting membrane potential was -80 mV instead, would that change your answer? If so, explain how in a sentence.

If the action potential threshold was -35 mV instead, would that change your answer? If so, explain how in a sentence.