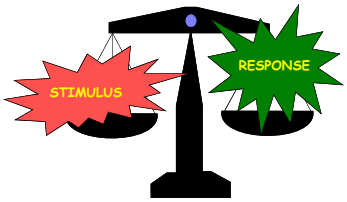
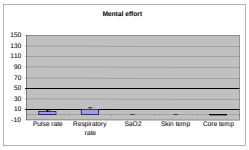
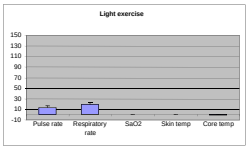
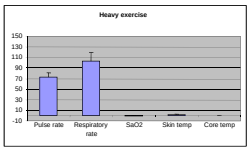
Homeostasis - I



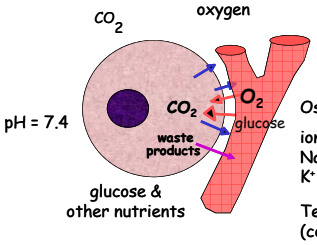
Results of homeostasis practical in our students







Extracellular environment



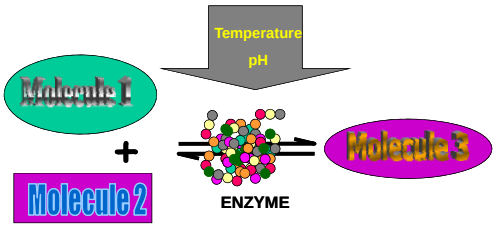
pH = 7.4

Osmolarity = 290 mosm/L

ion concentrations:
Na^+ = 145 mM
K^+ = 4 mM

Temperature
(core in humans) = 37.1°C

Cells live in a ***fluid environment***

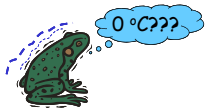


NB: Because all biochemical processes in cells are sensitive to conditions such as temperature, pH and concentrations of reacting molecules any change in these variables may be harmful for them.

1. Unicellular organisms have ***no control*** over their environment. They are limited to living where the conditions happen to be right.

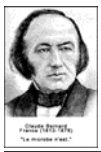
2. In complex animals and humans, cells are surrounded by the *extracellular* fluid which forms the "INTERNAL ENVIRONMENT" of the body. This environment **must be kept stable.**

3. Mammals have developed the ability to **MAINTAIN THEIR INTERNAL ENVIRONMENT WITHIN NARROW LIMITS in a wide variety of external conditions.**
This allows these animals to **survive where others cannot**



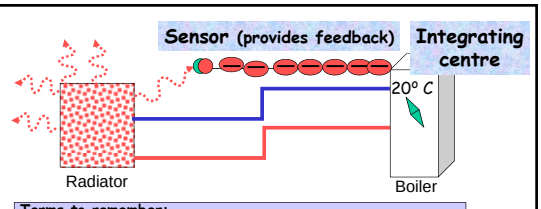
Homeostasis means maintenance of constant (static) conditions in the internal environment

- The concept was first framed by the XIX C biologist ***CLAUDE BERNARD*** who said ~"***the control of the internal environment is the condition of a free life".***
- In ***1932 WALTER CANNON*** introduced the term ***"HOMEOSTASIS"*** to describe this maintenance of constant conditions (in the internal environment).



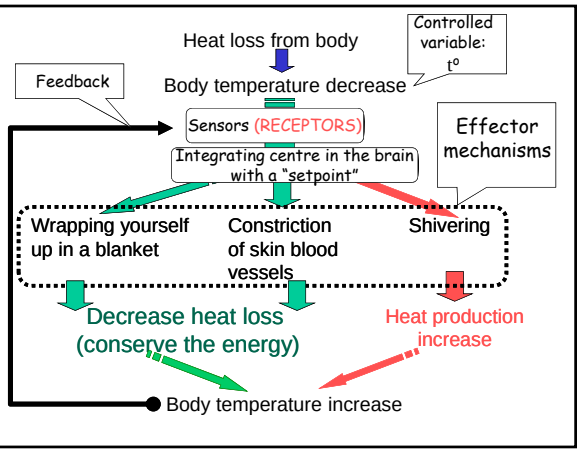
GENERAL PRINCIPLES OF THE OPERATION OF HOMEOSTATIC MECHANISMS

In order to stay stabile the system must be able to "measure" the variable, detect the errors and counteract these errors.



Terms to remember:

1. **Controlled variable** (temperature)
2. **Sensor** (receptor)
3. **Integrating centre** (controller)
4. **Effector**
5. **Set point: the value to which the system is trying to return if perturbed**
6. **Negative feedback: the principle of operation whereby a system reacts by a change opposite to the disturbance**
7. **Closed loop system: the system which adjusts its operation according to the result (in this example – temperature)**



1. **Controlled variables**

controlled variable	major controlling system(s)	behavioural components
temperature	skin blood vessels (heat loss) skeletal muscles (heat production)	
oxygen & CO_2	respiratory/cardiovascular	 get some fresh air!
blood glucose	GI tract, pancreas, liver	
osmolarity	kidney	drinking (water) 
blood pH	respiratory system, kidney	???

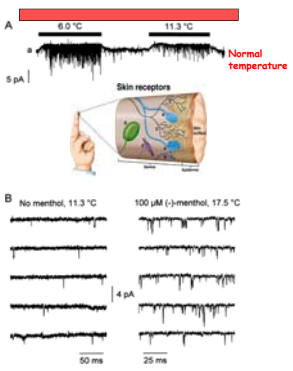
2. **Sensors (receptors)**

Sensors (receptors) are required to "measure" controlled variables

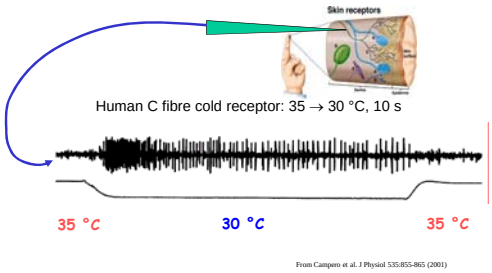
N.B. Nerve cells encode the information about controlled variables by frequency of action potentials. For a nerve cell measure a certain variable it should be able to generate more or less action potentials when that variable increases or decreases.

N.B. Many sensors are specialised ion channels

Cold receptors discovered by G. Reed and colleagues



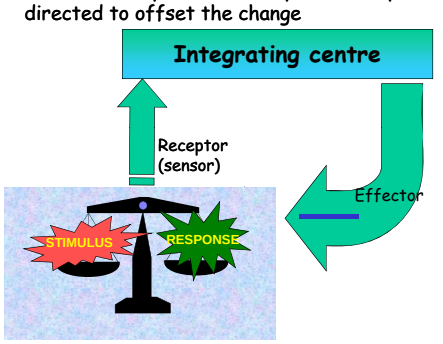
How about some chewing gum???



The cold and menthol receptor is a specialised ion channel which opens upon cooling and when menthol blinds to it

3. **Feedback (negative)**

Negative feedback is the principle of operation of homeostatic systems when system's response is directed to offset the change



THIS SLIDE HAS BEEN MOVED!

Can the system "foresee" the future? Is it possible to feed FORWARD ???

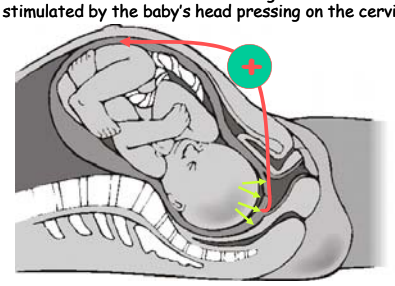
Feed-forward is when the system reacts BEFORE the actual change in controlled variable (response in anticipation).

Examples:
we dress *before* we get cold,
we get thirsty *while* eating salty food, *before* the blood concentration of NaCl has time to change

and many more...

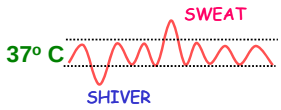
Positive feedbacks are also present in the body, but they are not parts of homeostatic mechanisms. They de-stabilise, rather than stabilise and accelerate transitions between different states.

An example of positive "feed-back":
contractions of uterus during labour are stimulated by the baby's head pressing on the cervix

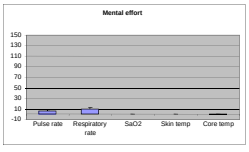


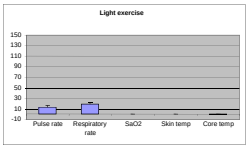
Effectors – mechanisms/organs/processes employed to bring the controlled variable to the set point.

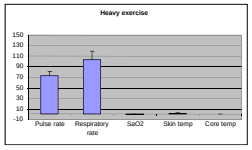
Use of antagonistic effectors



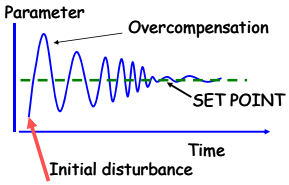
Results of the "homeostasis" practical







Set point



Biological systems are intelligent and normally DO NOT overcompensate.

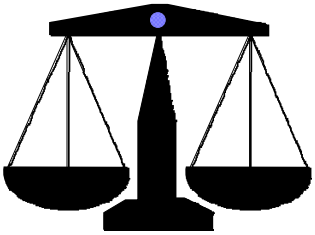
SET POINT in biological systems effectively is a range of "normal" values.
For example:
blood glucose concentration range:
~ 75-110 mg/100 ml
blood pH: 7.35-7.45

SUMMARY:

1. Homeostasis means "keeping the conditions for the cellular biochemistry stable
2. Elements of a "classical" homeostatic loop: sensor, integrating centre, effector mechanisms. It is concerned with a particular "controlled variable" and operates using negative feedback to keep it near the set point.
3. Humans have numerous behavioural responses which help to maintain homeostasis
4. Many sensors are specialised ion channels
5. Homeostatic systems include "feed forward" mechanisms (e.g. reactions which occur in advance)
6. Antagonistic effectors are used to increase the precision of control

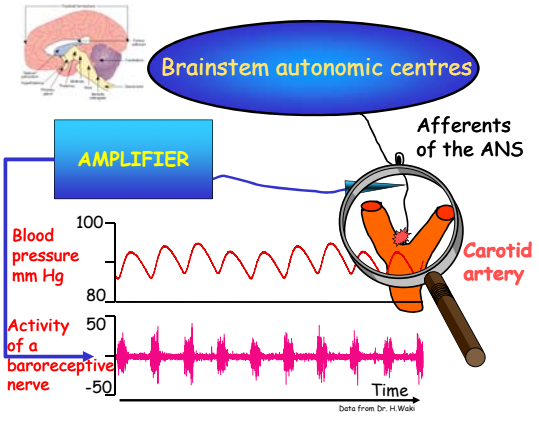
Homeostasis - 2

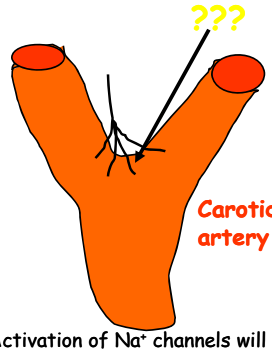
(application of homeostatic principles to physiology of body systems)



EXAMPLE 1

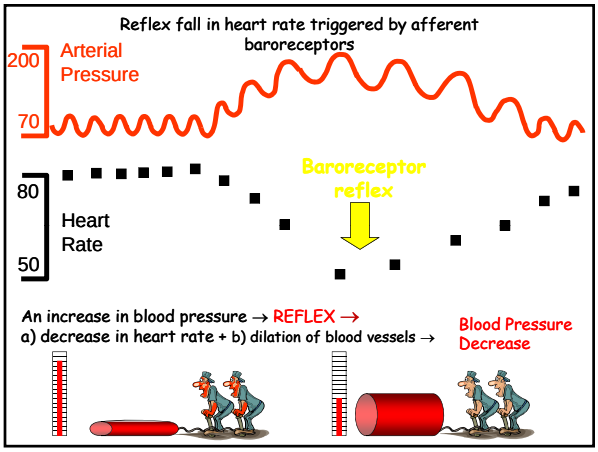
Homeostatic principles applied to regulation of arterial blood pressure

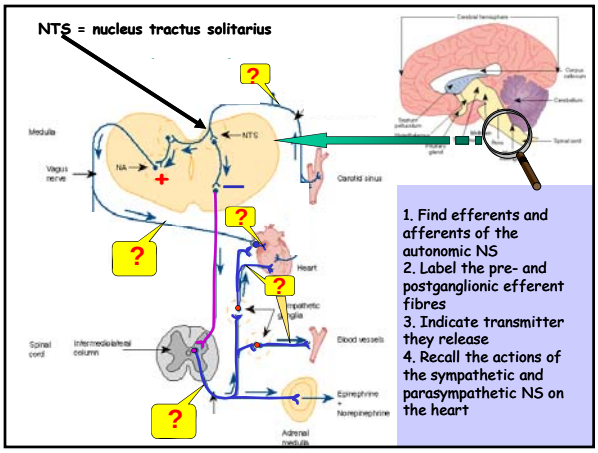




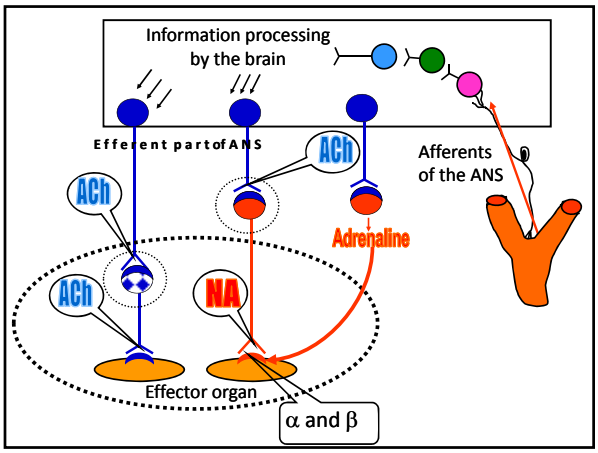
These sensory nerve endings are thought to have stretch-sensitive Na^+ channels

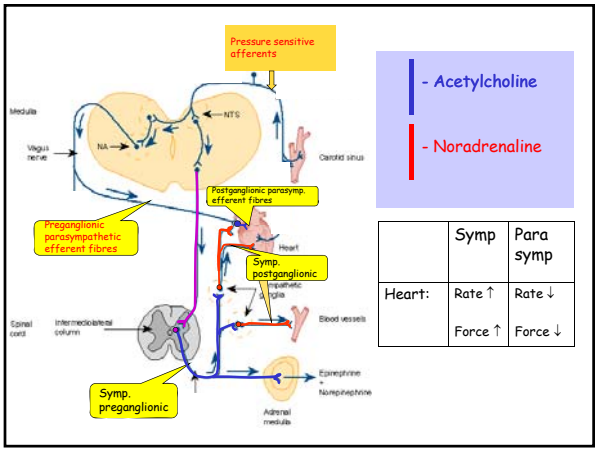
Activation of Na^+ channels will lead to depolarisation of the membrane of the sensory nerve ending and action potential generation!



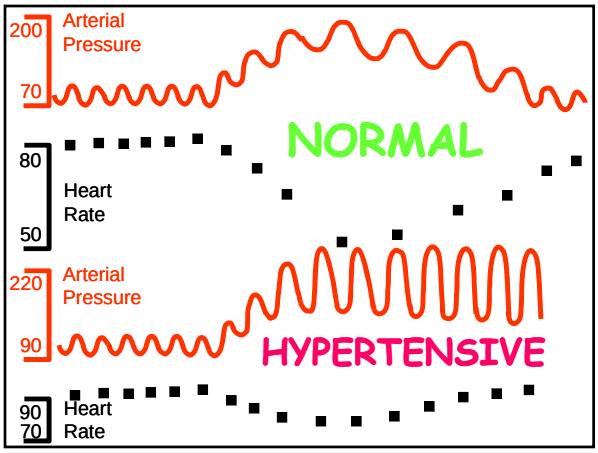


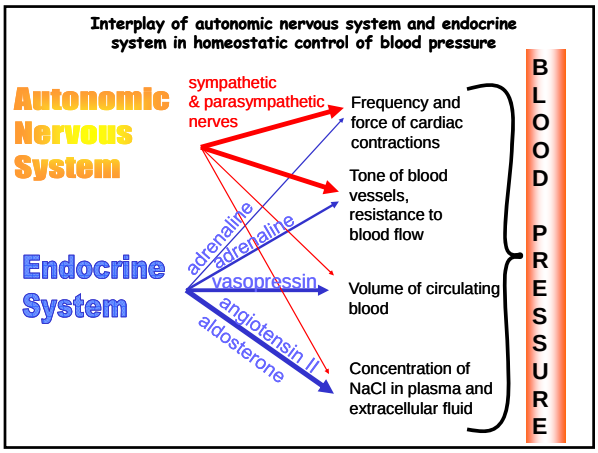
1. Find efferents and afferents of the autonomic NS
2. Label the pre- and postganglionic efferent fibres
3. Indicate transmitter they release
4. Recall the actions of the sympathetic and parasympathetic NS on the heart

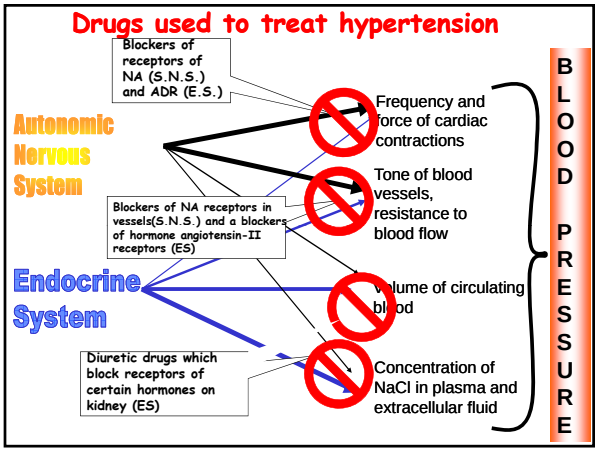




	Symp	Para symp
Heart:	Rate ↑ Force ↑	Rate ↓ Force ↓



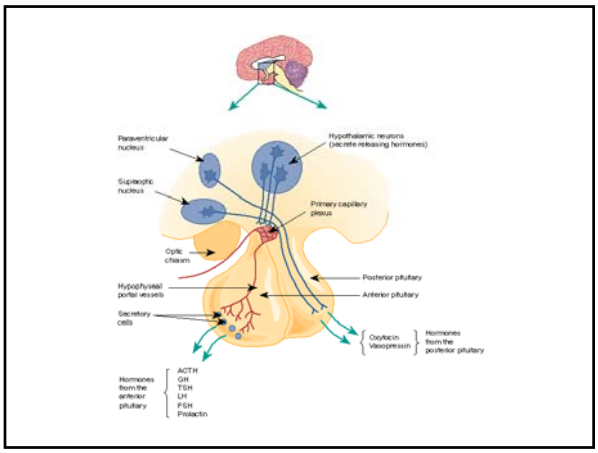




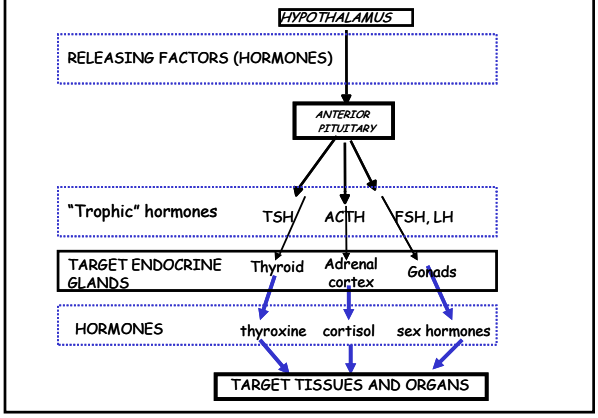
EXAMPLE 2

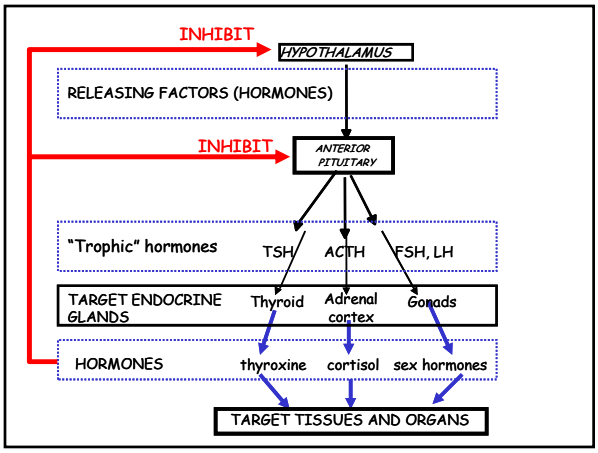
Homeostatic principles applied to regulation of hormone concentration

Knowledge of negative feedback loops is important for understanding of diseases and drug actions

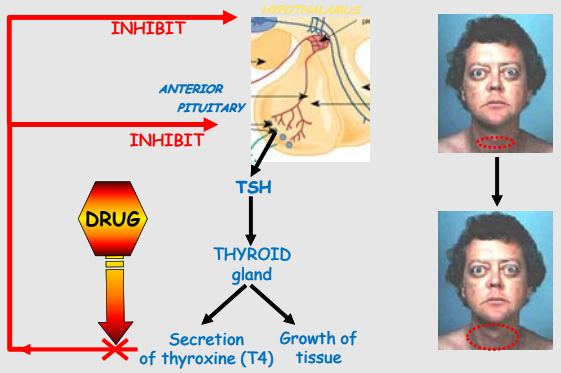


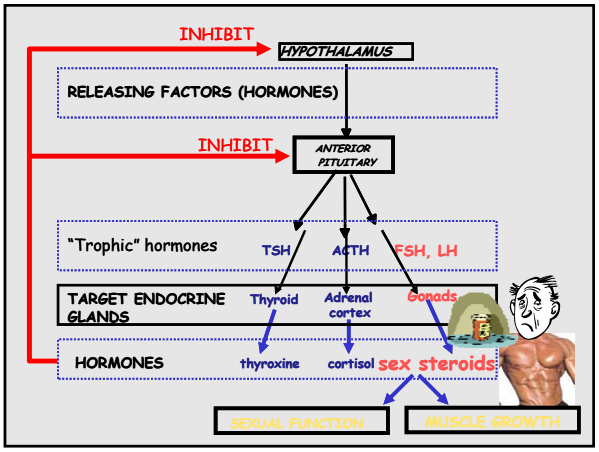
Organisation of the endocrine circuit which operates via anterior pituitary





Knowledge of negative feedback loops is important for understanding of diseases and drug actions

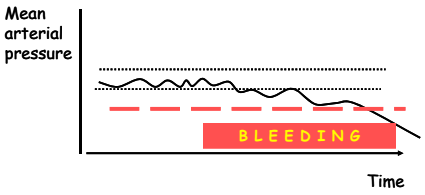




Summary:

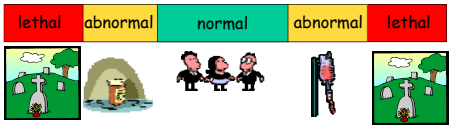
- The body is trying to keep the extracellular environment stable so that all chemical reactions occur at the optimal conditions. Basically, this is the idea of homeostasis.
- Homeostatic principles are applicable to essentially any physiological system of the body.
- Stability of all body functions is maintained by numerous **negative feedback loops:** the system responds in such a way so that to cancel any deviations from the optimal level.
- Most whole body homeostatic mechanisms involve a joint action of ANS, endocrine system and behavioural reactions.
- Failures in homeostasis lead to diseases and may be lethal.
- Medical interventions may be designed to restore homeostasis. However drugs may cause side effects due to unwanted interactions with homeostatic negative feedback mechanisms.

Homeostatic mechanisms have limited capacity.



N.B. If all attempts to restore homeostatis fail, this may lead to irreversible damage and death.

CONTROLLED VARIABLE



MEDICINE IS ABOUT RESTORING HOMEOSTASIS!!!

THE END!