OSMÓZA A VYUŽITÍ KOLEM NÁS

21. 11. 2022

OSMOTICKÝ TLAK

- Na přechod rozpouštědla mezi roztoky můžeme nahlížet jako na chemickou reakci (dochází k vyrovnávání chemického potenciálu)
- Pro bilanci rozpouštědla platí $\delta n_0' + \delta n_0 = 0$ $\quad \nu_0 = 1, \quad \nu_0' = -1$
- Pro rozpuštěnou látku platí $\delta n_1' = \delta n_1 = 0, \quad \nu_1' = \nu_1 = 0$
- Pro odpovídající koncentrace (předpokládejme čisté rozpouštědlo v jedné z částí)

$$c_0 = 1, \quad c_1 = 0,$$

$$c_0' = \frac{n_0'}{n_0' + n_1'}, \quad c_1' = \frac{n_1'}{n_0' + n_1'} = 1 - c_0'$$

OSMOTICKÝ TLAK

- Podmínka pro rozpouštědlo ve stavu rovnováhy

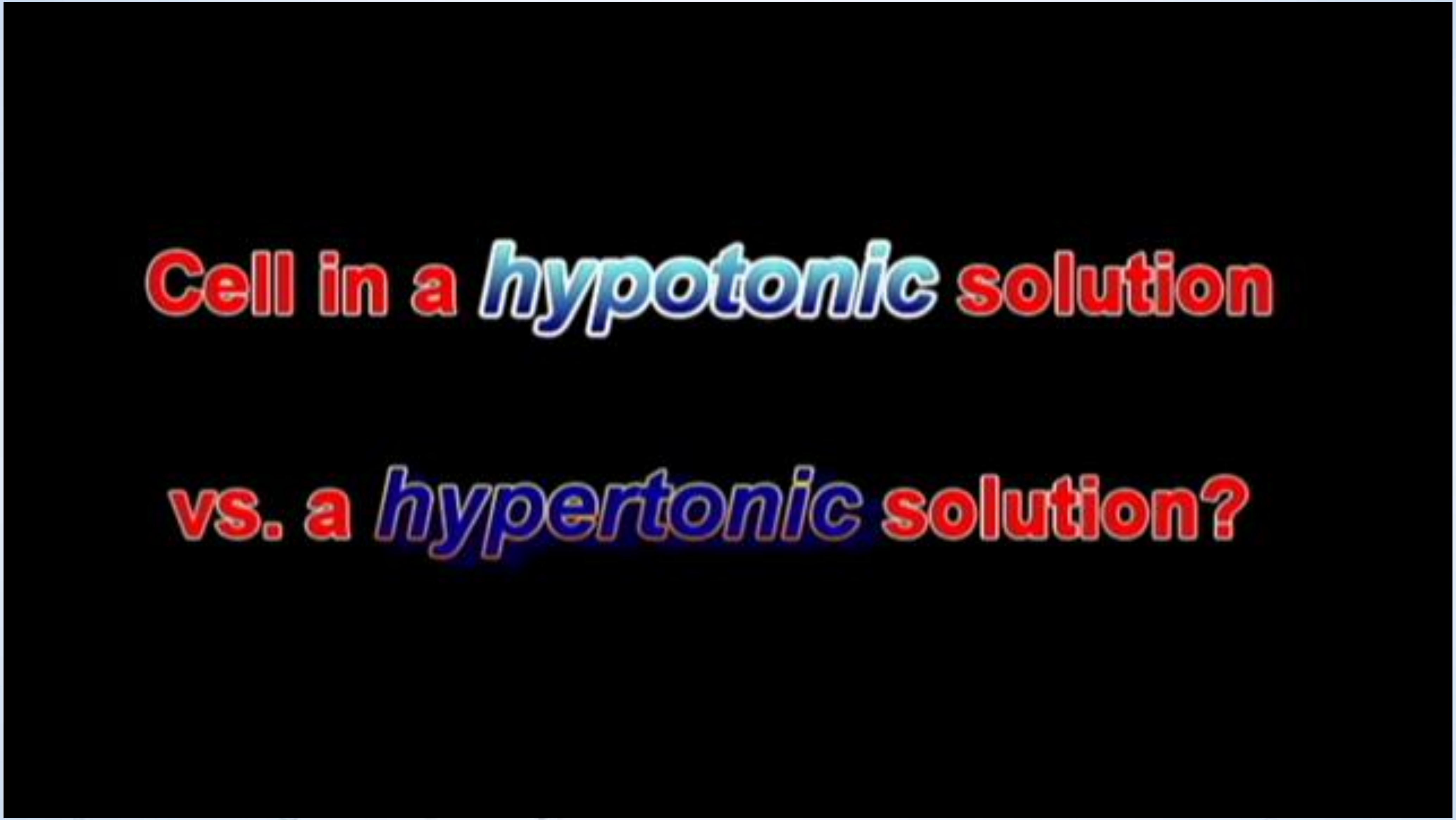
$$\log c_0 - \log c_0' = -\frac{\mu_0(T,P)}{RT} + \frac{\mu_0(T,P+\Delta P)}{RT}$$

Osmotický tlak je roven tlaku ideálního plynu o látkovém množství rovném množství rozpuštěné látky v objemu, ve kterém je rozpuštěno.

$$\mu_0\,(T,P+\Delta P) = \mu_0\,(T,P) + \left(\frac{\partial \mu_0}{\partial P}\right)\Delta P$$

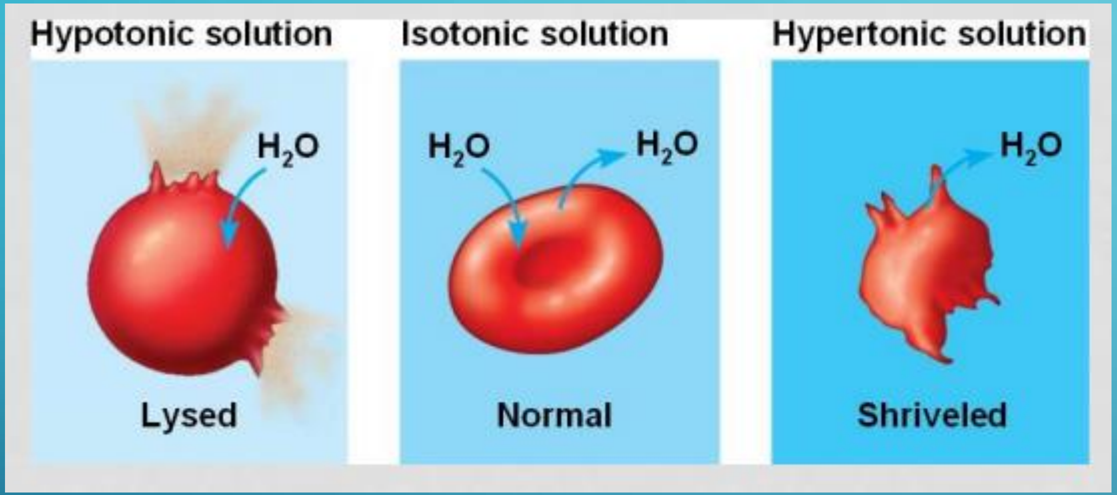
- Výsledně

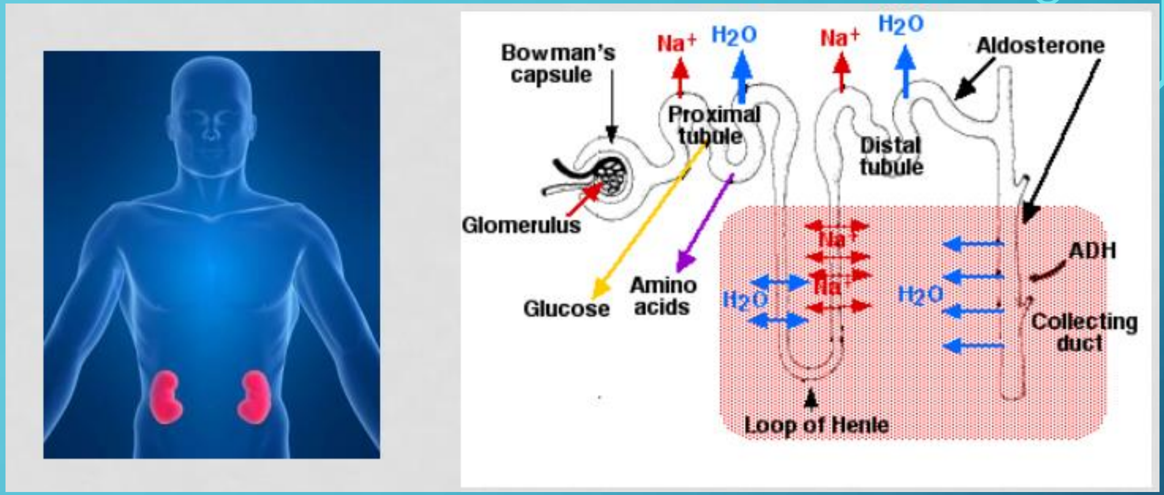
$$P_{osm} = \Delta P = c_1' \frac{R\,T}{\left(\frac{\partial \mu_0}{\partial P}\right)} \approx n_1' \frac{R\,T}{n_0' v_0}$$

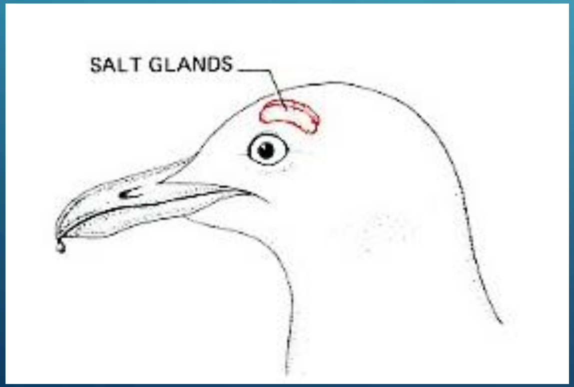

Cell in a hypotonic solution
vs. a hypertonic solution?

DŮSLEDKY A VYUŽITÍ

- Celá živá příroda

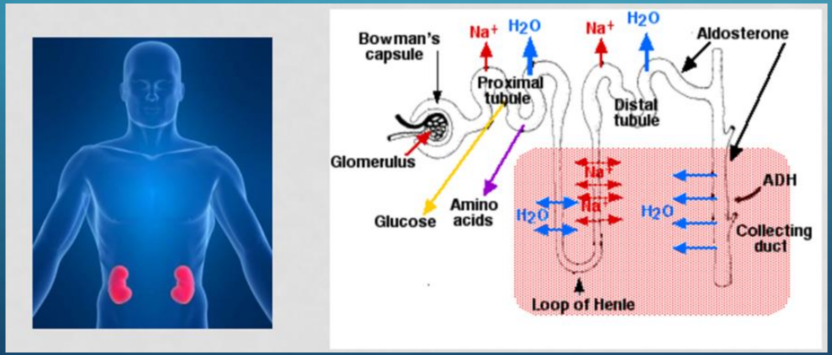


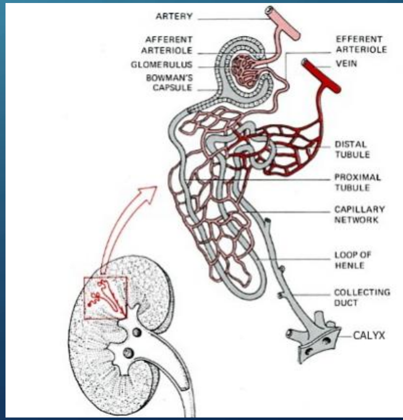




LEDVINY

- The nephron makes urine by filtering the blood of its small molecules and ions and then reclaiming the needed amounts of useful materials. Surplus or waste molecules and ions are left to flow out as urine. In 24 hours the kidneys reclaim ~1,300 g of NaCl ~400 g NaHCO3 ~180 g glucose almost all of the 180 liters of water that entered the tubules.
- The steps:
  - Blood enters the glomerulus under pressure.
  - This causes water, small molecules (but not macromolecules like proteins) and ions to filter through the capillary walls into the Bowman's capsule. This fluid is called nephric filtrate. As the table shows, it is simply blood plasma minus almost all of the plasma proteins. Essentially it is no different from interstitial fluid.

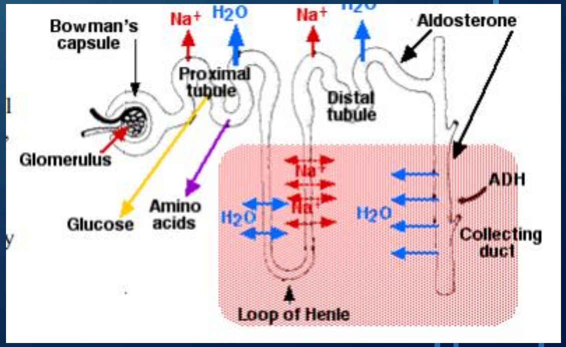




https://www.biology-pages.info/K/Kidney.html

LEDVINY

- Nephric filtrate collects within the Bowman's capsule and then flows into the proximal tubule.
- Here more than 90% of the glucose and all of the amino acids, >90% of the uric acid, and ~60% of inorganic salts are reabsorbed by active transport.
- The active transport of Na+ out of the proximal tubule is controlled by angiotensin II. The active transport of phosphate (PO4 3-) back into the blood is regulated (suppressed) by both the parathyroid hormone and fibroblast growth factor 23 (FGF-23).
- As these solutes are removed from the nephric filtrate, a large volume of the water follows them by osmosis (80–85% of the 180 liters deposited in the Bowman's capsules in 24 hours).
- As the fluid flows into the descending segment of the loop of Henle, water continues to leave by osmosis because the interstitial fluid is very hypertonic. This is caused by the active transport of Na+ out of the tubular fluid as it moves up the ascending segment of the loop of Henle.
- In the distal tubules, more sodium is reclaimed by active transport, and still more water follows by osmosis.
- Final adjustment of the sodium and water content of the body occurs in the collecting ducts.



LEDVINY – TVORBA MOČI

Composition of plasma, nephric filtrate, and urine (each in **g/100 ml** of fluid). These are representative values. The values for salts are especially variable, depending on salt and water intake.

Component	Plasma	Nephric Filtrate	Urine	Concentration	% Reclaimed
Urea	0.03	0.03	1.8	60X	50%
Uric acid	0.004	0.004	0.05	12X	91%
Glucose	0.10	0.10	None	-	100%
Amino acids	0.05	0.05	None	-	100%
Total inorganic salts	0.9	0.9	<0.9–3.6	<1–4X	99.5%
Proteins and other macromolecules	8.0	None	None	-	-

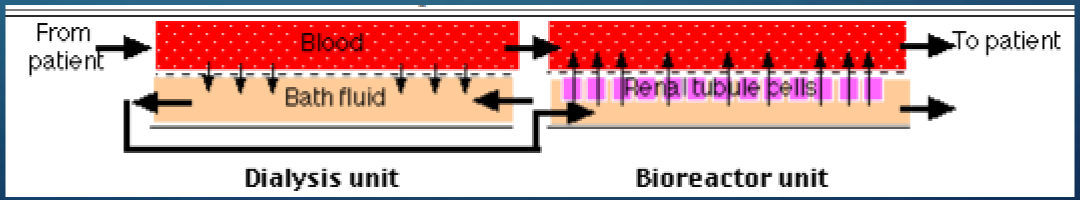
LEDVINY – DALŠÍ FUNKCE

- SODÍK

Although 97% of the sodium has already been removed, it is the last 3% that determines the final balance of sodium — and hence water content and blood pressure — in the body. The reabsorption of sodium in the distal tubule and the collecting ducts is closely regulated by the synergistic action of the hormones vasopressin and aldosterone.

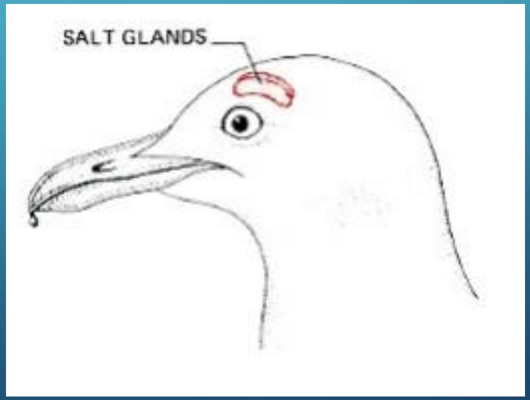
- VODA
  - The hypertonic interstitial fluid surrounding the collecting ducts provides a high osmotic pressure for the removal of water.
  - Transmembrane channels made of proteins called aquaporins are inserted in the plasma membrane greatly increasing its permeability to water. (When open, an aquaporin channel allows 3 billion molecules of water to pass through each second.)
  - Insertion of aquaporin-2 channels requires signaling by vasopressin. It is also known as arginine vasopressin (AVP), the antidiuretic hormone (ADH), and vasotocin (VT).
    - Vasopressin binds to receptors (called V2 receptors) on the basolateral surface of the cells of the collecting ducts.
    - Binding of the hormone triggers a rising level of cAMP within the cell. This "second messenger" initiates a chain of events culminating in the insertion of aquaporin2 channels in the apical surface of the cell.

- VODA II
- The release of vasopressin (from the posterior lobe of the pituitary gland) is regulated by the osmotic pressure of the blood. Anything that dehydrates the body, such as perspiring heavily, increases the osmotic pressure of the blood; turns on the vasopressin → V2 receptors → aquaporin-2 pathway.
- The result:
  - As little as 0.5 liter/day of urine may remain of the original 180 liters/day of nephric filtrate.
  - The concentration of salts in the urine can be as much as four times that of the blood. (But not high enough to enable humans to benefit from drinking sea water, which is saltier still
  - If the blood should become too dilute (as would occur after drinking a large amount of water), Vasopressin secretion is inhibited. The aquaporin-2 channels are taken back into the cell by endocytosis. The result: a large volume of watery urine is formed (with a salt concentration as little as one fourth of that of the blood).



MOŘSKÉ PTACTVO

- Marine birds, which may pass long periods of time away from fresh water, and sea turtles use a similar device. They, too, drink salt water to take care of their water needs and use metabolic energy to desalt it. In the herring gull, shown here, the salt is extracted by two glands in the head and released (in a very concentrated solution — it is saltier than the blood) to the outside through the nostrils. Marine snakes use a similar desalting mechanism.



STROMY – DVA PŘÍSPĚVKY

The water potential measurement combines the effects of **solute concentration (s)** and **pressure (p):**

Ψsystem = Ψs + Ψp

where Ψs = solute potential, and Ψp = pressure potential. Addition of more solutes will *decrease* the water potential, and removal of solutes will *increase* the water potential. Addition of pressure will *increase* the water potential, and removal of pressure (creation of a vacuum) will *decrease* the water potential.

Water always moves from a region of **high** water potential to an area of **low** water potential, until it equilibrates the water potential of the system. At equilibrium, there is no difference in water potential on either side of the system (the difference in water potentials is zero). In order for water to move through the plant from the soil to the air (a process called **transpiration**), Ψ^{soil} must be > Ψ^{root} > Ψ^{stem} > Ψ^{leaf} > $\Psi^{atmosphere}$.

Xylém (také *dřevní cévní svazek* nebo ***dřevo***) je botanické označení pro druh pletiva cévnatých rostlin, které přivádí a rozvádí minerální živiny z kořenové soustavy rostliny směrem nahoru do jejích nadzemních částí. Výraz „xylém“ je odvozen ze starořeckého slova *xúlon*, což znamená „dřevo“. Xylém může mít v rostlině funkci mechanickou (opora), transportní (rozvod živin) a zásobní. Živiny se pohybují uvnitř xylému na základě tzv. kořenového vztlaku.

STROM

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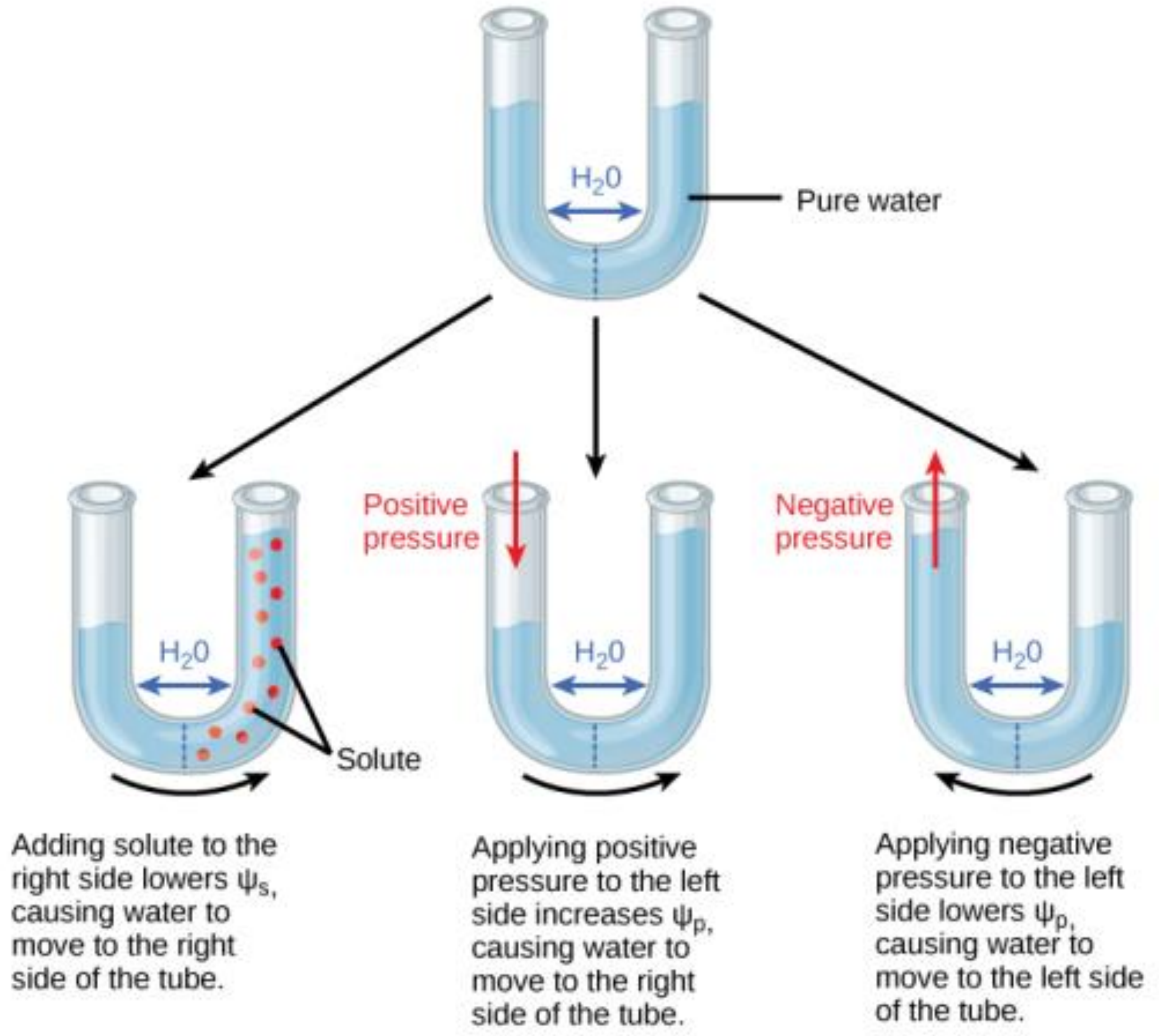

In this example with a semipermeable membrane between two aqueous systems, water will move from a region of higher to lower water potential until equilibrium is reached. Solutes (Ψs) and pressure (Ψp) influence total water potential for each side of the tube. Water moves in response to the difference in water potential between two systems (the left and right sides of the tube). Image credit: OpenStax Biology.

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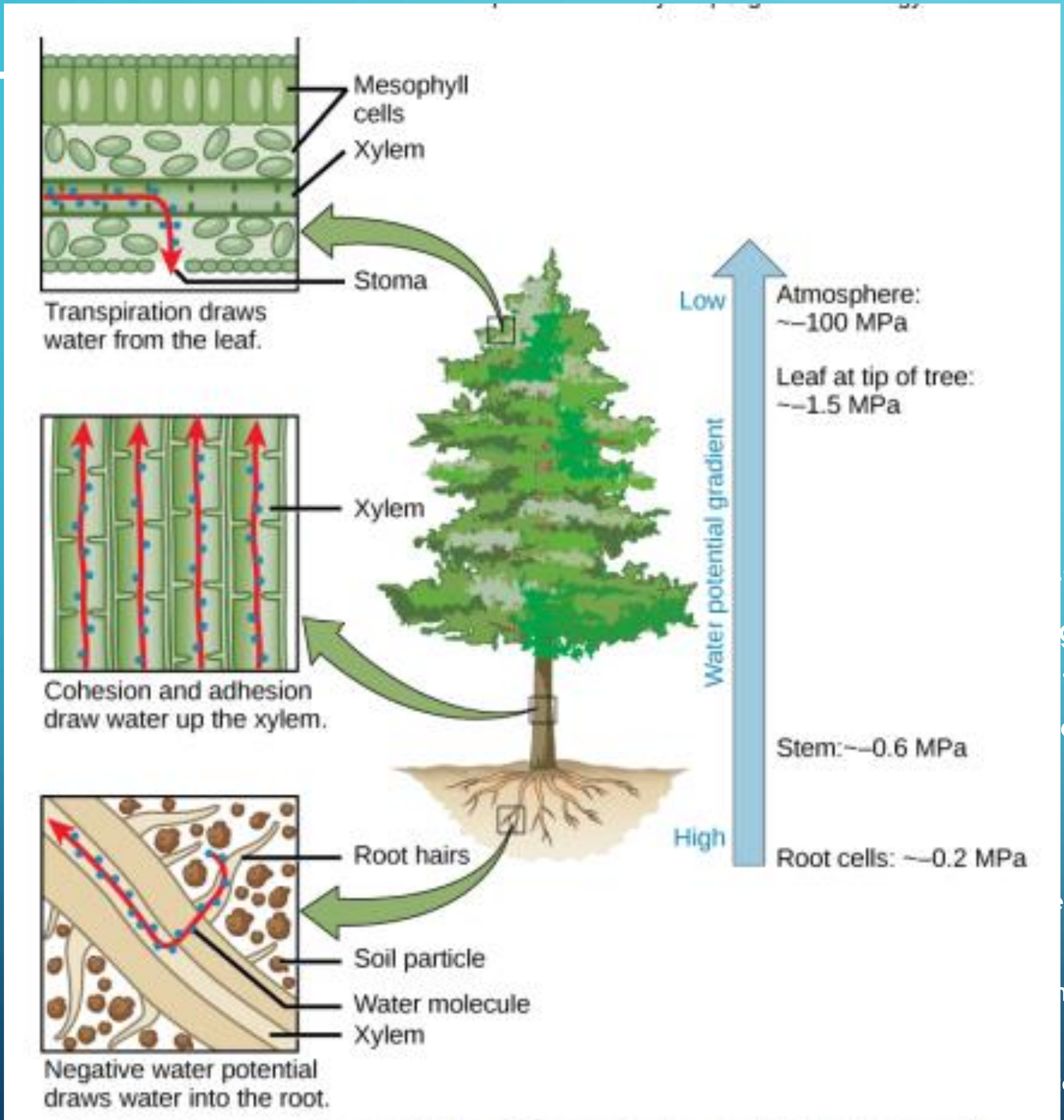
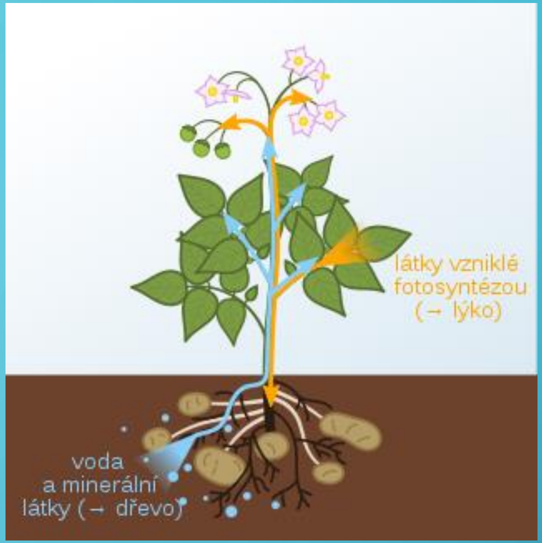


The cohesion-tension theory of sap ascent is shown. Evaporation from the mesophyll cells produces a negative water potential gradient that causes water to move upwards from the roots through the xylem. Image credit: OpenStax Biology



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- water moves into the roots from the soil. Water moves ial in the roots (lower Ψs in roots than in soil). This g water up. In extreme circumstances, root pressure the leaves. However, root pressure can only move o move water up the height of a tall tree.
- up against gravity when confined within a narrow tube
  - r molecules is stronger at the air-water interface than among
  - e case of xylem, adhesion occurs between water molecules and
  - er, cohesion occurs due to hydrogen bonding between water

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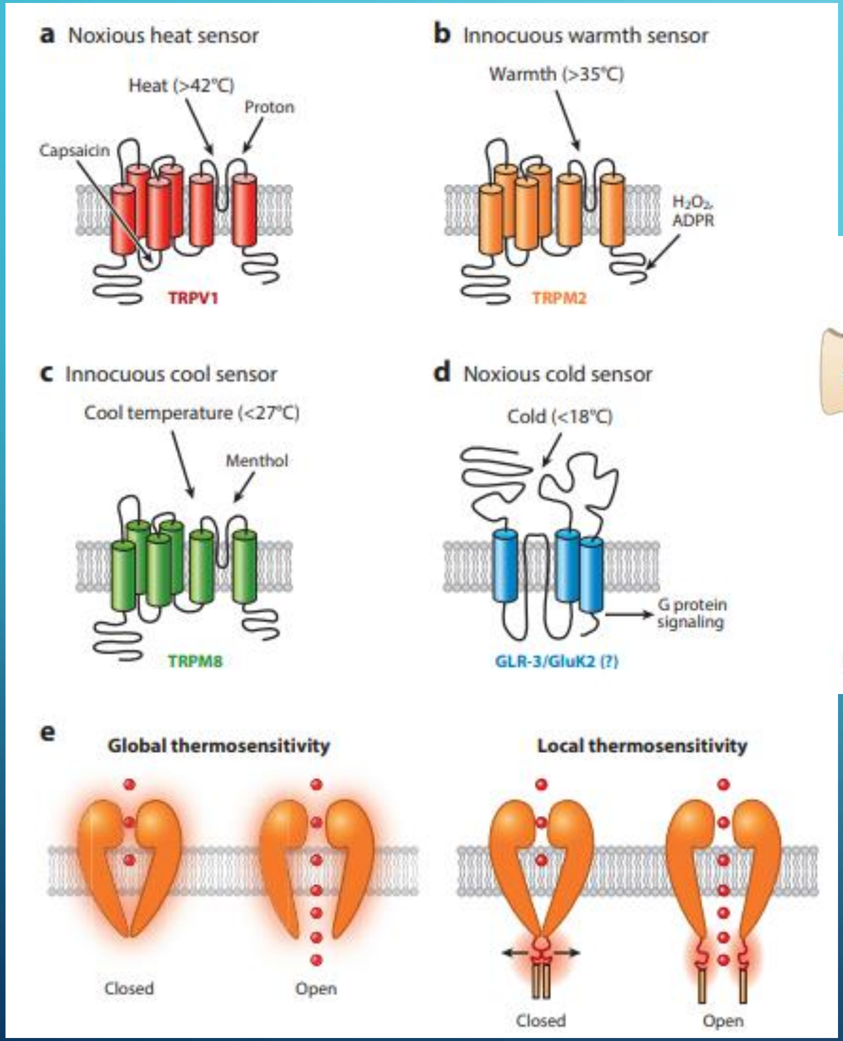
TEPELNÉ VJEMY

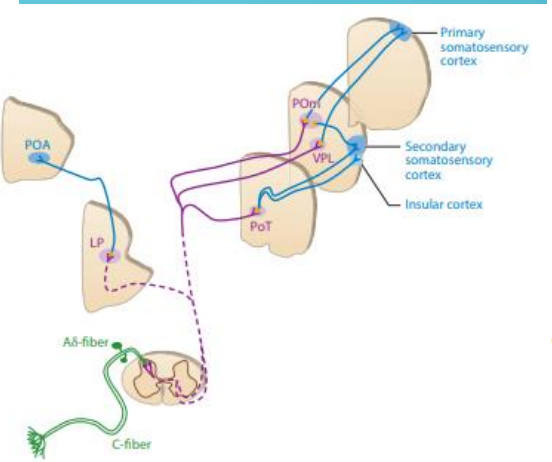
$$S = M - W_k - E_{sk} - E_r - C - R - C_k \, [\mathrm{W\,m^{-2}}]$$

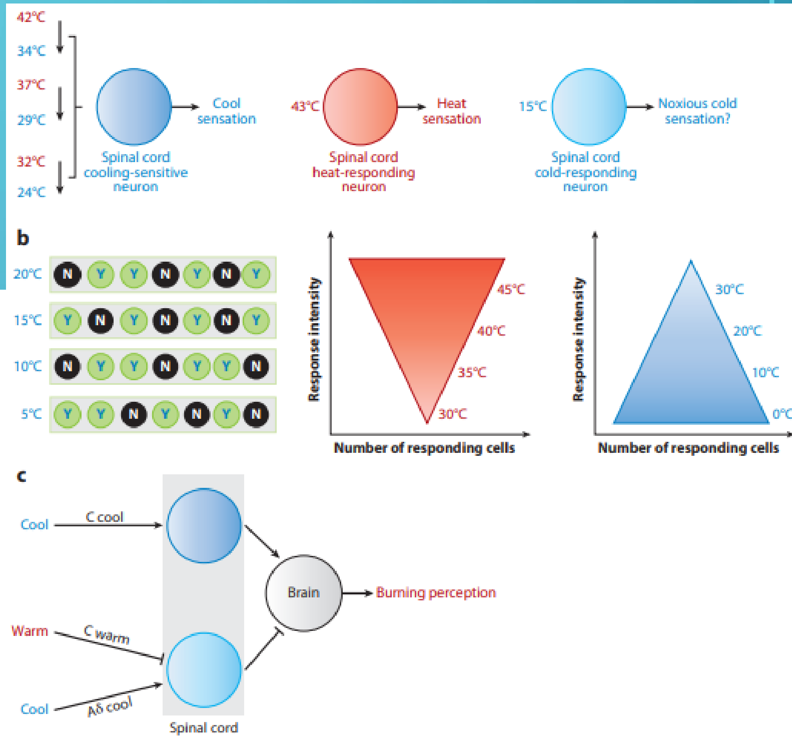
where S = instantaneous energy balance of human body; M = metabolic rate, i.e. internal heat production of the body; W_k = external work; E_{sk} = heat loss by evaporation from the skin; E_r = respiration heat loss, latent and dry; C = heat loss by convection from outer surface of the clothed body to air; R = heat loss by radiation from outer surface of the clothed body to its environment; C_k = heat loss by conduction due to the contact skin/solid object.

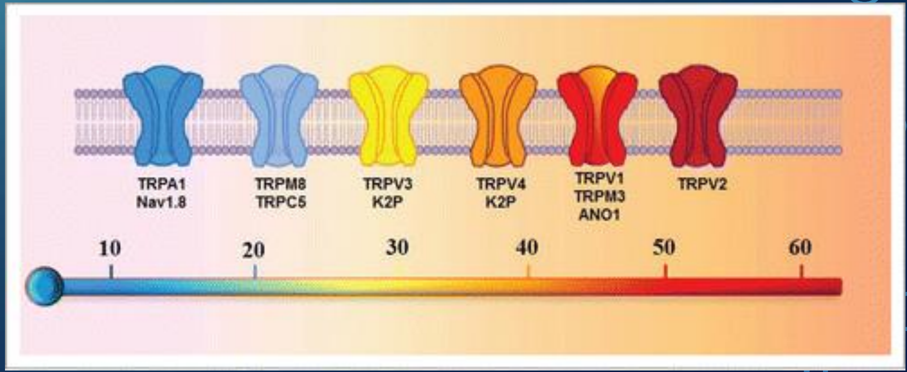
$$A_{DU} = 0.202 \cdot (w_b)^{0.425} \cdot (h_b)^{0.725} \, [\mathrm{m^2}]$$

POCIT TEPLA A CHLADU

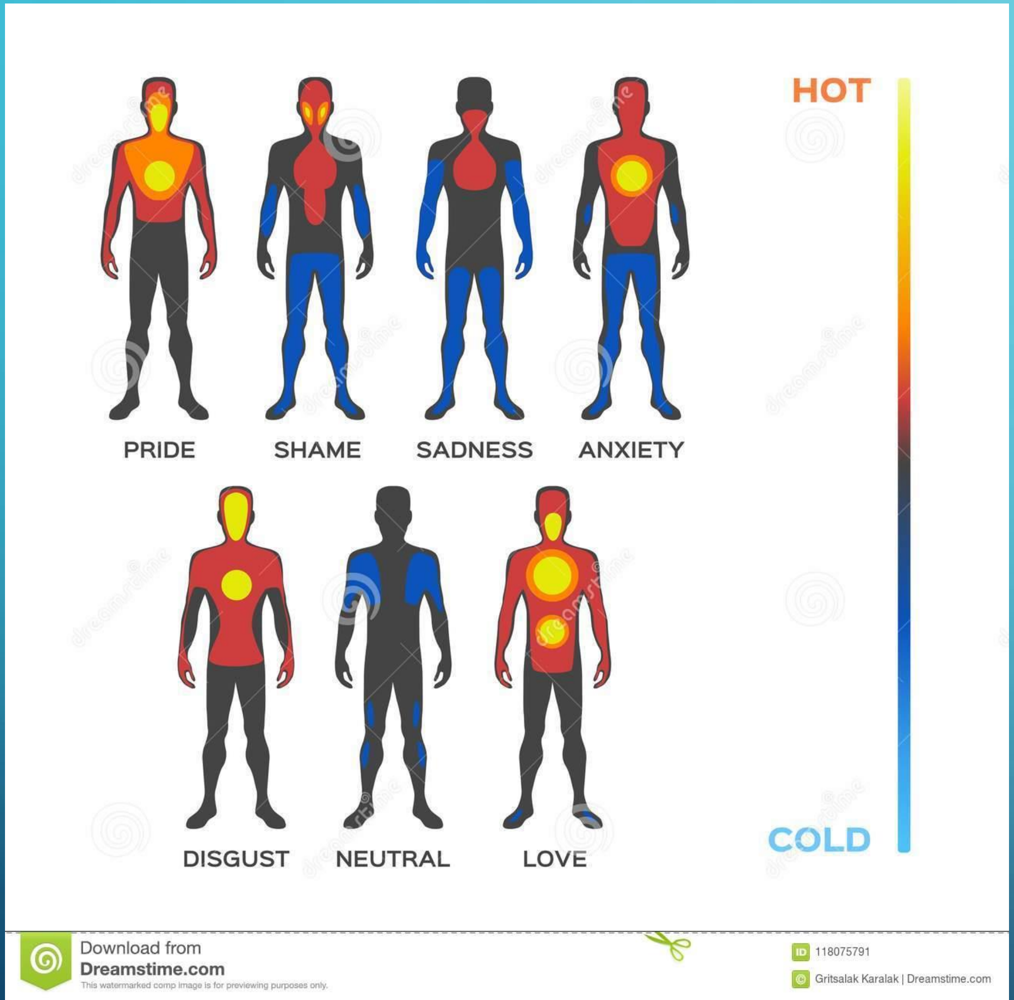


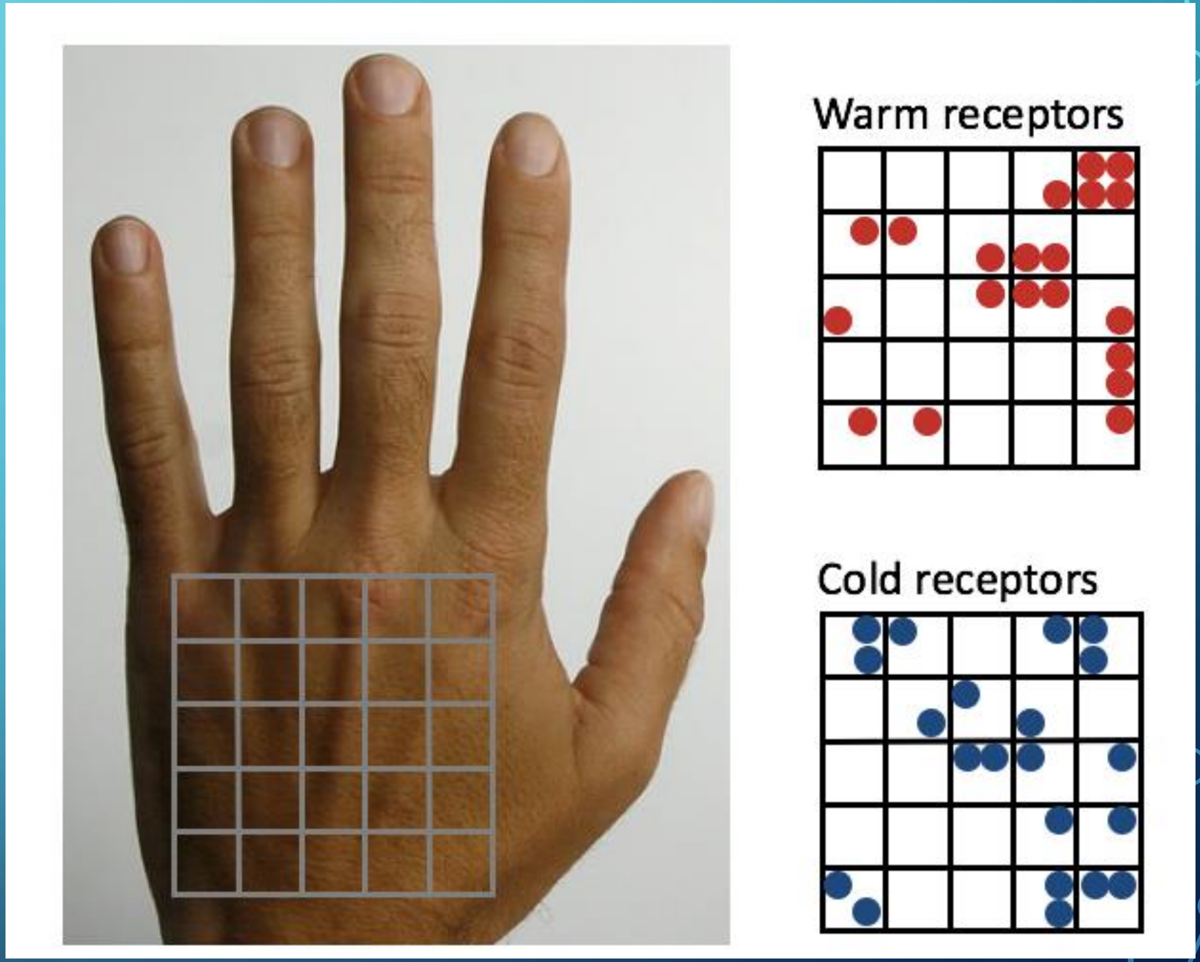






POCIT TEPLA A CHLADU





7 cold spots and 0.24 warm spots per 100 mm2

Cold signal -- 10-20 m/s, warm signal 1-2 m/s