Virtual Current- and Voltage-clamp Labs for Students' Practical Courses

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The teaching software **cLabs-Neuron** offers computer animations and simulations for a better understanding of basic neurophysiology. These programs, so far, have mainly been used in **lectures** and **seminars** and for students **home-studies.**

Now, we have modified the cLABs-Neuron teaching applets for utilization in **student's practical courses** according to the "**Virtual Physiology**" series (SimNerv, SimPatch, SimHeart etc.). This also includes detailed **tutorials, manuals** and **protocol forms**.

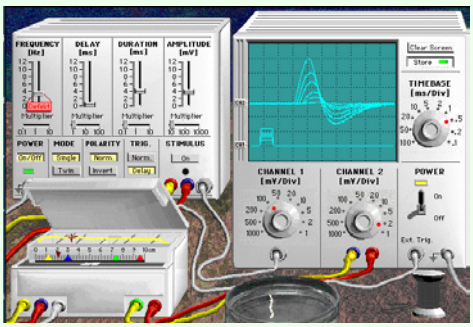
Main emphasis of the **Virtual Physiology** programs is laid on a realistic lab environment and the understanding of the experimental setup.

cLabs-Neuron instead focus on teaching of principle neuronal dynamics as a prerequisite for successful experimentation and data interpretation in virtual as well as real neurophysiology labs.

Accordingly, cLabs-Neuron prefers an easy to overlook **screen design for intuitive experimentation**.

Examples:

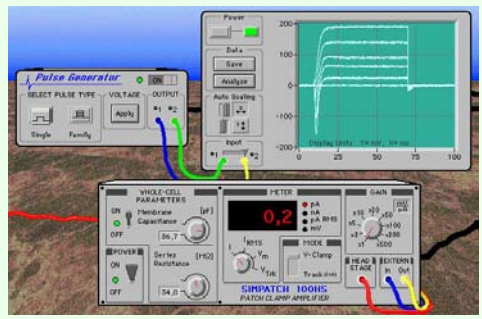
- the neurophysiology labs **SimNerv** and **SimPatch** of the **Virtual Physiology** series



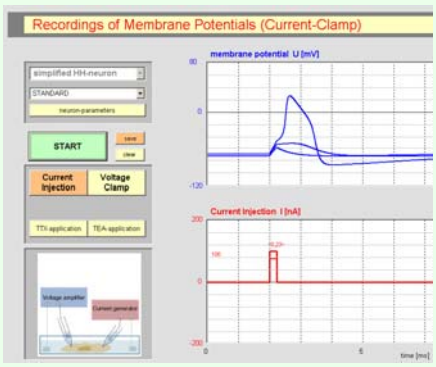
Realistically appearing virtual labs, where successful experimentation essentially depends on correct handling of the virtual devices.

SimNerv (extracellular recordings from isolated nerve fibers; left): The amplitude of compound action potentials gradually changes with stimulus strength.

SimPatch (patch-clamp recordings from single neurons; right): Na^+- and K^+- ion-currents in response to stepwise changes of the clamp voltage.

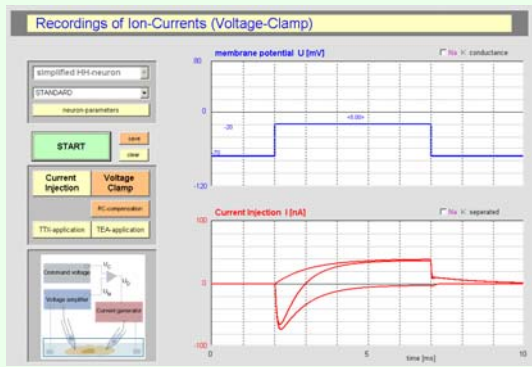


- and the **current- and voltage-clamp** labs of **cLabs-Neuron**



Experiments with more easily accessible control parameters

- Action potential as an all-or-none response of a single neuron and sub-threshold responses with and without local potentials (TTX application) recorded in the current-clamp lab (left).
- Ion currents during a single voltage-clamp step recorded in control solutions and during TTX and TEA application, respectively, in the voltage-clamp lab (right).



BACKGROUND and CONCEPTS :

The idea for cLabs-Neuron came from our experience with student difficulties to understand the interrelations between changes of membrane potentials, voltage dependent ionic conductances and currents, and effects of the driving force.

This was the reason for us to develop a more easily accessible virtual lab where the students can do basic voltage-clamp AND current-clamp experiments.

Indeed, we have seen that students can attain a much better understanding of such interrelations when they can change, by own hands, the control parameters and immediately see the effects on the neuron's response.

Tutorials / Manuals for Experiments in the Current- and Voltage-Clamp Lab are provided which include:

1) an overview on the functional elements
of the current and voltage-clamp lab and the neuron editor

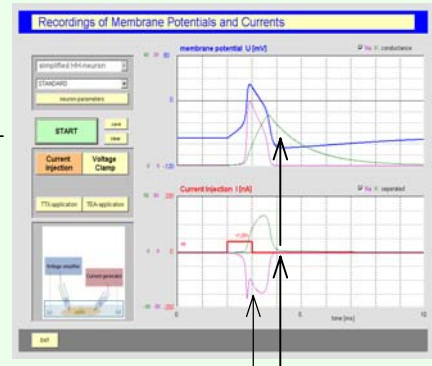
2) an introductory manual/tutorial
basic current-/voltage-clamp experiments and work with the neuron editor

3) suggestions for students experiments
detailed descriptions of students' tasks and brief repetition of required knowledge

4) protocol forms
for students and teachers, the latter showing typical results (obtained from the „standard neuron").

cLabs-Neuron uses simplified Hodgkin-Huxley type algorithms. A „**Neuron Editor**" allows to change the neuron parameters.

Example from the Introductory Manual: Ion currents - Conductances - Driving force



In the upper diagram you can see:

1) that the first part of the depolarization is purely passive,

2) that the fast upward deflection is correlated with fast activation of the Na-conductance

3) that repolarization is associated with both g_{Na} decrease and g_K increase,

4) that after-hyperpolarization results from the fact that g_K is still increased when g_{Na} is already back to zero.

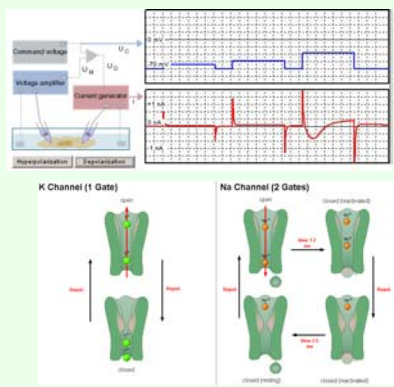
Can you explain:
- why the Na-current transiently decreases?
- why the I_K is almost back to zero when the g_K is still relatively high?

Hints: use **Ohms Law** but don't forget to consider the "**Driving Force**".
go to the voltage-clamp lab for a better understanding (see below).

Example from the Tutorials: Suggestions for Students' Experiments - which also refer to other cLabs-Neuron tools

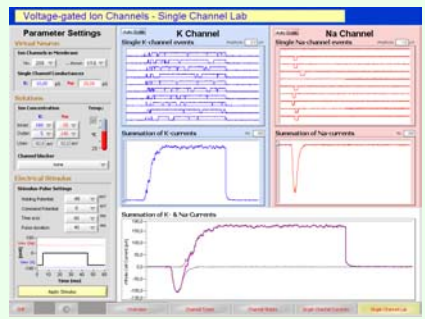
5. Basic Voltage-Clamp Experiments:

5.1 Before you are going to do the voltage-clamp experiments we recommend first to visit the module "**voltage- and current-clamp introduction**" which gives you some more information about the different recording techniques.



5.2 You additionally can prepare for these experiments with the "**single-channel**" module. At least you should know the basics of ion channel activation and inactivation as illustrated in the submodules "channel-types", "channel-states" and "single-channel currents".

5.3 You also should do some basic experiments in the "**single-channel lab**" (see figure below) before going to the "voltage-clamp lab".



Example from the Protocol Forms (Teachers Version)

(Principle results are shown on the right)

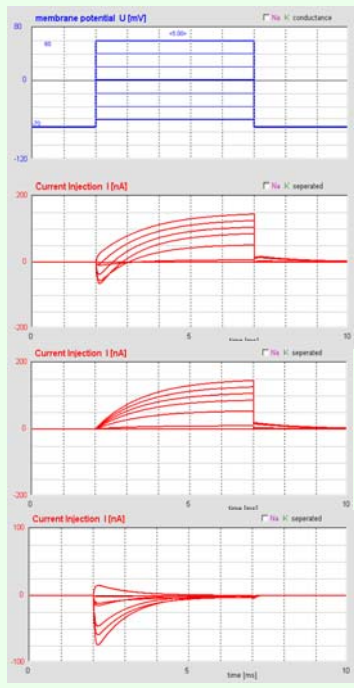
6. Voltage-Dependencies of Na^+- and K^+-currents:

6.1 Apply a complete "family" of command voltages (different voltage steps) from the same holding potemtial) to see how the current curves change.

6.2 Do the same experiments again
- 6.2.1 with application of TEA
- 6.2.2 with application of TTX

Can you explain why the amplitude of the K-current increases monotonically with increasing command voltages whereas the maximum value of Na-currents first increase but then decreases and even turns into an opposite direction?

Use these recordings to plot the Current-Voltage-Curves (**I-V-curves**, see # 7) and to deterrnine the voltage-dependent **conductances** (see # 8)



More information is given at our homepage

www.clabs.de

which also offers **free access** to many of the cLabs-Neuron applets

and provides **ordering informations** for **cLabs-Neuron**

as well as for the **Virtual Physiology** programs

In case of any questions don't hesitate to send a mail to

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see also

www.uni-marburg.de/physiology/braun

for your cards