

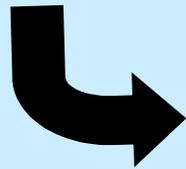
Biophysical principles of sensory function

Participants of sensory function

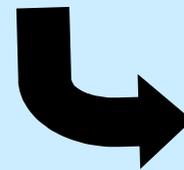
stimuli
from the external
or
internal environment



Specific
transducers - **receptors**



neurons



**Central
nervus system**

Parameters of the stimulus

What?

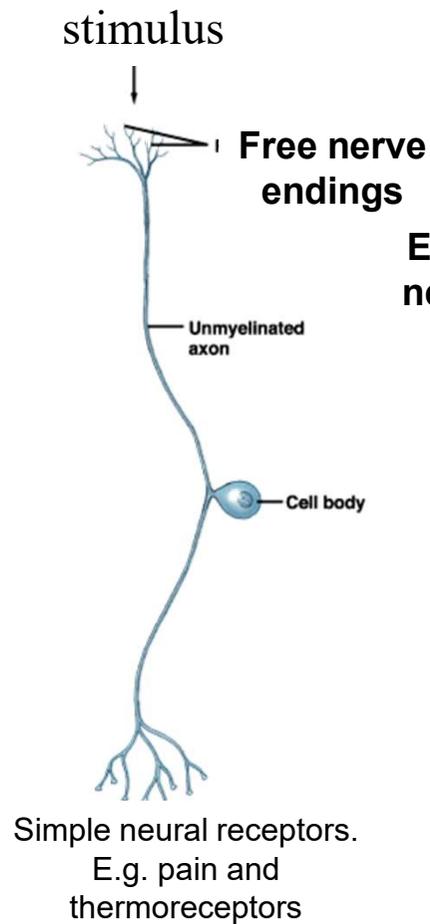
Where?

How much?

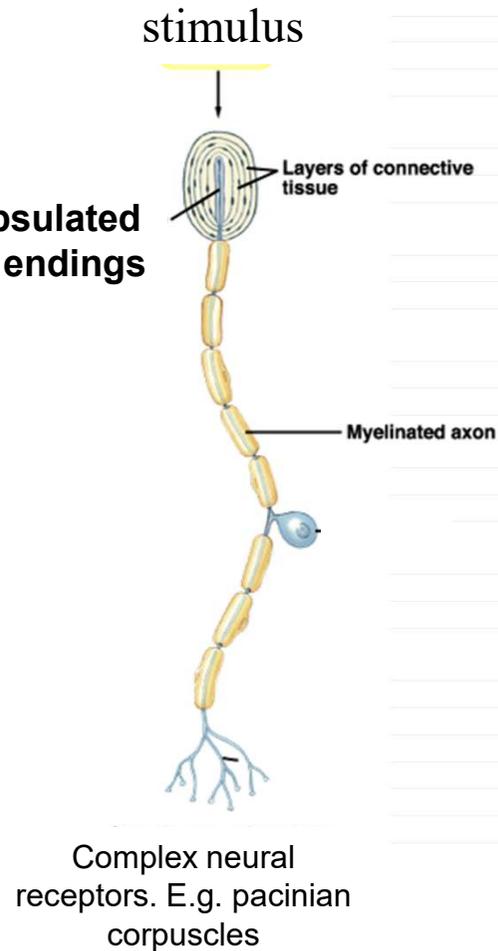
How long?

Types of Sensory Receptors

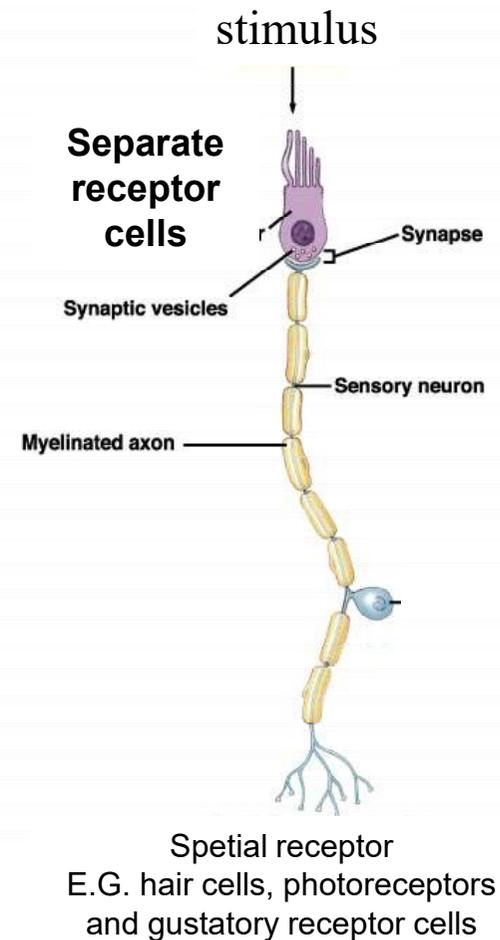
Primary receptor



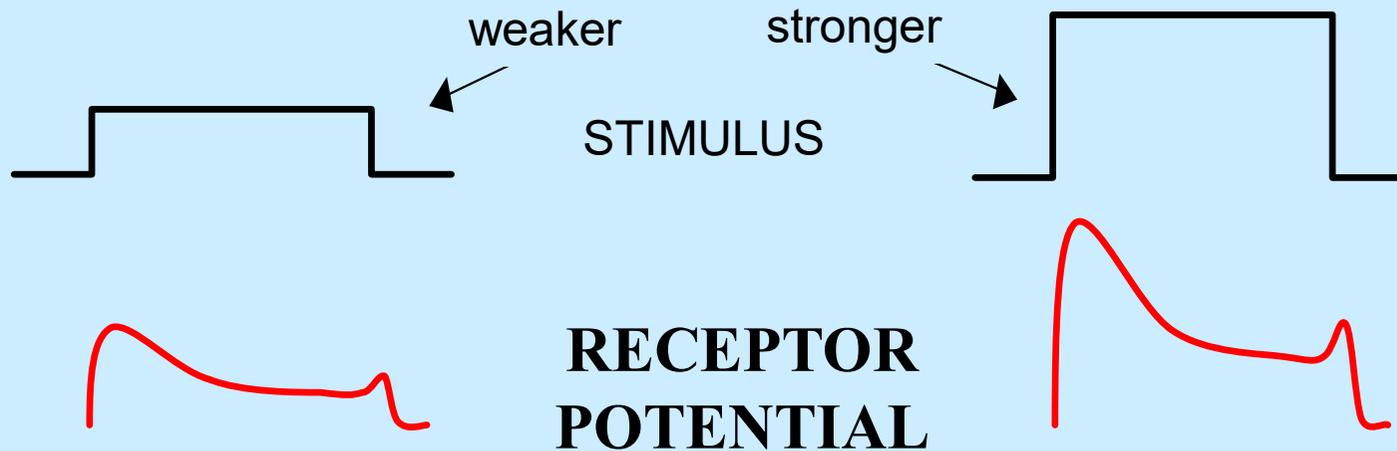
Encapsulated nerve endings



Secunder receptor



Reaction of receptor cell for specific stimulus

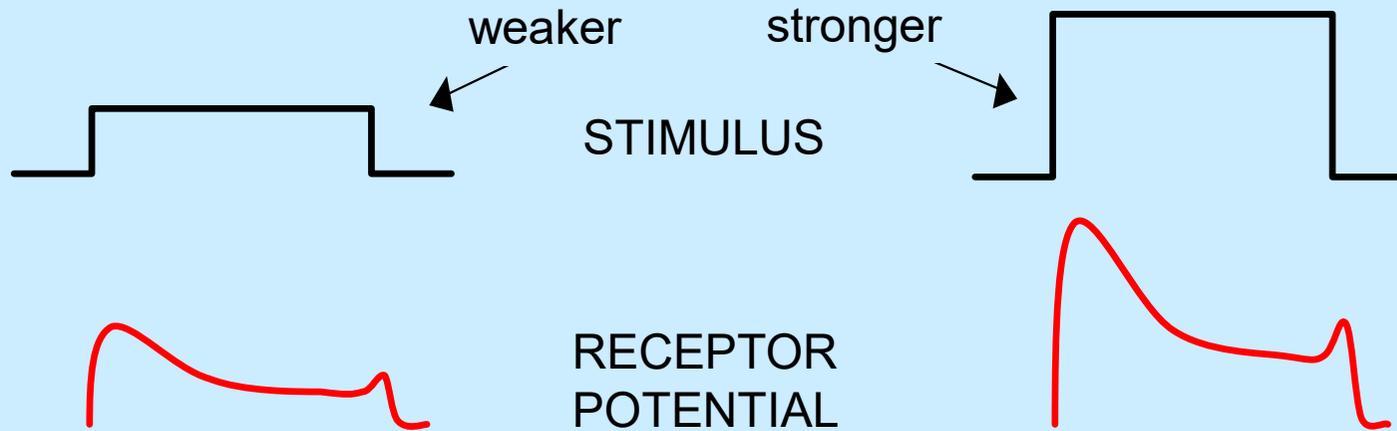


Answer is general and uniform:

alteration of the membrane potential on receptor cell

RECEPTOR POTENTIAL

Analogue signal conversion



Its amplitude is proportional to the stimulus amplitude.

Its duration is identical to the stimulus duration

It is a local potential change.

It is not Na-potential.

Stimulus

Code

What?



Type of receptor

Where?



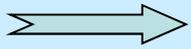
Receptive field

How much?



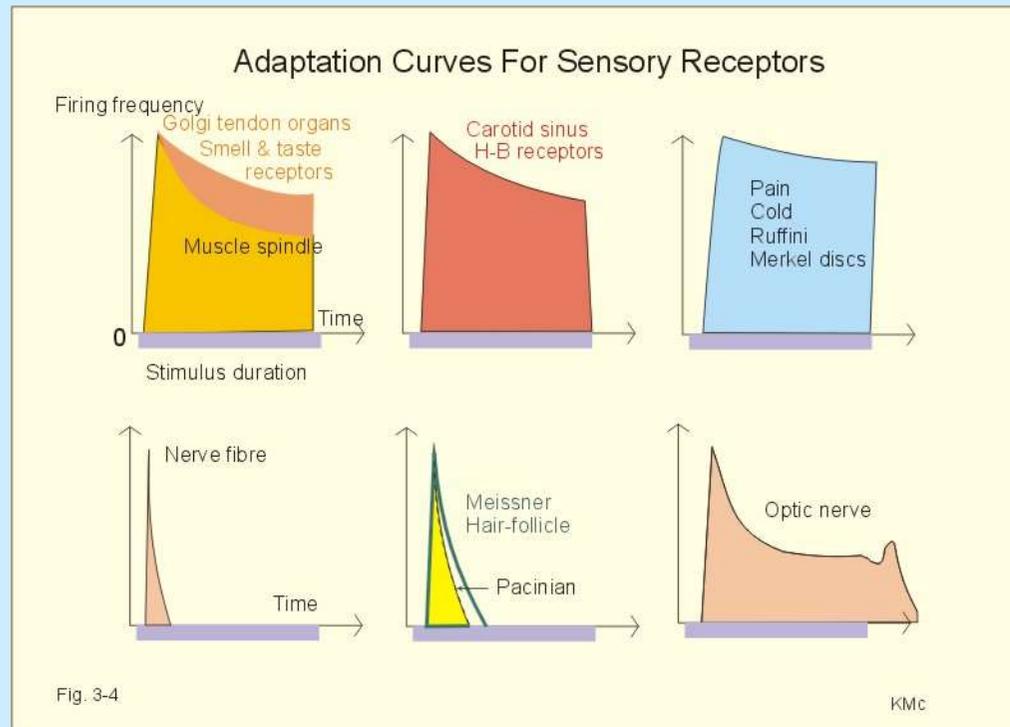
Amplitude of receptor potential

How long?



Duration of receptor potential

Adaptation of Receptors



Rapidly adapting receptors (Rapid receptors): e.g. pacinian and hair receptors
detect the change in stimulus strength (detect movement)

Slowly adapting receptors (Tonic receptors): e.g. joint capsule, muscle spindle
detect continuous stimulus strength (give report to the brain about the status of the body).

Non adapting receptors: pain receptors and chemoreceptor

Transition of information from receptor to neuron / axon

Secunder receptor \Rightarrow synapse \Rightarrow axon

receptor potential

neurotransmitter

?

quantity

quality

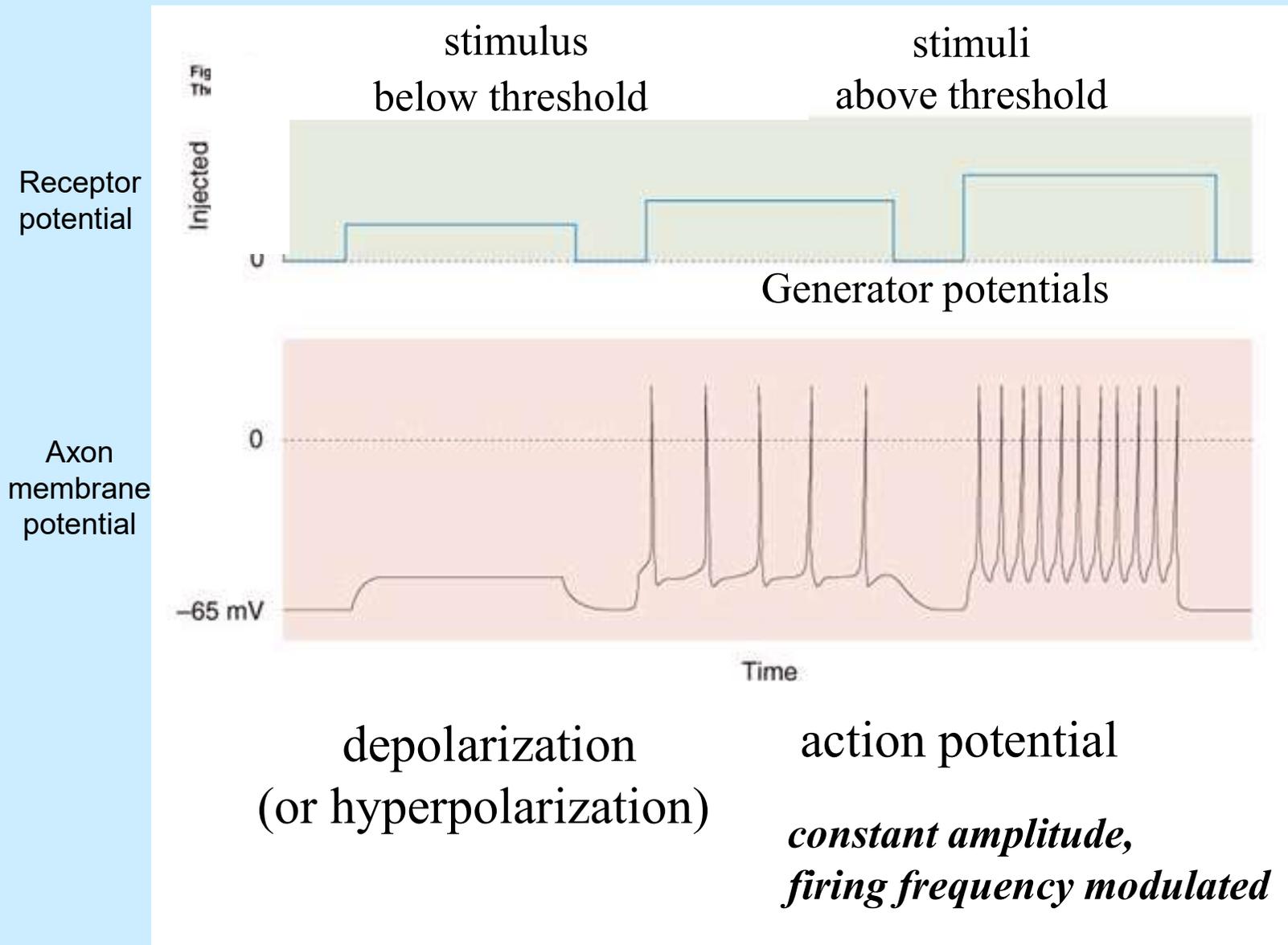
Primery receptor \Rightarrow local currents \Rightarrow axon

receptor potential

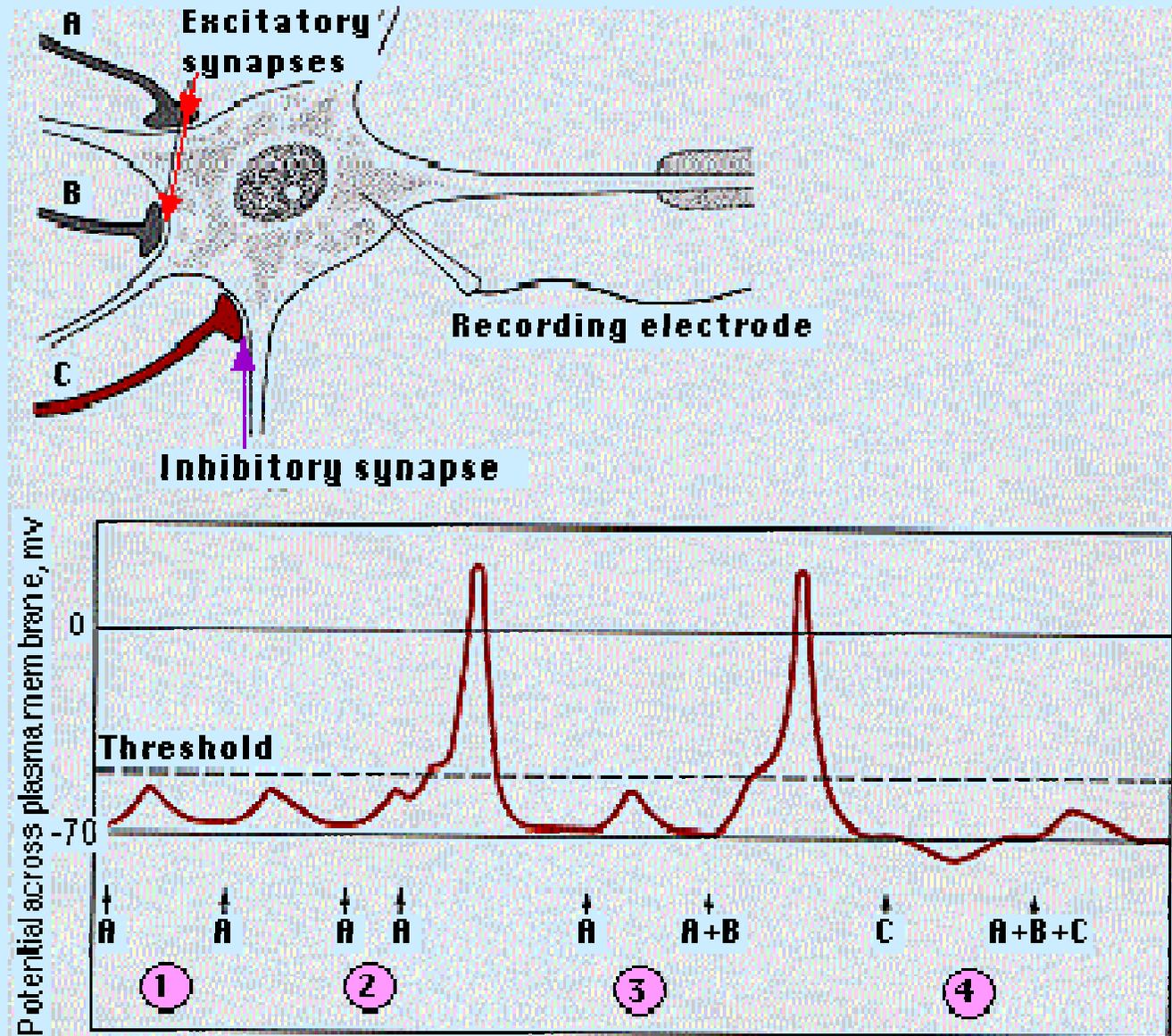
current intensity

?

Receptor potential acting on nerve cell membrane



Temporal and spatial summation



Stimulus threshold



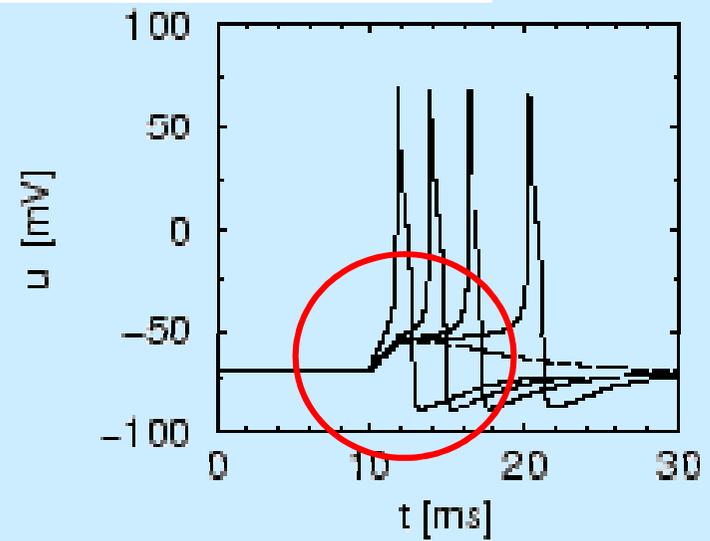
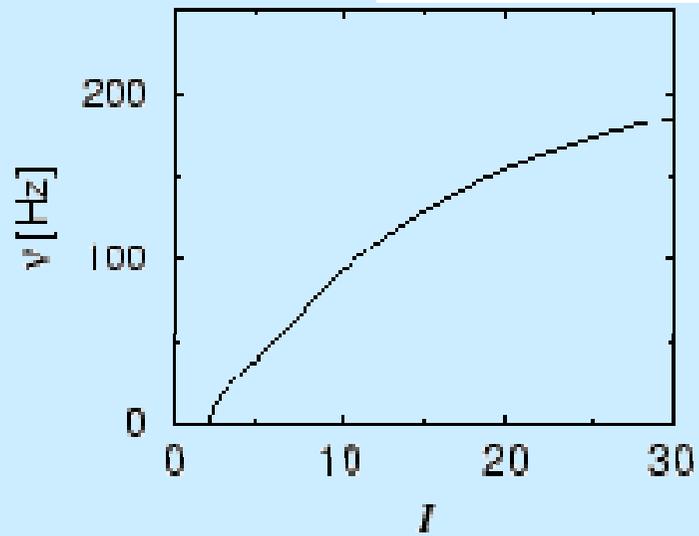
1.6 x threshold



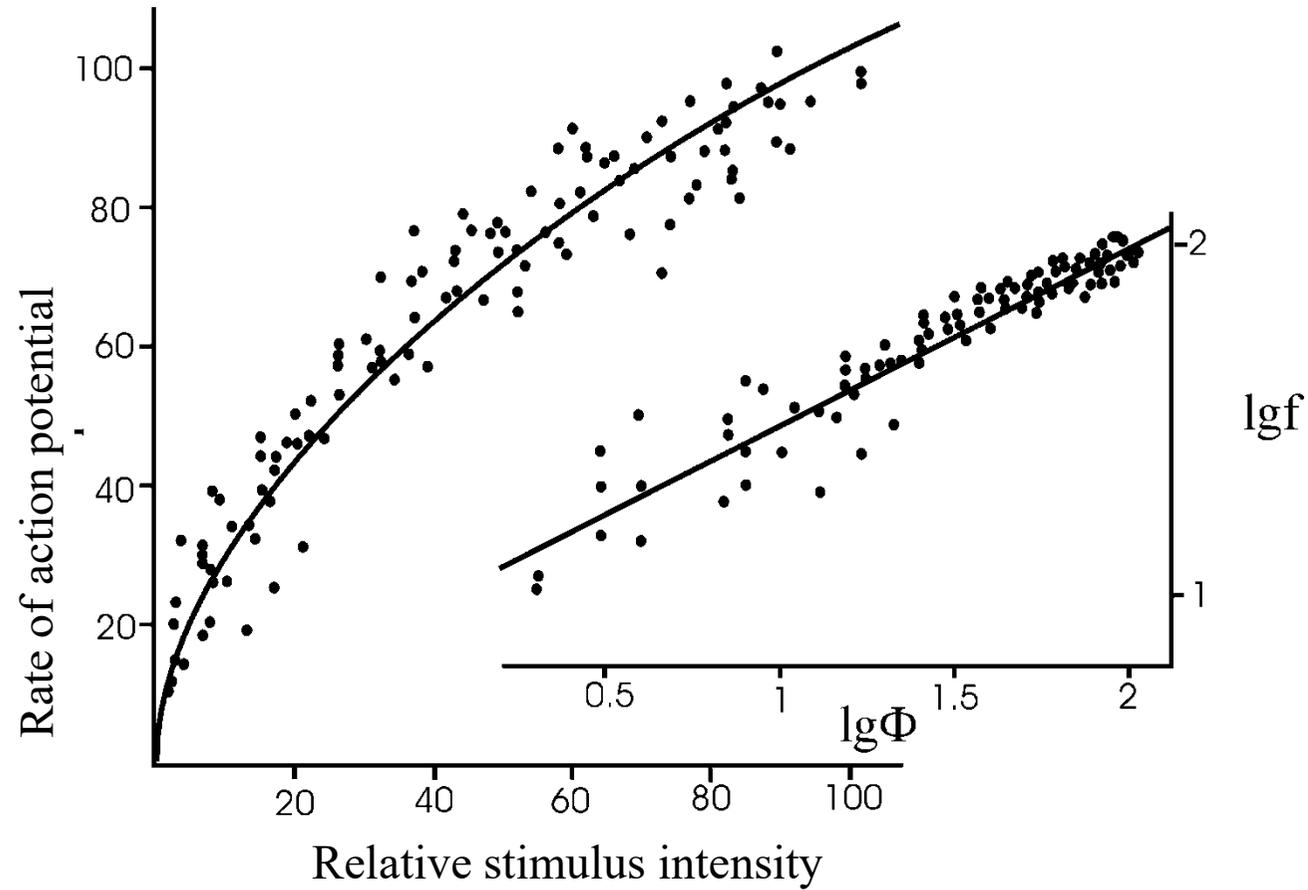
2.7 x threshold



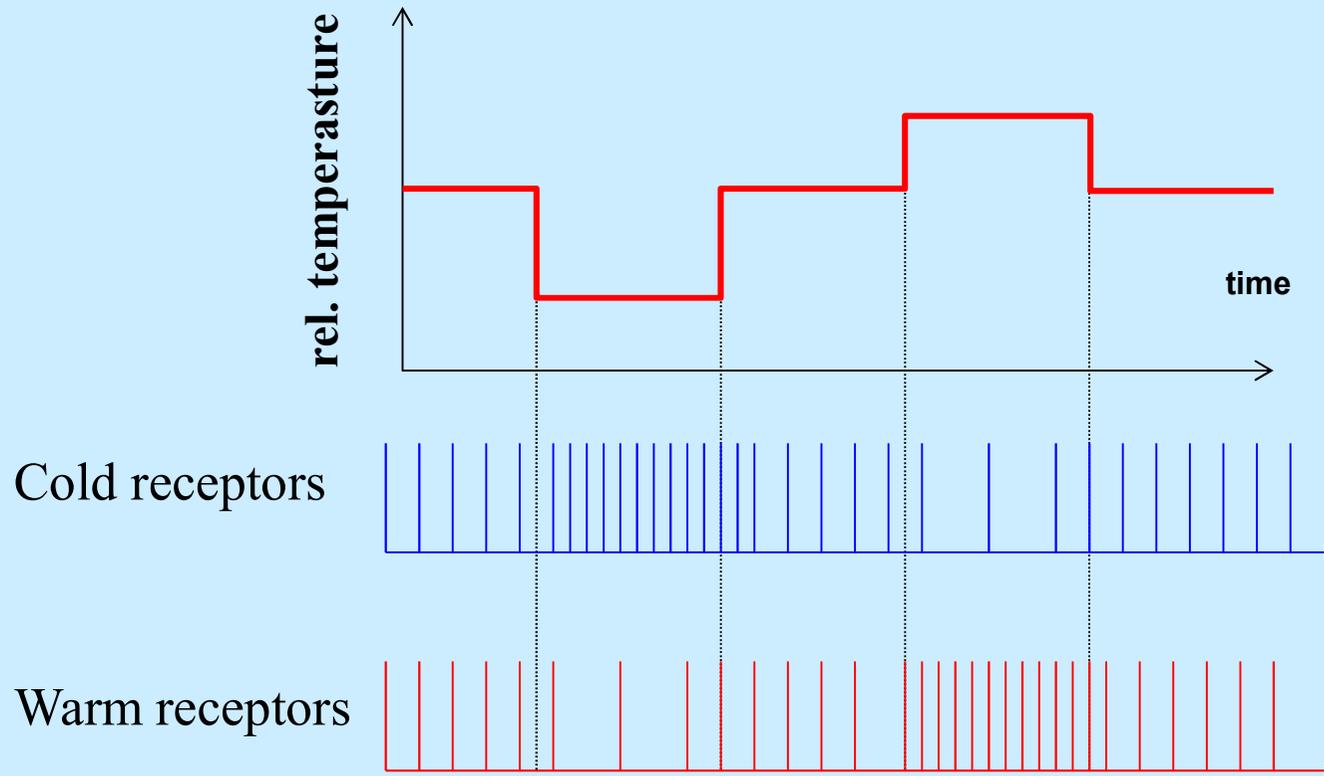
500 msec



AP frequency and stimulus intensity



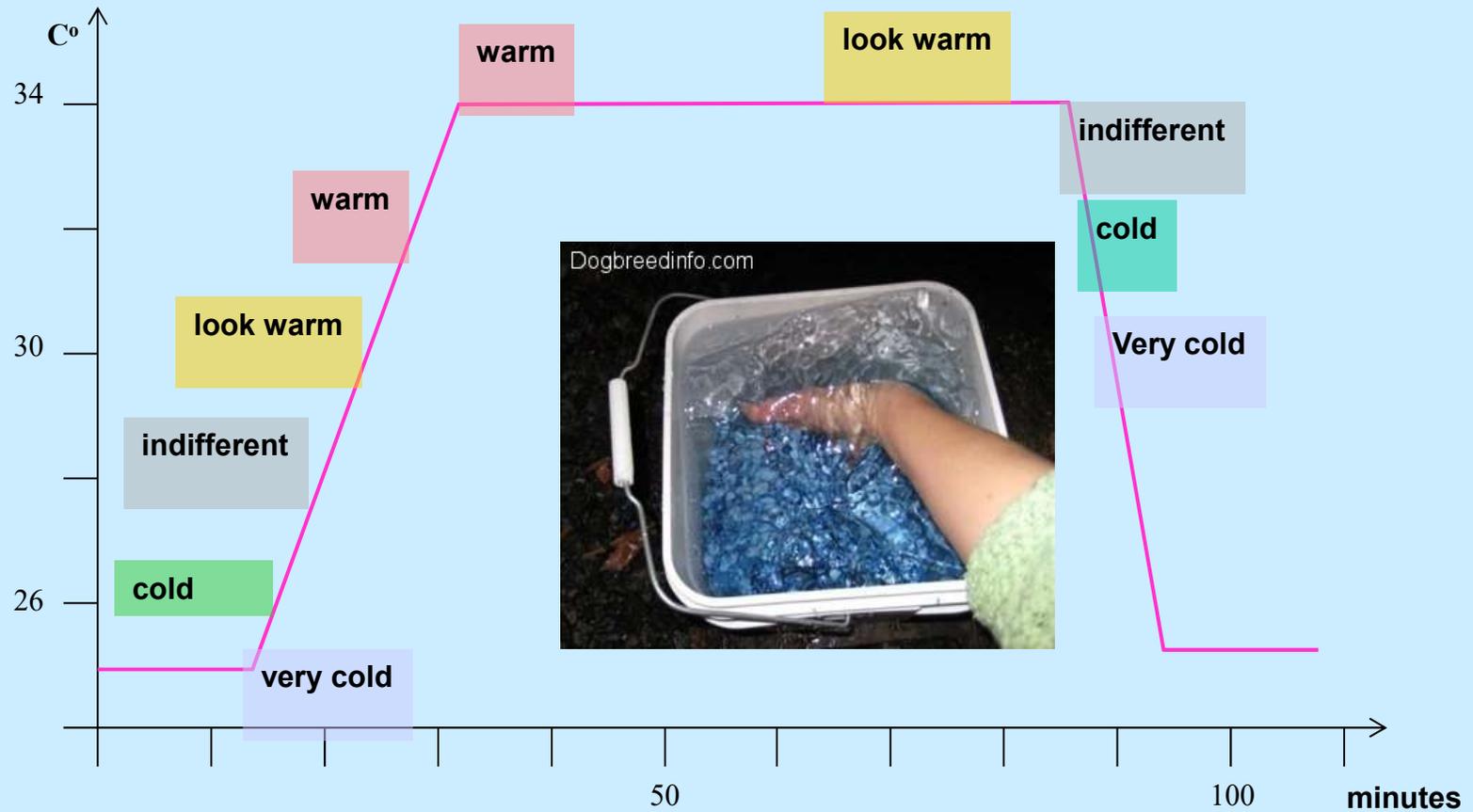
Persistent APs



For a warm receptor warming results in an increase in their action potential discharge rate, cooling results in a decrease in discharge rate. For cold receptors their firing rate increases during cooling and decreases during warming. Some cold receptors also respond with a brief action potential discharge to high temperatures, i.e. typically above 45°C , and this is known as a paradoxical response to heat.

Thermal receptors

codes absolute and relative changes in temperature



CNS is composed of neuronal pools with
different mechanisms of signal processing.

Excitation

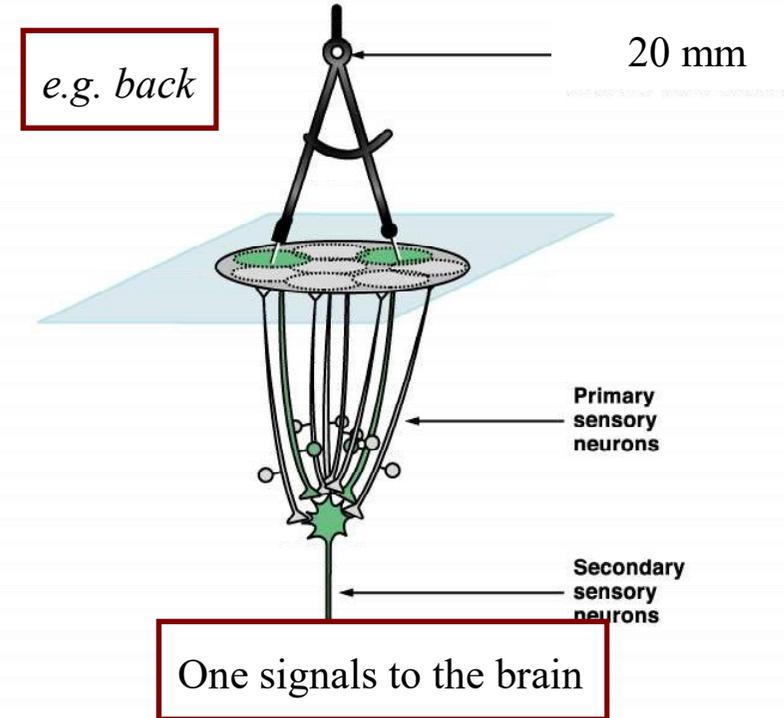
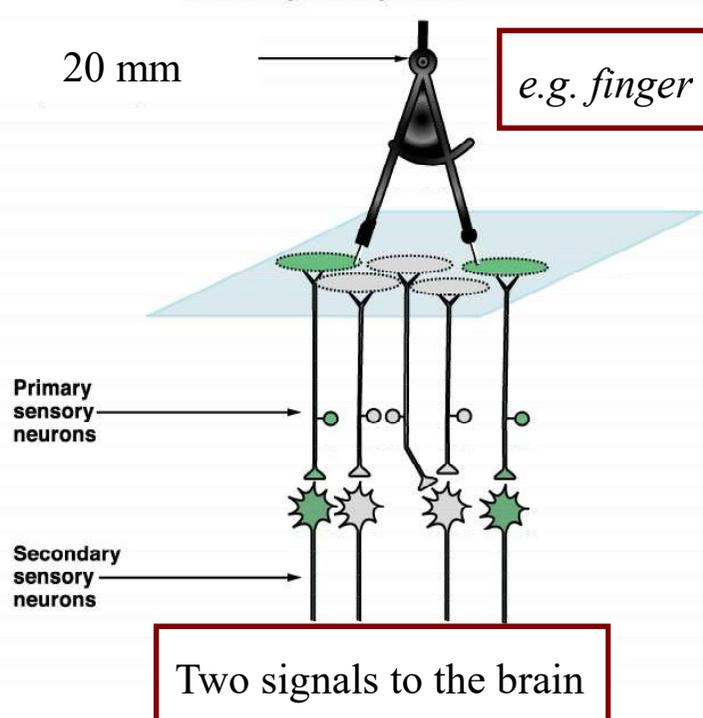
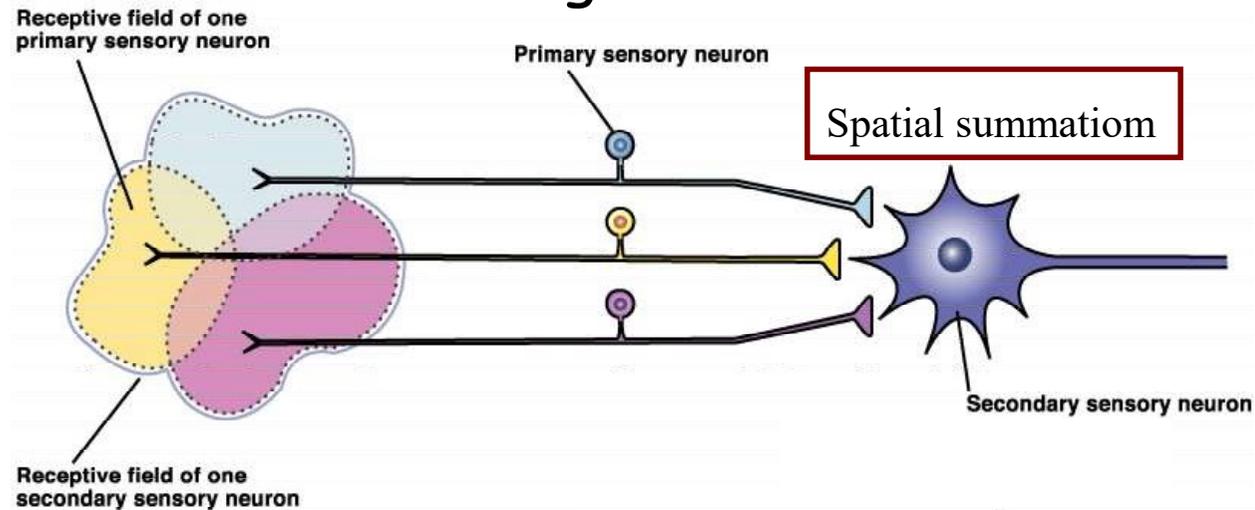
Facilitation

Inhibition

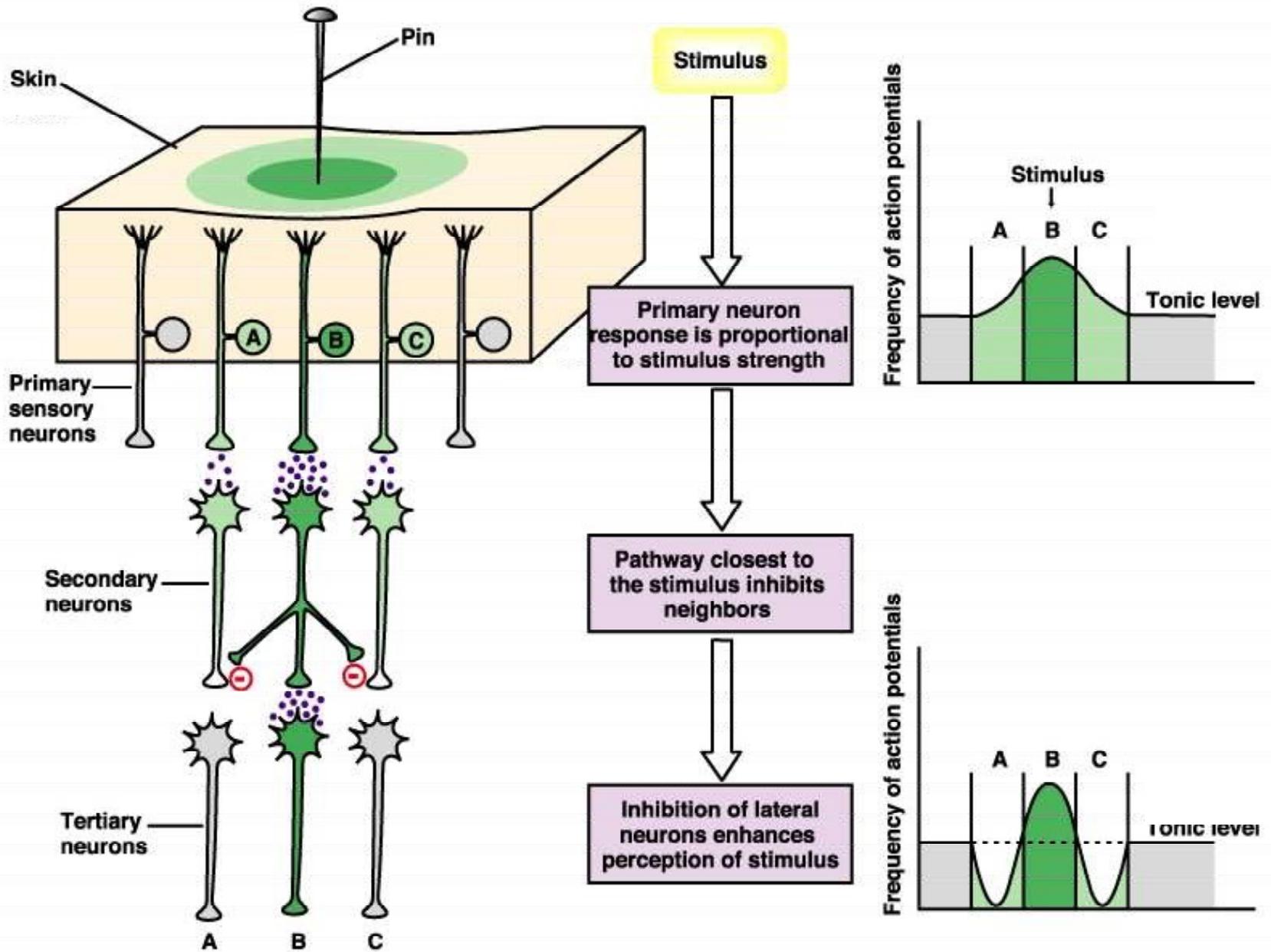
Convergence

Divergence

Convergence of Signals: multiple inputs uniting to excite a single neuron

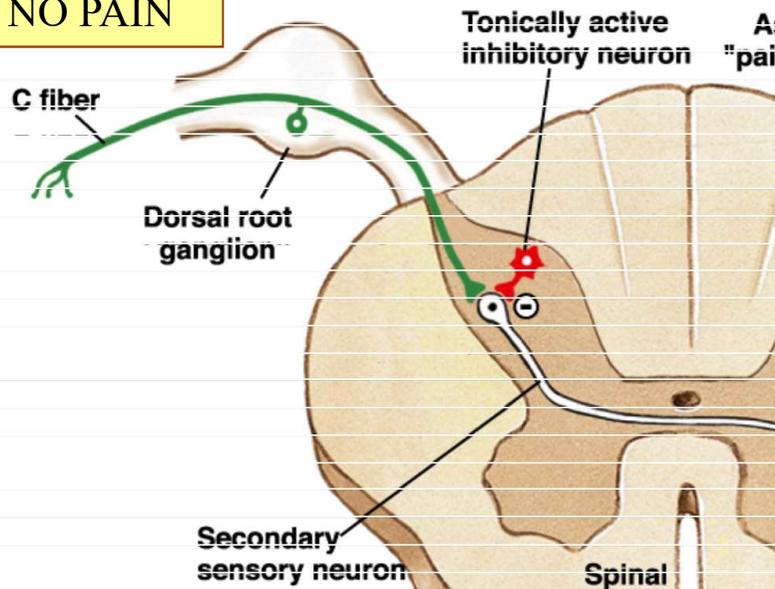


Divergence of Signals

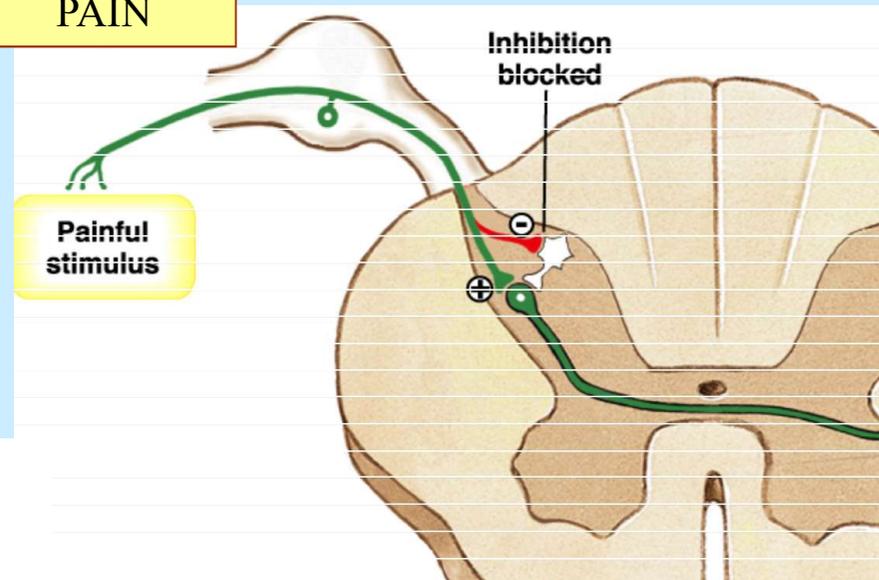


Divergence of Signals

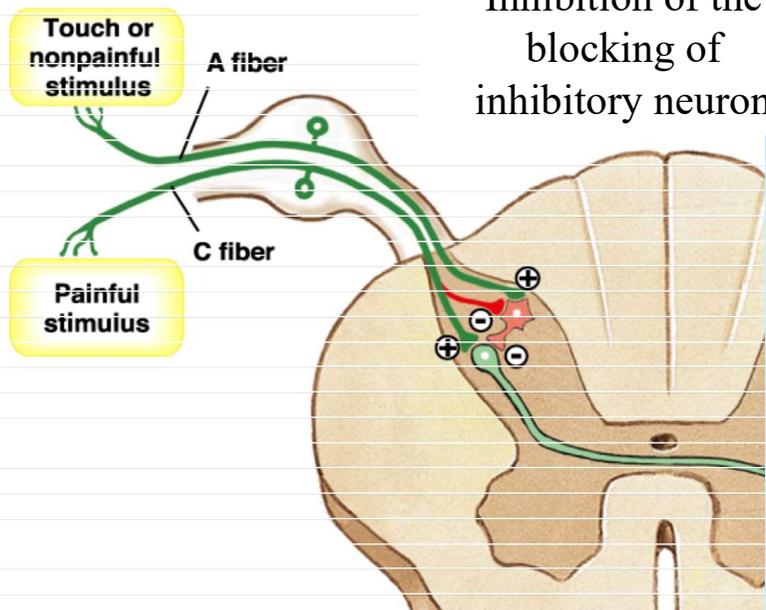
NO PAIN



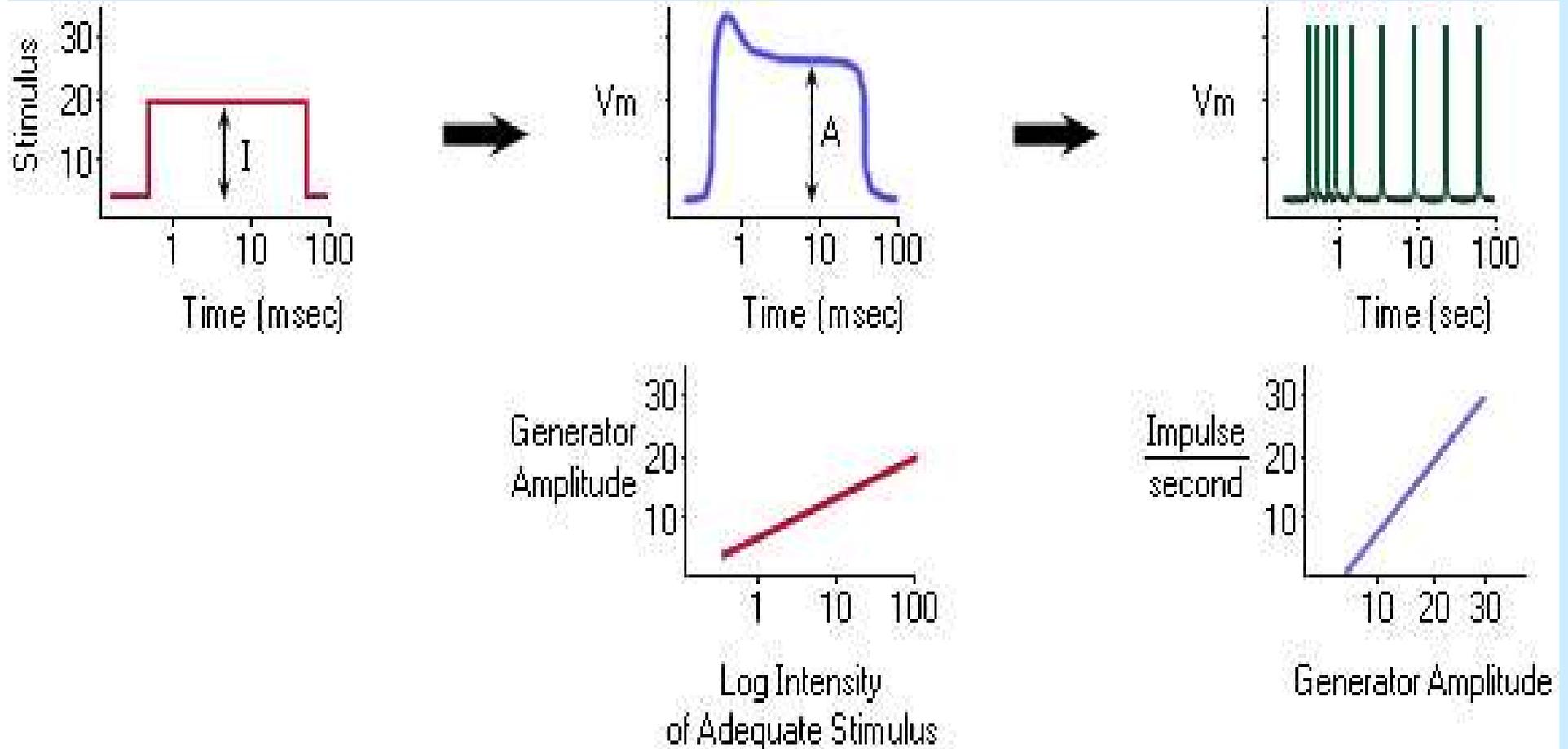
STRONG PAIN



PAIN and TOUCH



Summary



Psychophysics

Study the relationship between stimuli
&
our psychological response to them

Investigation of threshold stimulus

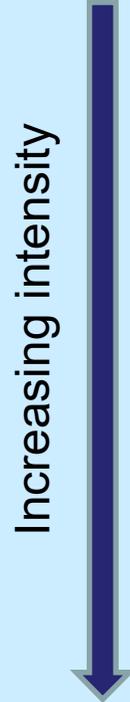
Absolute threshold

This is the minimum amount of a stimulus that is necessary for us to notice it 50% of the time

Decision method – yes - no

Determination of threshold by simple decision

answer



stimulus	V1	V2	V3	V4	YES (%)
I1	NO	NO	NO	NO	0 (0)
I2	NO	NO	NO	NO	0 (0)
I3	NO	NO	NO	NO	0 (0)
I4	NO	NO	NO	NO	0 (0)
I5	NO	NO	NO	NO	0 (0)
I6	YES	NO	NO	NO	1 (25)
I7	YES	NO	YES	NO	2 (50)
I8	YES	NO	YES	YES	3 (75)
I9	YES	YES	YES	YES	4 (100)
I10	YES	YES	YES	YES	4 (100)
I11	YES	YES	YES	YES	4 (100)
I12	YES	YES	YES	YES	4 (100)

Threshold studies

Absolute threshold – the smallest intensity of stimulus to be recognized

Decision method – yes - no

Adjusting method – (see audiometry experiment)

Differential threshold : smallest difference between two intensities to be recognized as different

Forced decision method

Just Noticeable Difference: Smallest difference in amount of stimulation that a specific sense can detect

$$\text{Just Noticeable Difference} = I - I_0$$

Intensity recognised
as different

Reference intensity



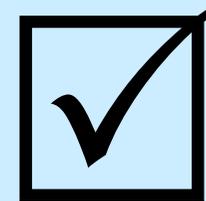


Ernst Weber (1795-1878)

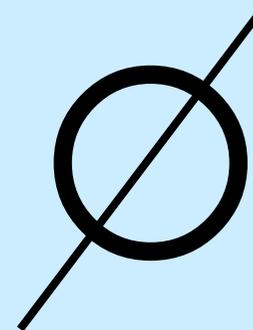
"just-noticeable difference" (JND)

How much more you have to be offered to change your workplace?

50000 + 5000



500000 + 5000



$$\mathbf{JND = I - I_0}$$

Higher initial stimulus – bigger JND

Weber's law

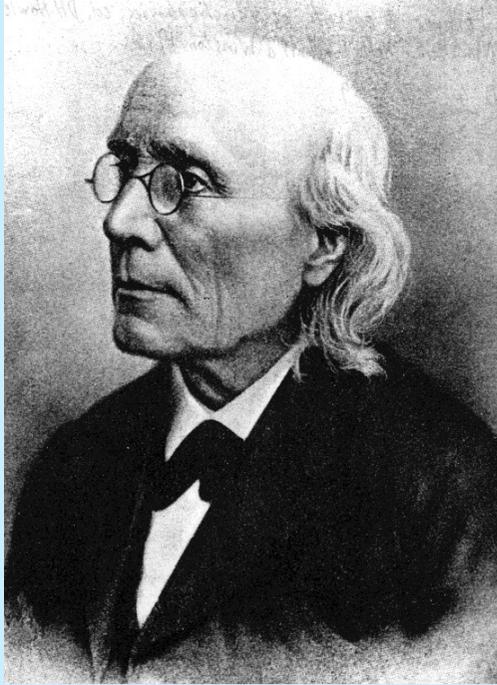
The size of the JND is a constant proportion of the initial stimulus. With other words the ratio of the increment threshold to the background intensity is a constant.

$$\frac{\Delta I}{I_0} = k$$

k : Weber ratio – can be determined by experiments

Each of the sensory perceptions has a consistent sensitivity to change.

<i>stimulus</i>	<i>Weber ratio</i>
brightness	0,079
loudness	0,048
touching	0,022
pressure	0,02
tasting (salt)	0,083
electric shock	0,013



Gustav Theodor Fechner
(1801-1887)

$$\Delta I = I - I_0$$

ΔI is a function

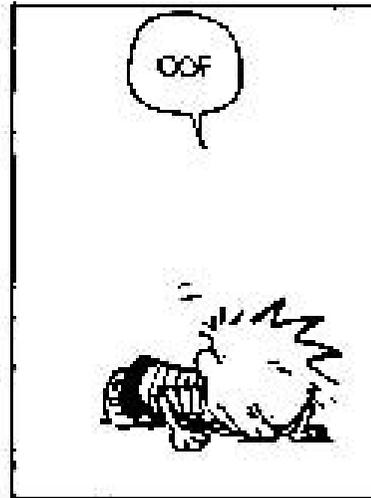
ΔI is the function of stimulus
intensity

RRGGGH...25...

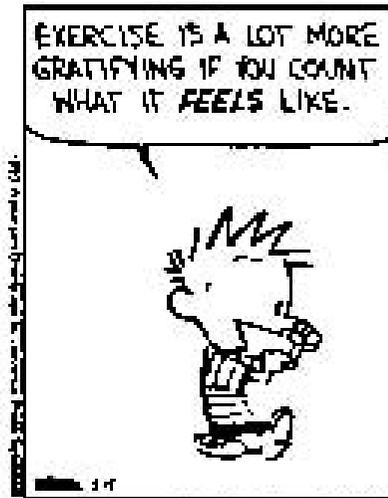
RRGGGh...5200!!!!

CALVIN & HOBBES

RRGGGH... 125 ...



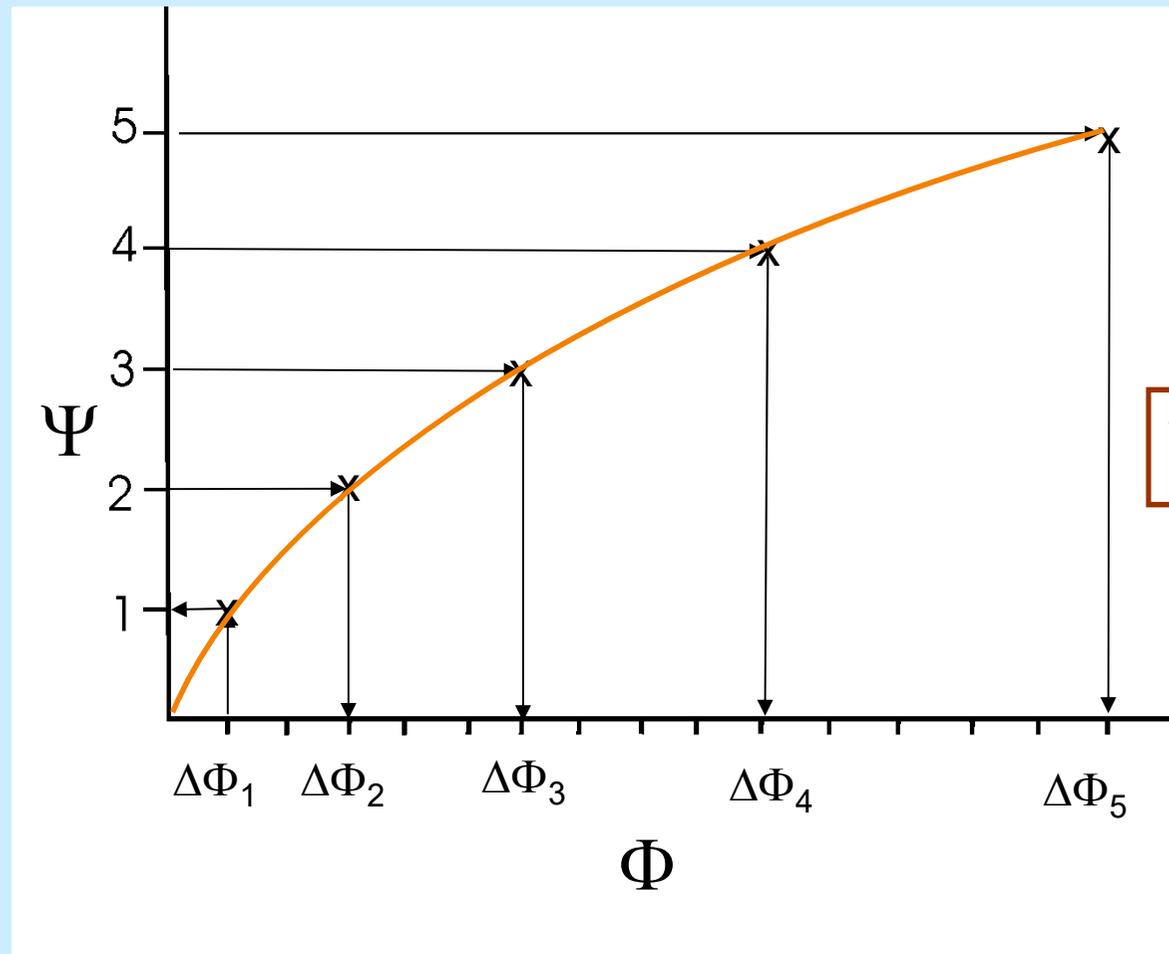
RRGGGH... 5,200!



Fechner : connection between stimulus intensity and sensation magnitude

Fechner assumed that the relative change of the stimulus is proportional to the change in the sensation magnitude

$$\Delta\Phi/\Phi \sim \Delta\Psi$$



$$\Psi \sim \lg\Phi$$



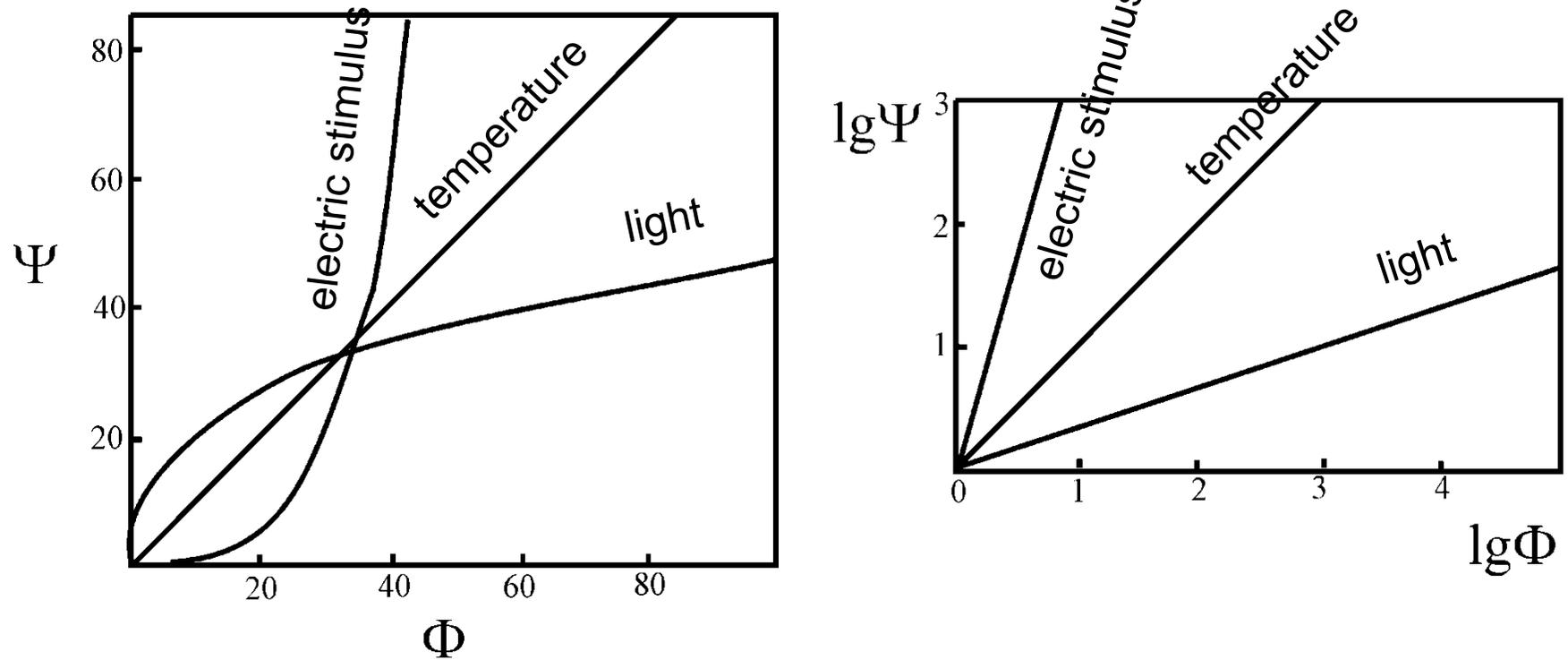
Establish relationship between
relative stimulus intensity (Φ/Φ_0)
and psychological magnitude (Ψ).

Performed measurements

Stanley Smith Stevens
(1906-1973)

sensation scale

Results of experiment



Sensation intensity increases with some expanding stimulus intensity. Equal stimulus ratios produce equal sensation ratios. This law is the power function

$$\Psi \approx \Phi^n$$

The exponent varies with the particular sensory modality, and also within a modality for different stimulus conditions, such as adaptation, inhibition, size, and duration of stimuli.

$$\Psi \approx \Phi^n$$

<i>stimulus</i>	<i>exponent</i>
short light pulses	0,5
smell (heptane)	0,6
loudness (3000 Hz sinus)	0,67
ambient temperature	1,00
taste (salt)	1,30

Summary

Two different approaches:

Weber – Fechner :

$$\Psi \sim \lg \Phi$$

Stevens :

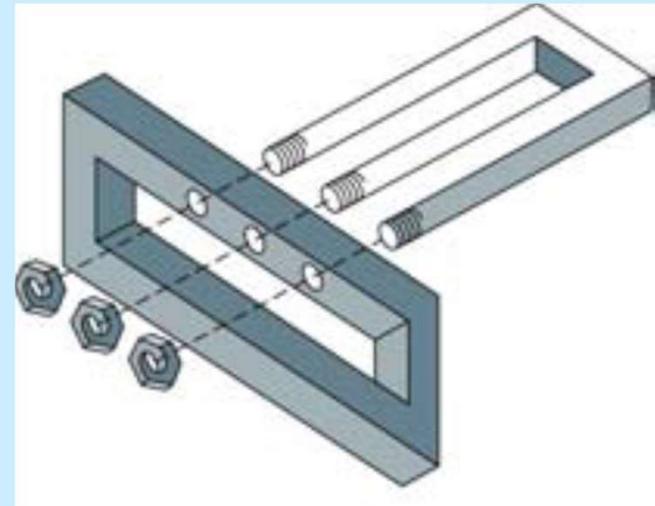
$$\Psi \approx \Phi^n$$

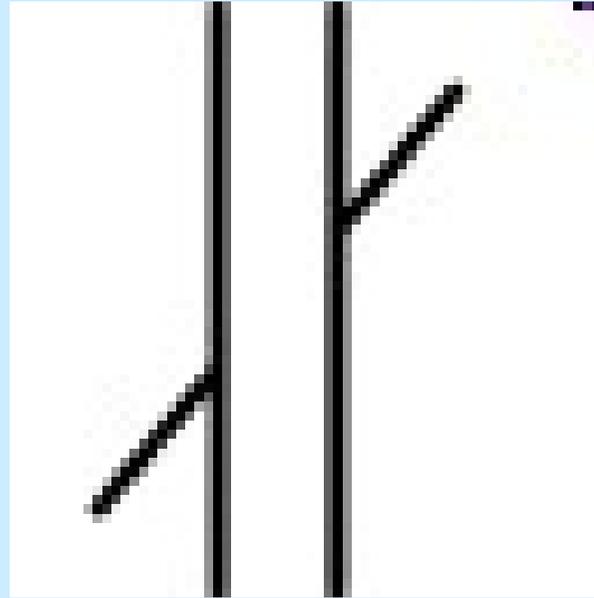
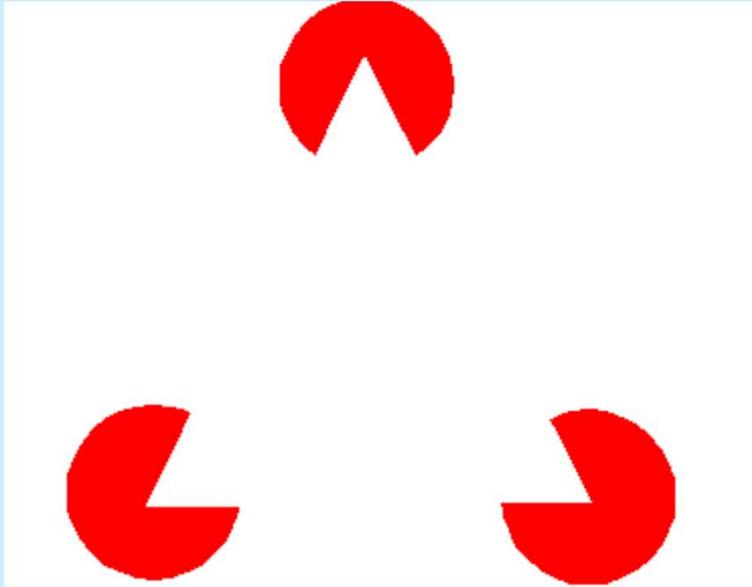
The second one received better experimental support.

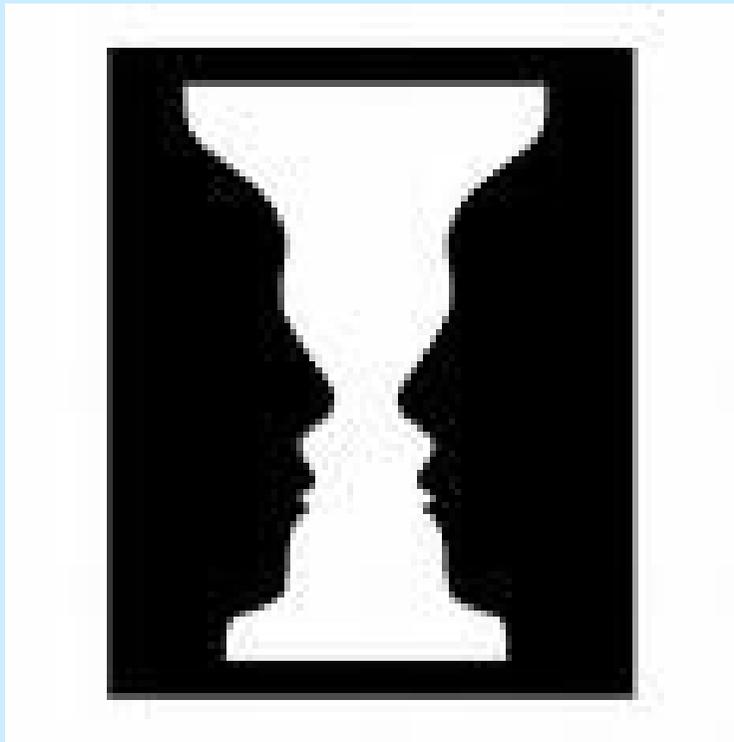
Perception - Organizing sensations into meaningful patterns

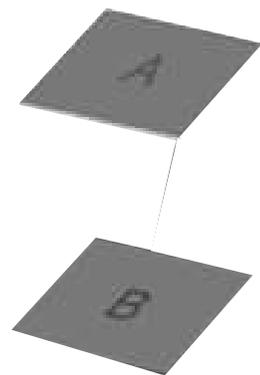
- analyzing
- organizing
- understanding

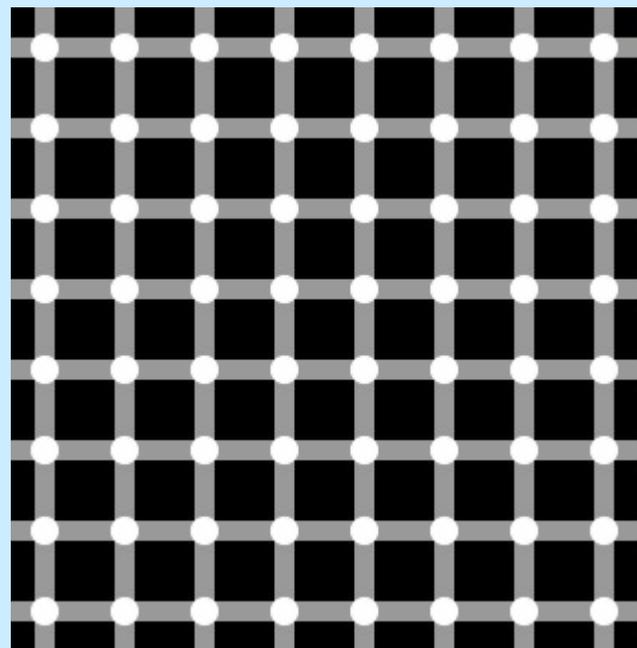
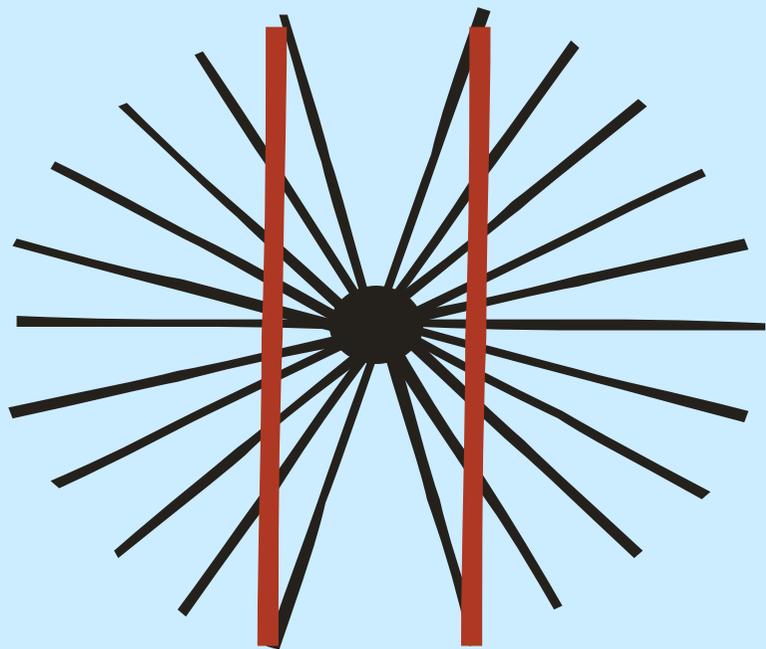
Perception might be correct or false.

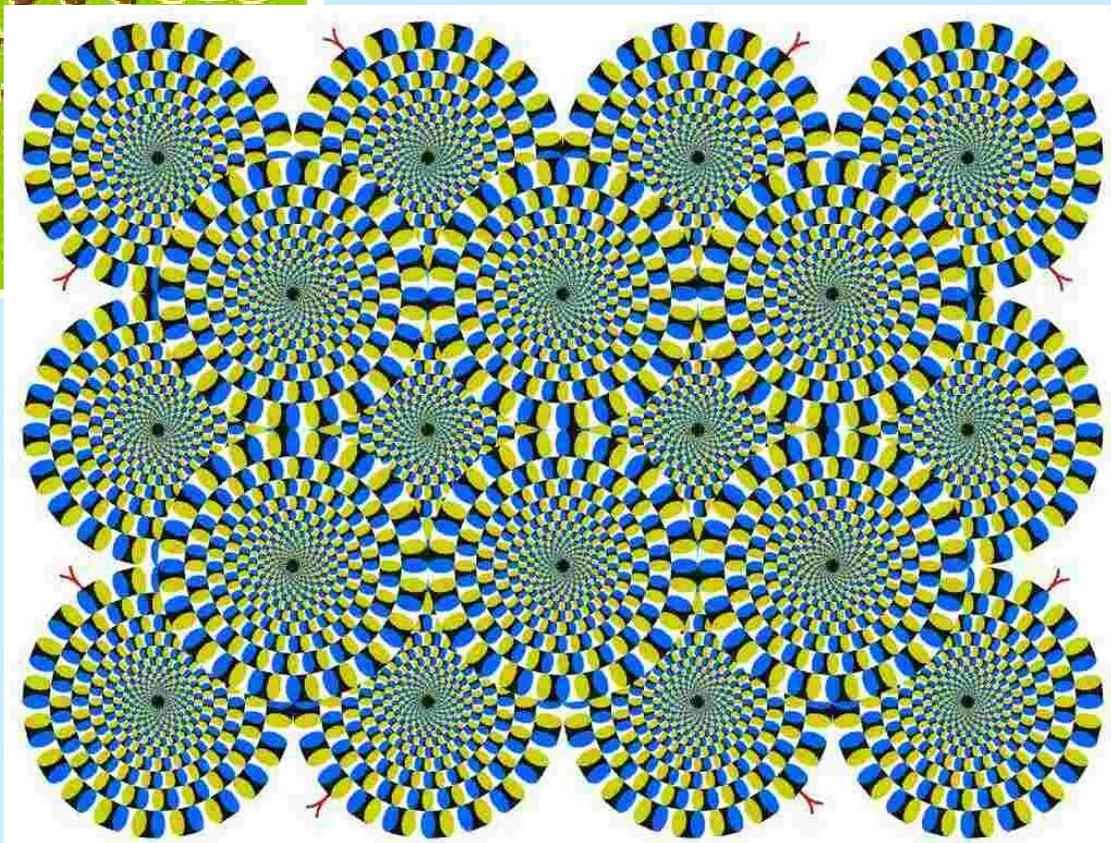
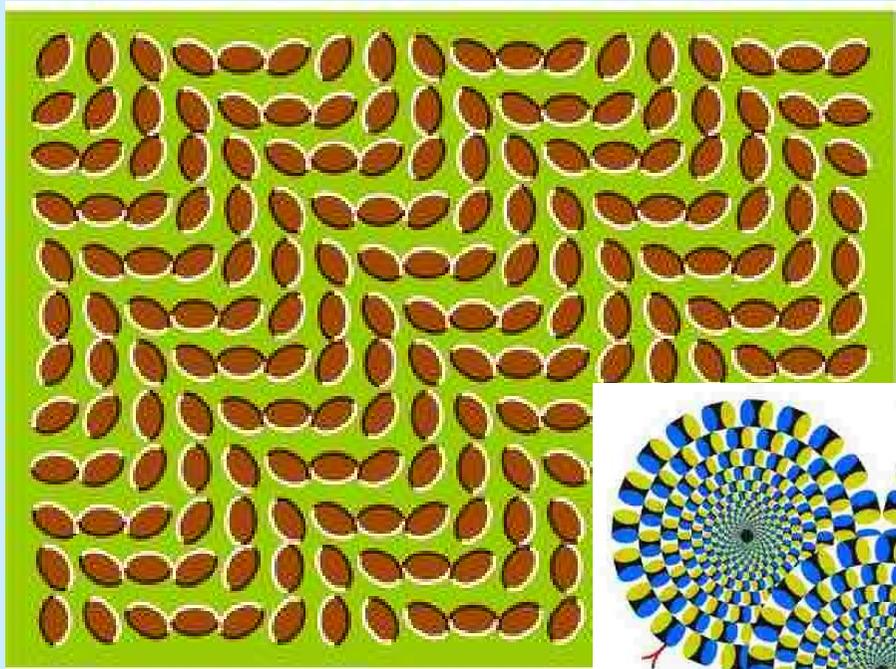


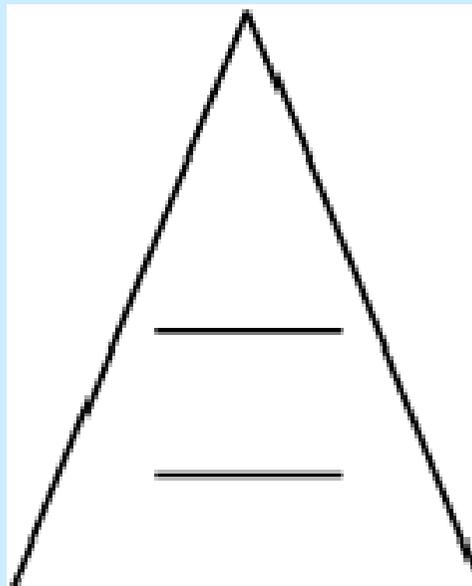
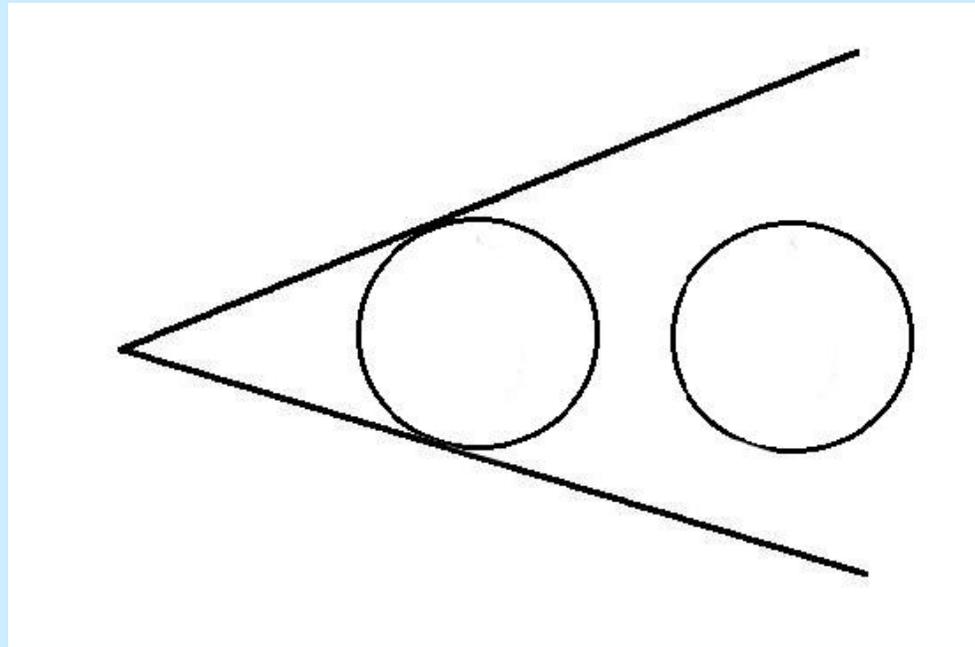












<http://www.michaelbach.de/ot/>