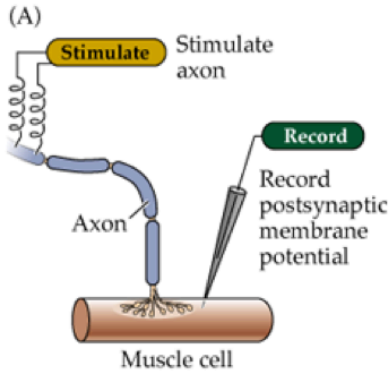
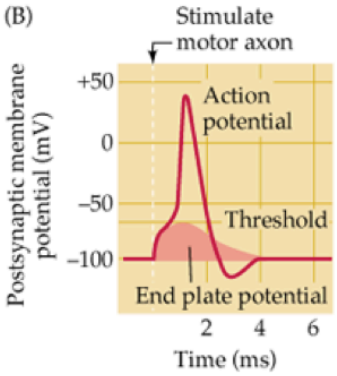
MCB 80 – Section Week 3 Worksheet **TF: Alix Lacoste**

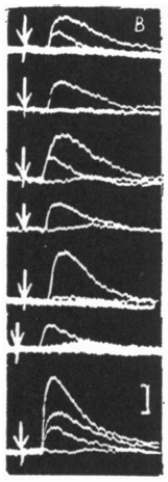
Quantal Analysis

The experiment:





lower $[Ca^{2+}]_{external}$ =>



epp = end-plate potential (general term is epsp for excitatory post-synaptic potential)
mepp = miniature end-plate potential (general term is mepsp) = quantal unit

No more APs, only epps and mepps

Quantal hypothesis: Single, spontaneous quantal events (mepps) represent the building blocks of for the synaptic potentials evoked by stimulation (epps).

m = "quantal content" = mean number of quanta (a.k.a. vesicles) that are released to make up the end-plate potential (epp)

<u>There are two ways of calculating m.</u>

<u>First method:</u> (this is essentially a restatement of the hypothesis!)

$$m_1 = \frac{epp}{mepp}$$

epp = mean amplitude of epp response (the post-synaptic response to one or usually more quanta being released)
mepp = mean amplitude of miniature epp (in response to one quanta released)

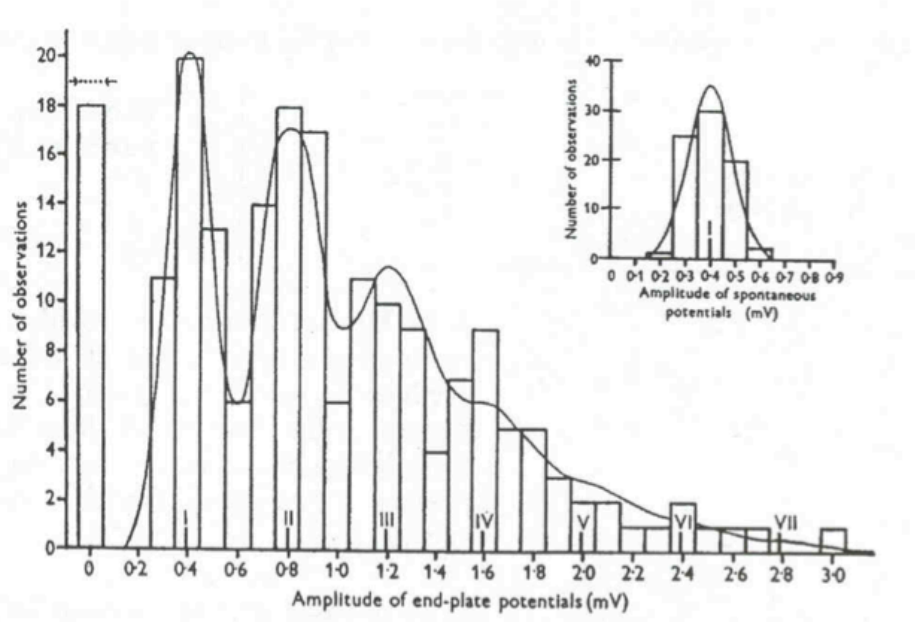
<u>Second method:</u> (probabilistic)
Failures and variability in EPP amplitude implied probabilistic nature of transmission
Katz and colleagues considered models in which there were **n** quanta (vesicles) available for release with probability **p**.

$$m_2 = n \times p$$

One special case that accounts for situations where n is very large, and p is very small is Poisson statistics. After a little bit of math, you can arrive at:

$$m_2 = \ln(\frac{trials}{failures})$$

If $m_1 = m_2$, then transmitter release from vesicles obeys Poisson statistics.



Bars: observations
Line: sum of predictions from Poisson statistics

Some definitions:
Quantal content (m): (see definition on first page) = quantal number: the number of quanta that are released, measured by the size of the epp in mV. It is modulated pre-synaptically by changing transmitter release.
Quantal size: the size of 1 quanta, measured as the smallest post-synaptic depolarization (mepp) in mV, i.e. the response to a single vesicle being released. It is modulated post-synaptically by changing the response to transmitter release.

Perturbation	mepp	epp	quantal content (m)	quantal size	pre or post?
Decrease $[Ca^{2+}]_{ext}$	⇔	⇓	⇓	⇔	pre
Increase # receptors on post-synaptic terminal	⇑	⇑	⇔	⇑	post
Add botulinum toxin	⇔	⇓	⇓	⇔	pre
Increase # voltage-gated Ca^{2+} channels on pre-synaptic terminal	⇔	⇑	⇑	⇔	pre
Add serotonin to the bath (provided the pre-synaptic cell responds to serotonin)*	⇔	⇑	⇑	⇔	pre, facilitation

* serotonin (5-HT) can have different roles. In class, we saw that a particular 5-HT receptor, a GPCR, leads to a signaling cascade where the formation of cAmp activates protein kinase A, which in this case leads to the closing of K+ channels. As a result, the post-synaptic cell's response is longer (see slide 20 of lecture 8 for all the steps.)