Electrodes: bio-electronic interface.

	METAL	SOLUTION (brain).
Charge carriers:	e^- e^-	IONS!

↑ double layer: separates the two systems.

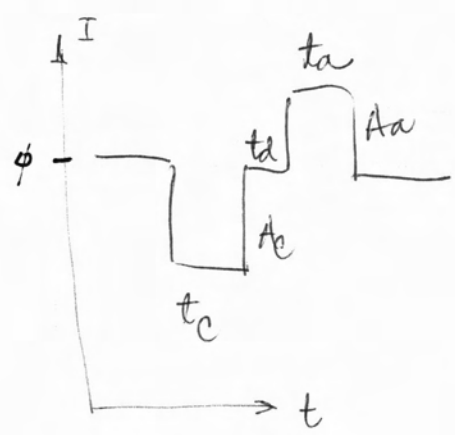
Definitions:

- IPE → ideally polarizable electrode (C)
- INPE non- " (R)

- Reversible = desirable for in vivo & in vitro tests.
- Irreversible = electrode damaged after use.

- CSC charge storage capacity
- CPP charge per period max(CPP) = CSC
- J, I, Q → traditional definition.

Charge balance:



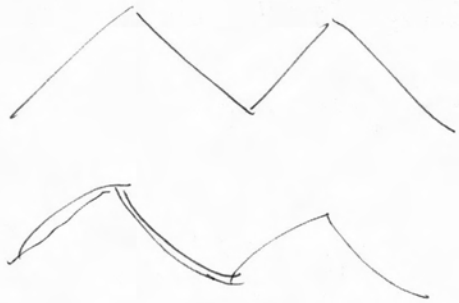
necessary condition

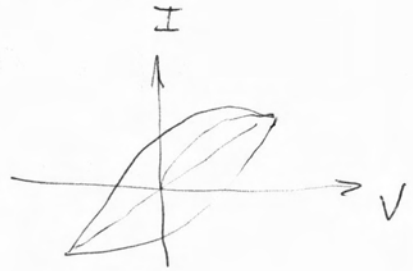
$$t_c A_c = t_a A_a$$

Cyclic Voltammetry (CV)

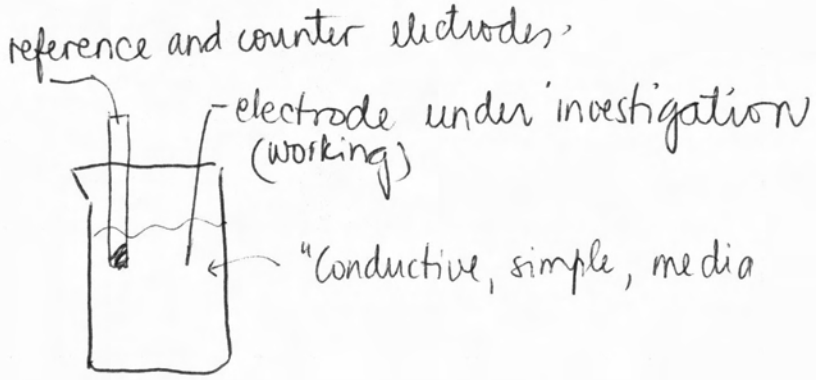
IMPOSE ⇨ V

MEASURE: I





SYSTEM:



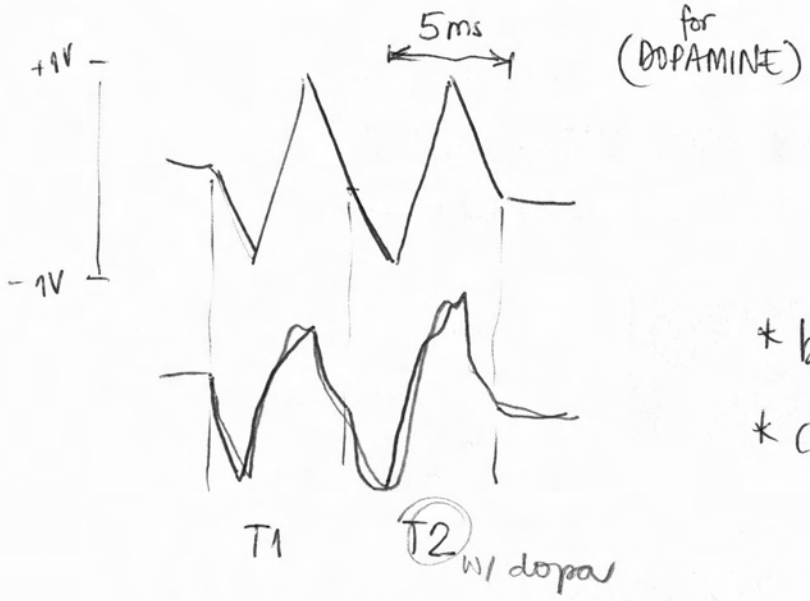
CV: scan rate defines your target molecule or process. Molecules have to be "electroactive"

Ex. - dopamine* detection: fast CV (> 1V/s).

- O_2 (molecular Oxygen) < 100mV/s
- capacitive effects: usually < 100mV/s.

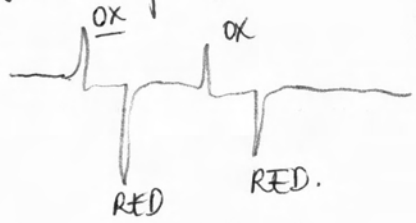
* dopamine: neurotransmitter. Synthesized in the body (by neurons + adrenal glands). It's a precursor to epinephrine + norepinephrine.

EXAMPLE OF FCV:



* background current
* carbon fiber electrode

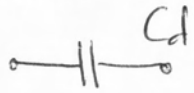
difference: $f(T2) - f(T1)$



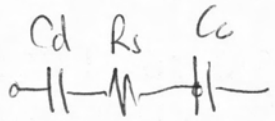
SLOW CV : trying to get the most charge out of the electrode in the brain.

(Derive –)

Electrode model:



In solution:



counter electrode.

$Q = C\frac{dv}{dt}$

$C = \frac{\varepsilon A}{d}$

$V = RI$

$q = \int i\,dt$

System response to:

voltage ramp:

$E = vt$, where E in $[V]$, v in $\left[\frac{V}{s}\right]$ (sweep rate)

t time $[s]$

$$vt = E_s + E_d$$

$$vt = R_s i + \frac{q}{C_d}$$

$$vt = R_s \frac{dq}{dt} + \frac{q}{C_d}$$

$$\frac{dq}{dt} = \frac{v}{R_s}t - \frac{q}{R_s C_d}$$

initial condition: $t=0$. $q=0$. (

$$i = C_d v\left[1 - e^{-t/C_d R_s}\right].$$

for $t \to \infty$, $i = vC_d$

sweep rate

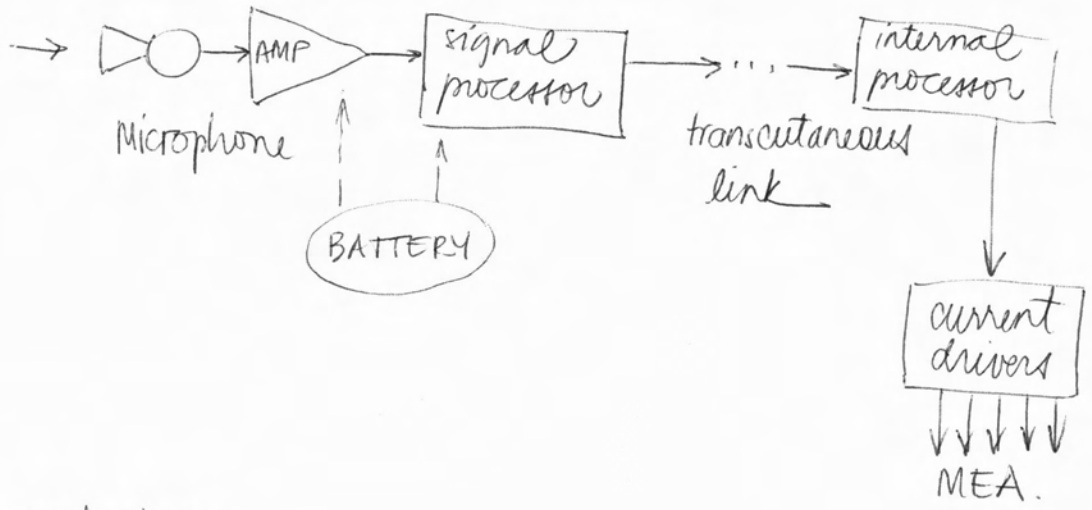
COCHLEAR IMPLANT

first test: 1800, Volta — electrodes in each ear, prob. 50V discharge — he describes he heard a huge noise/bang. Never tried it again.

1957 — Djourno + Eyries: 1 patient, identifies rhythm of speech.

Major advancement: 80's → from one electrode to MULTIELECTRODES — better results.

Block diagram:



Websites:

www { bionics, cochlear, medel. } .com

1999: 900,000 Americans could not function without the use of a hearing aid.

How does it start?

Conductive: may be temporary. Outer or middle ear prevent signal from being transmitted.
* Usually mild hearing loss – surgery, medication, or hearing aids can help.

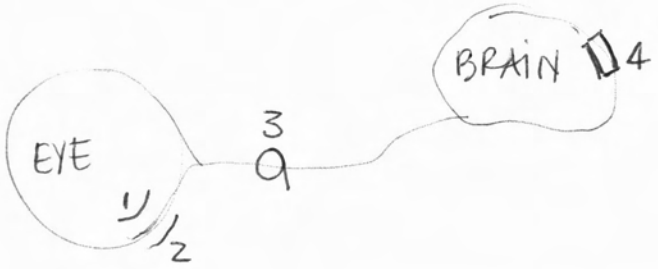
Sensorineural: missing hair cells. Usually permanent.
No surgeries! Hearing aids can help, as well as the cochlear implant.

Neural: absence or damage ~~of~~ to auditory nerve.
↳ cochlear implant won't help.
maybe brainstem implant (100 people implanted in the U.S.A., versus 20K in 1999).

RETINA IMPLANT

* EYE - how it works.
* Blindness
  - birth
  - retinitis pigmentosa
  - macular degeneration

* Strategies:
  - Subretinal : 1
  - Epiretinal : 2
  - Optic nerve : 3
  - LGN / cortical : 4



Advantages / disadvantages of each:

- surgery / placement / infection
- processing
- repeatability from patient to patient

HOMEWORK → due 09/11 – 7pm.

Nature Vol 442 | 07/13/06 – p 164 – 171

Neuronal ensemble control of prosthetic devices by a human with tetraplegia.

Leigh R. Hochberg et al.

① It's easy to suggest improvements on ~~this~~ the BrainGate®. What do you think would be a straightforward, feasible next step?

② a. Two points that surprised you or:
b. Two things that you can't understand.

③ What ~~is~~ was – in your point-of-view – the bottleneck for this technology to take off?

④ Cite at least one failure mode with this project (why wouldn't it work ~~for a long~~ in a long-term situation?)