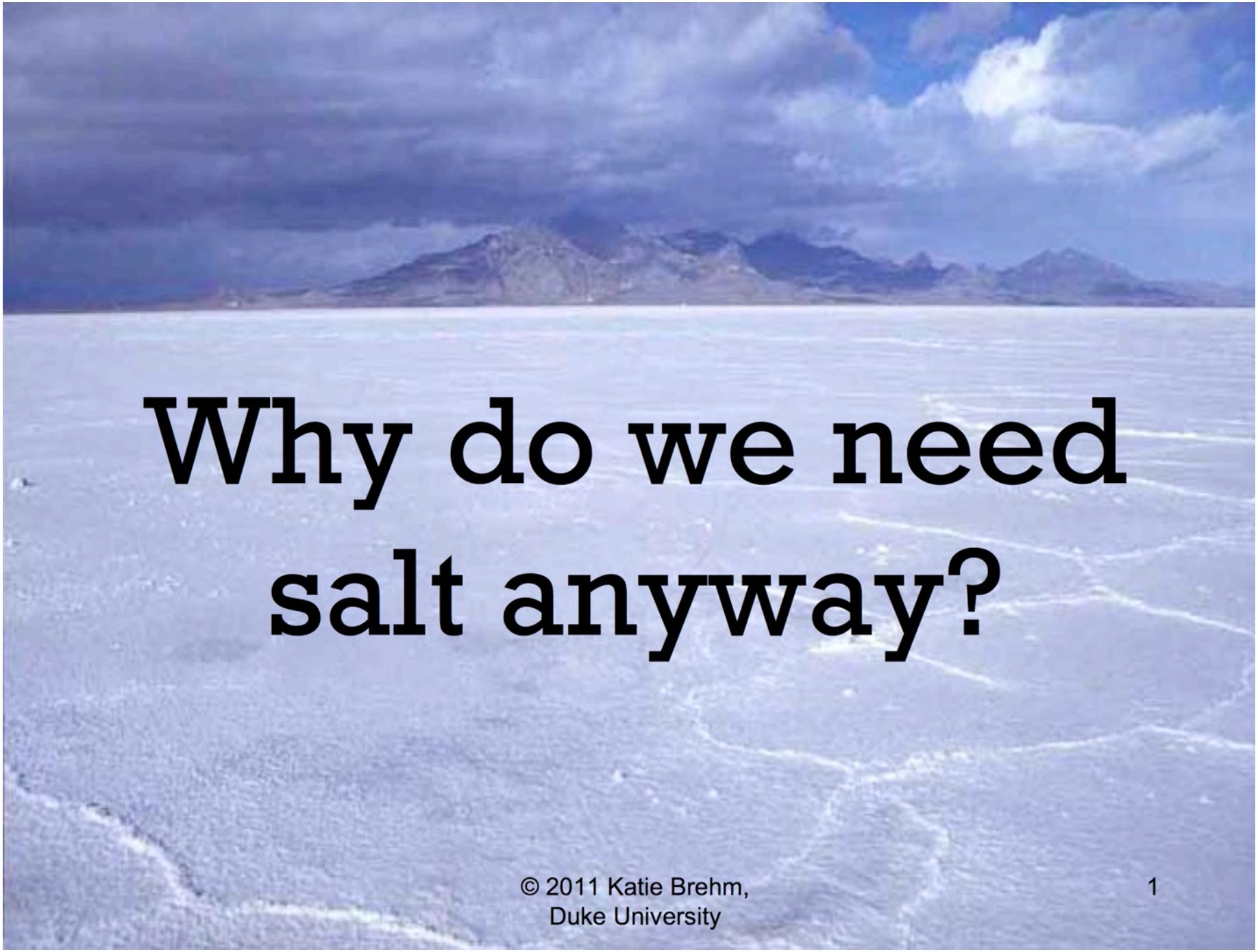

Why do we need salt anyway?
© 2011 Katie Brehm, Duke University
1

It's all about ..... *balance.*

What does balance mean?

What things can be balanced?


Flakes


Flakes

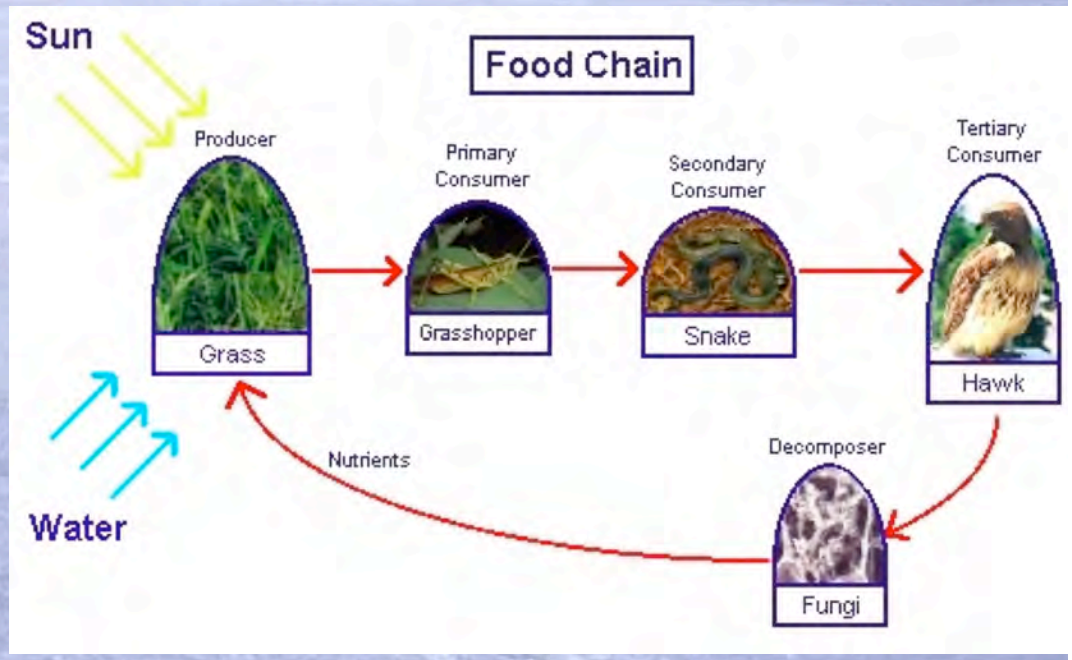

Flakes


Flakes


EXPENDITURES
REVENUE

What about balance in science?

What about balance in science?



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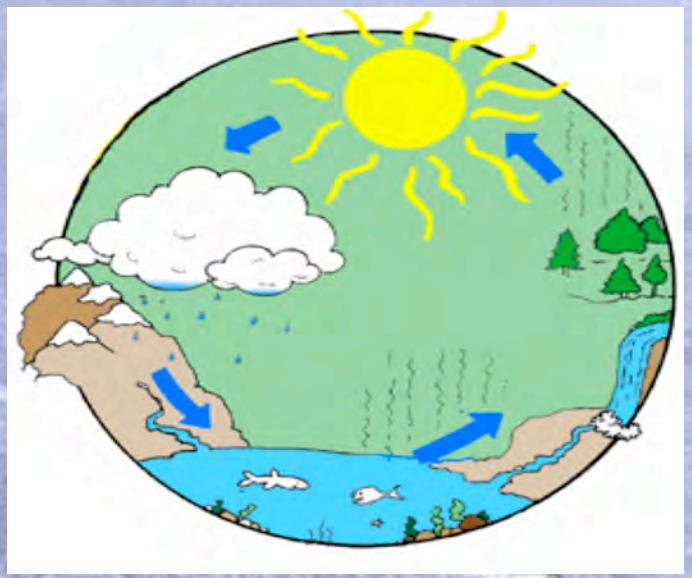

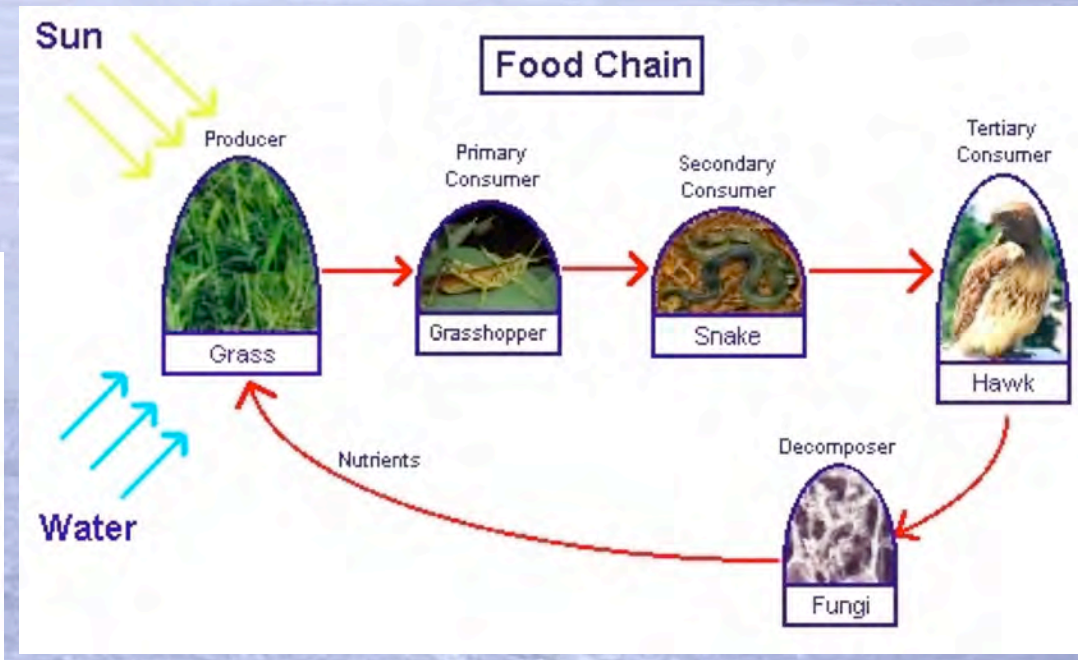

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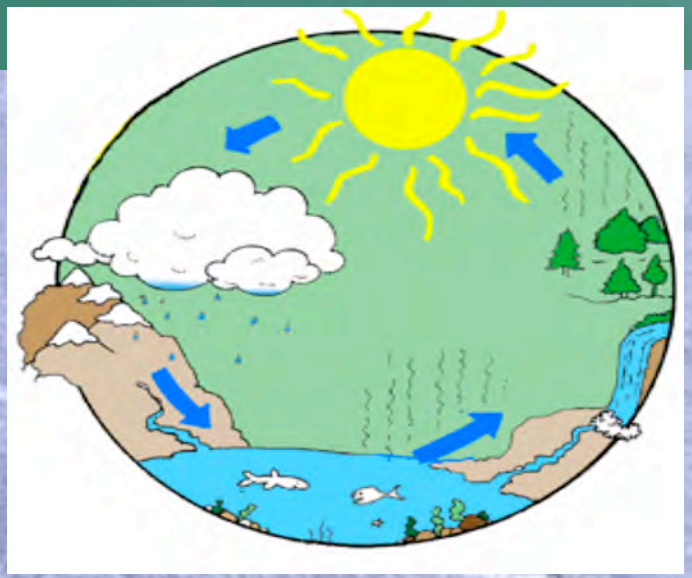
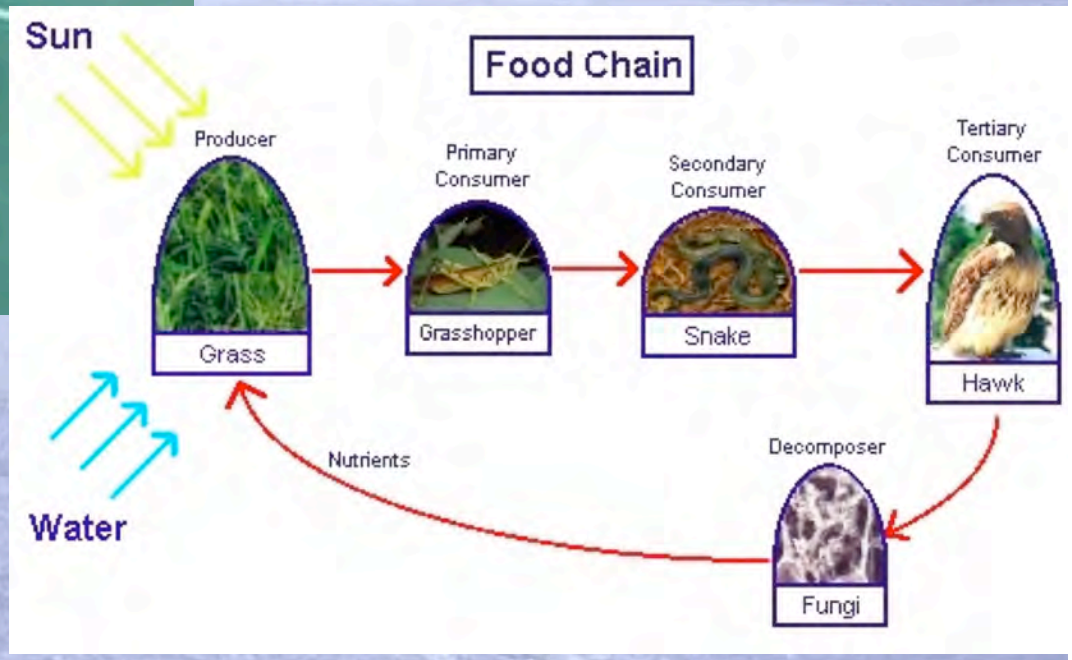
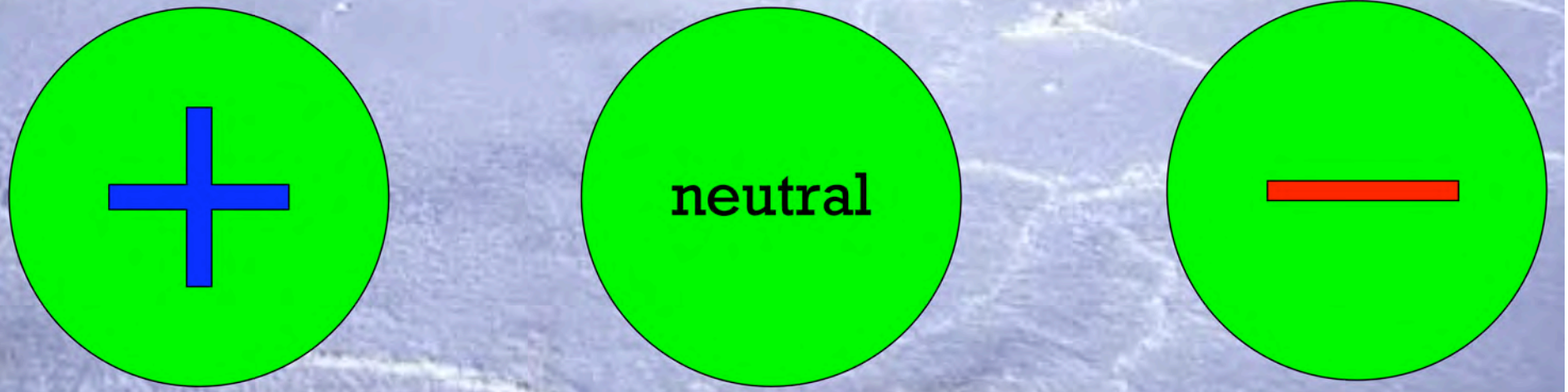




Now, for a little chemistry…

Chemistry explains what substances make up all matter on earth.

Much of chemistry is based on *electrical charges.*



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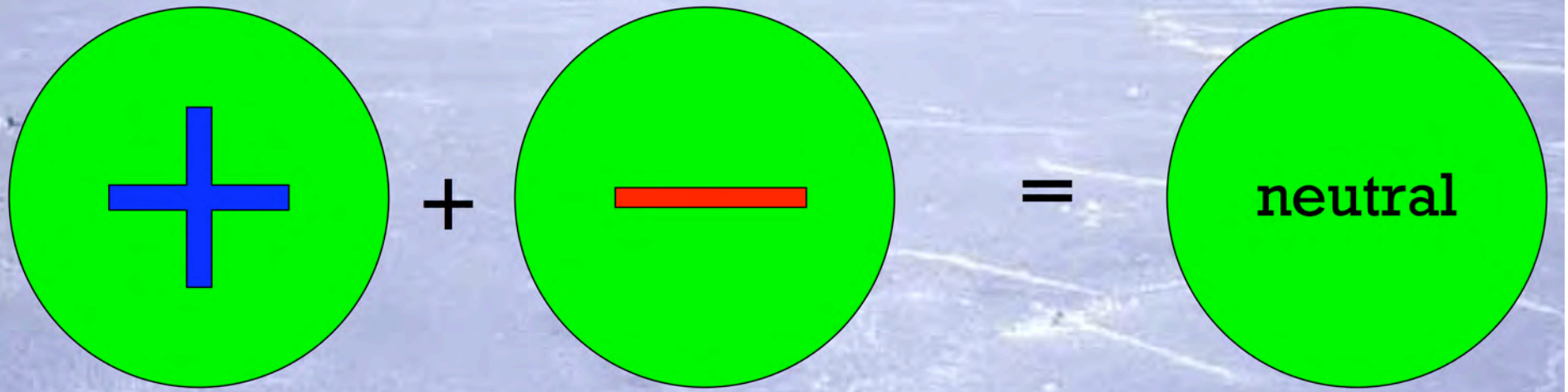
A salt is defined as…



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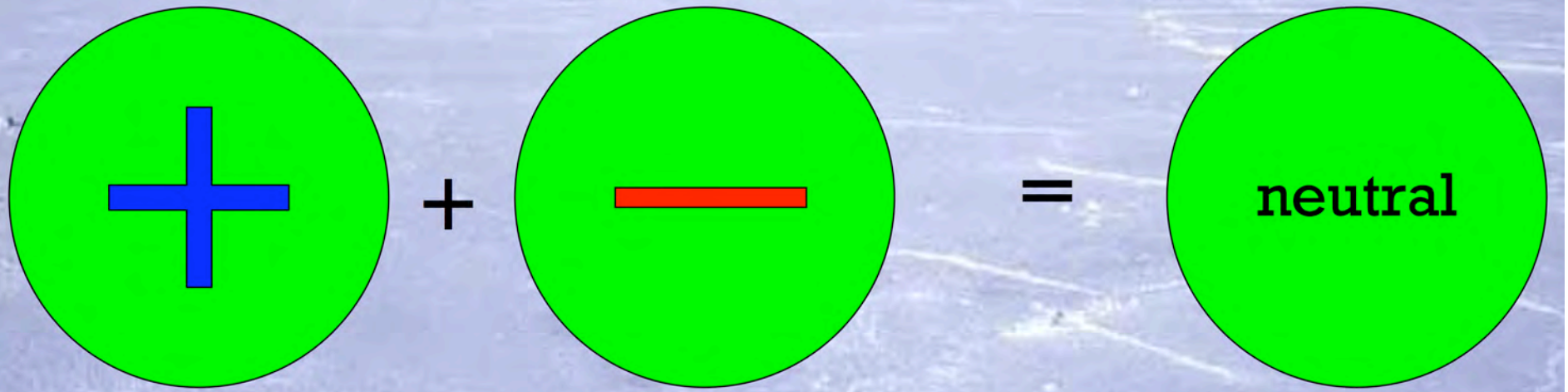

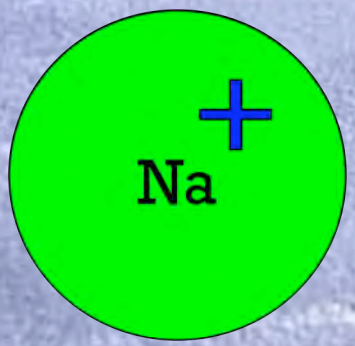

+

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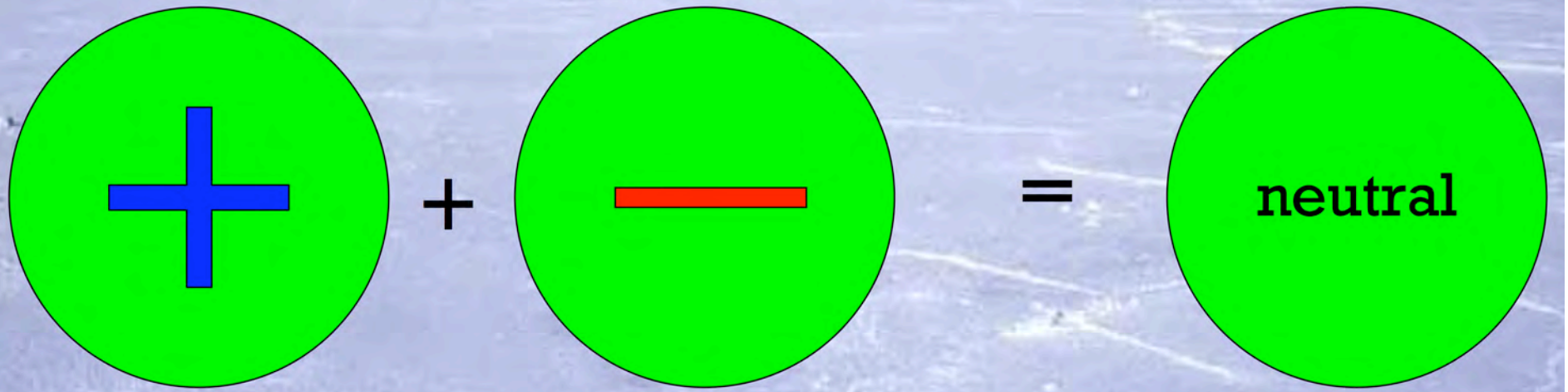

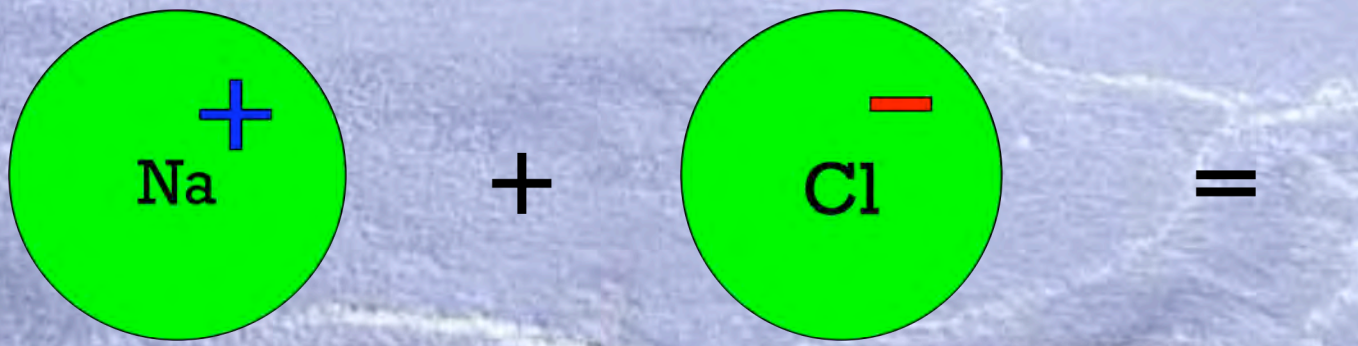

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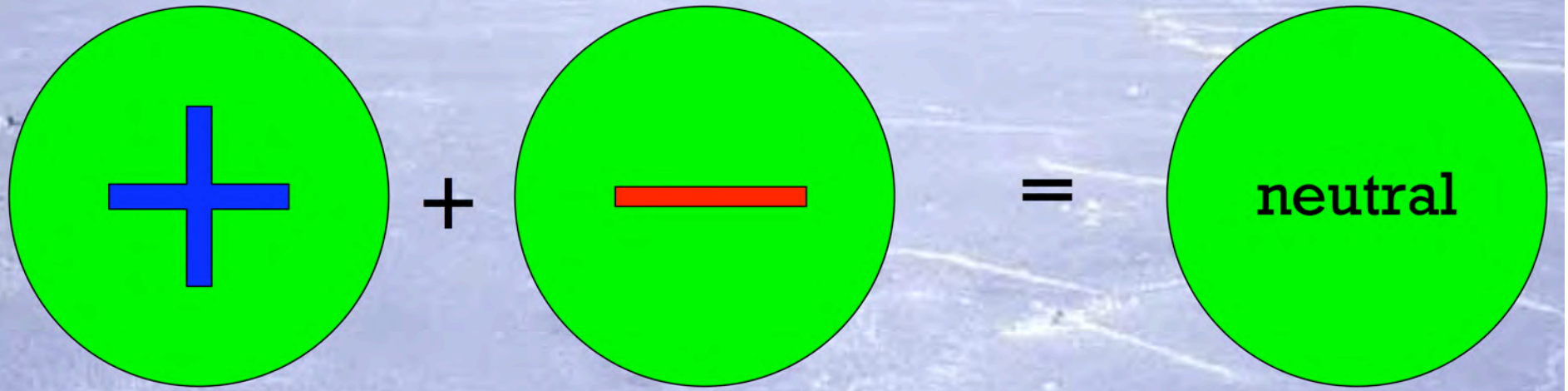
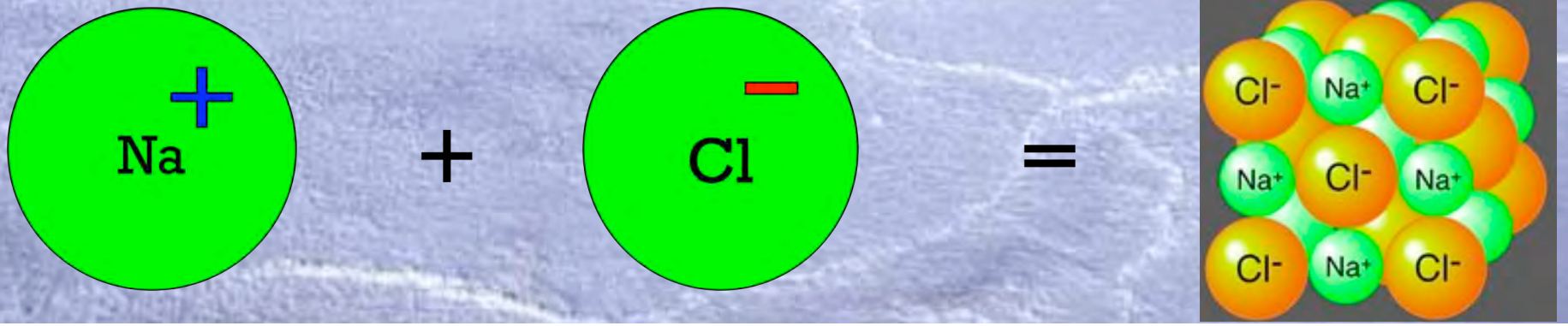
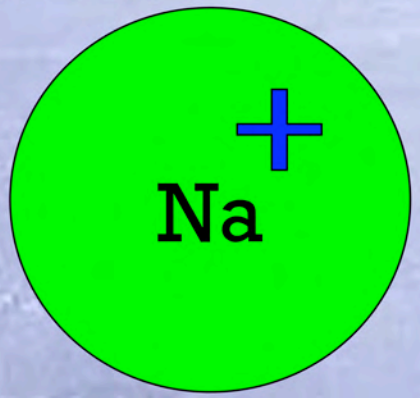


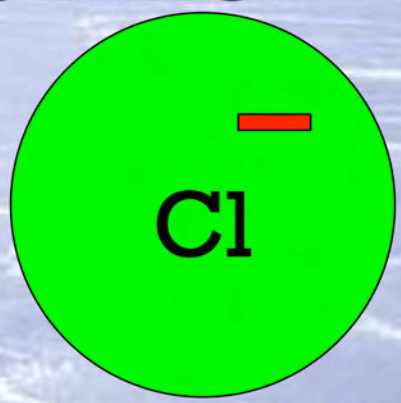


Now, for a little chemistry…

sodium = Na



chlorine = Cl



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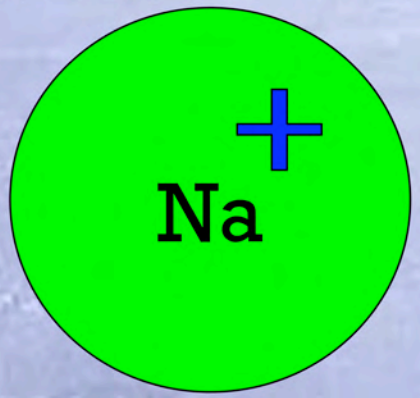

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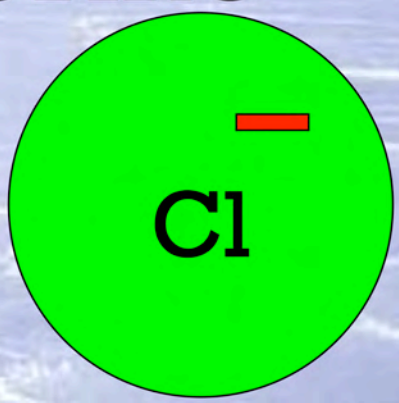
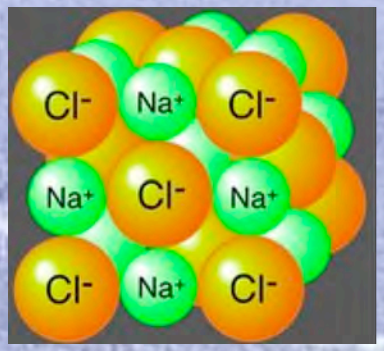
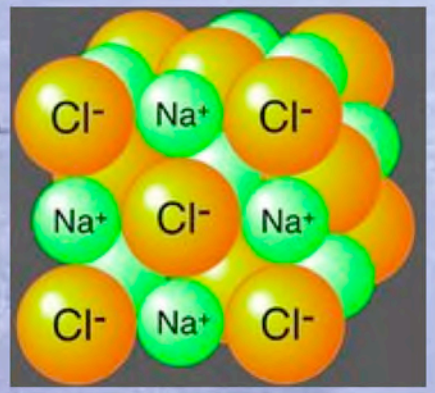




= sodium chloride (NaCl)

Now, for a little chemistry…

What if a salt is dissolved in water…?



+ H_2O =

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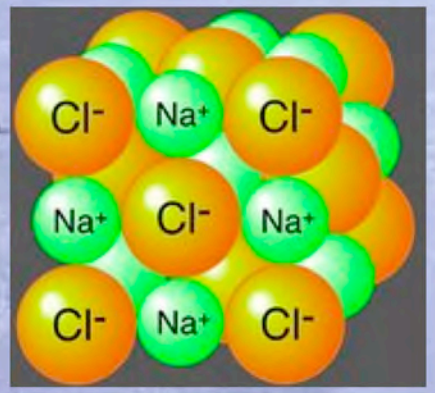

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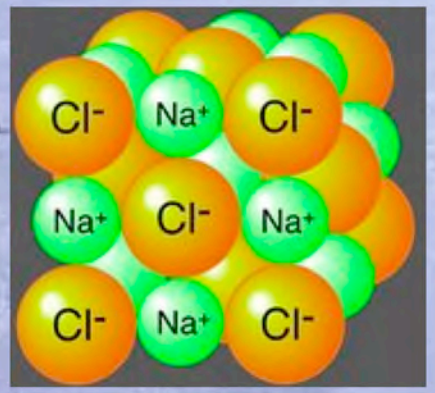

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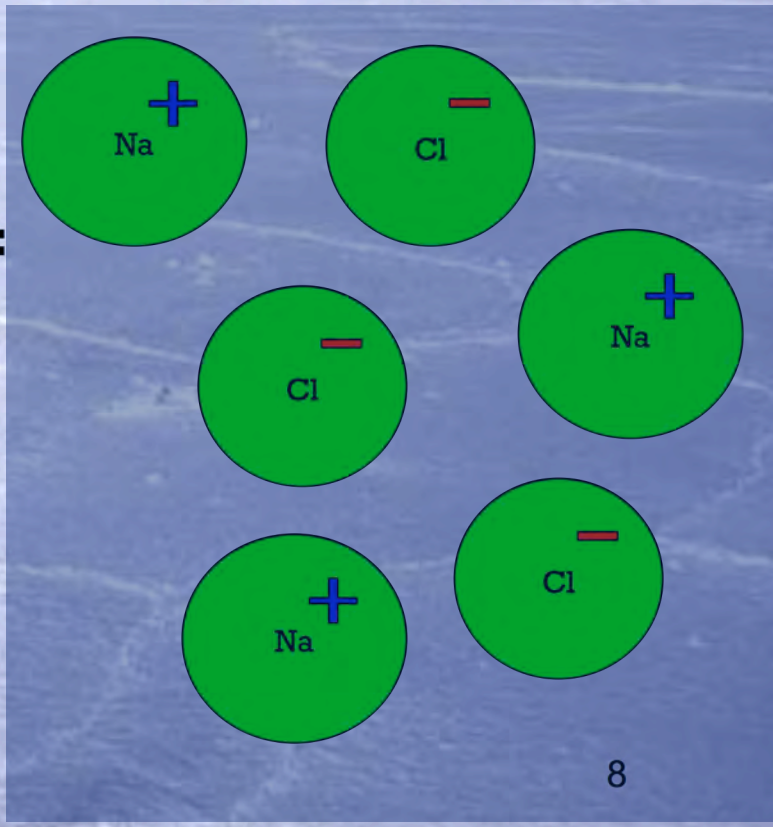

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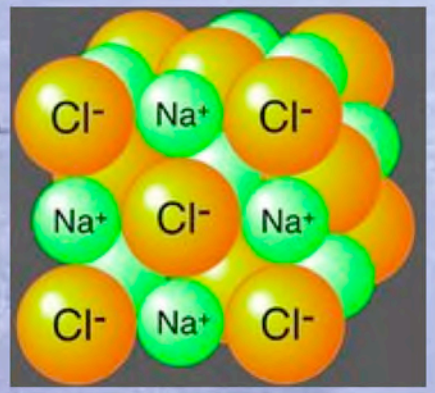

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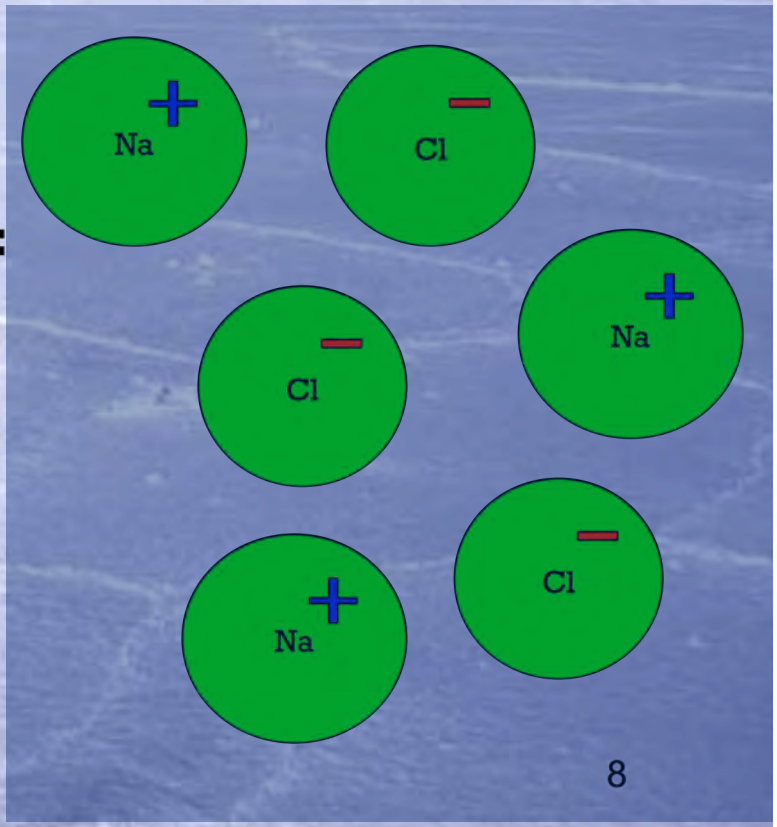
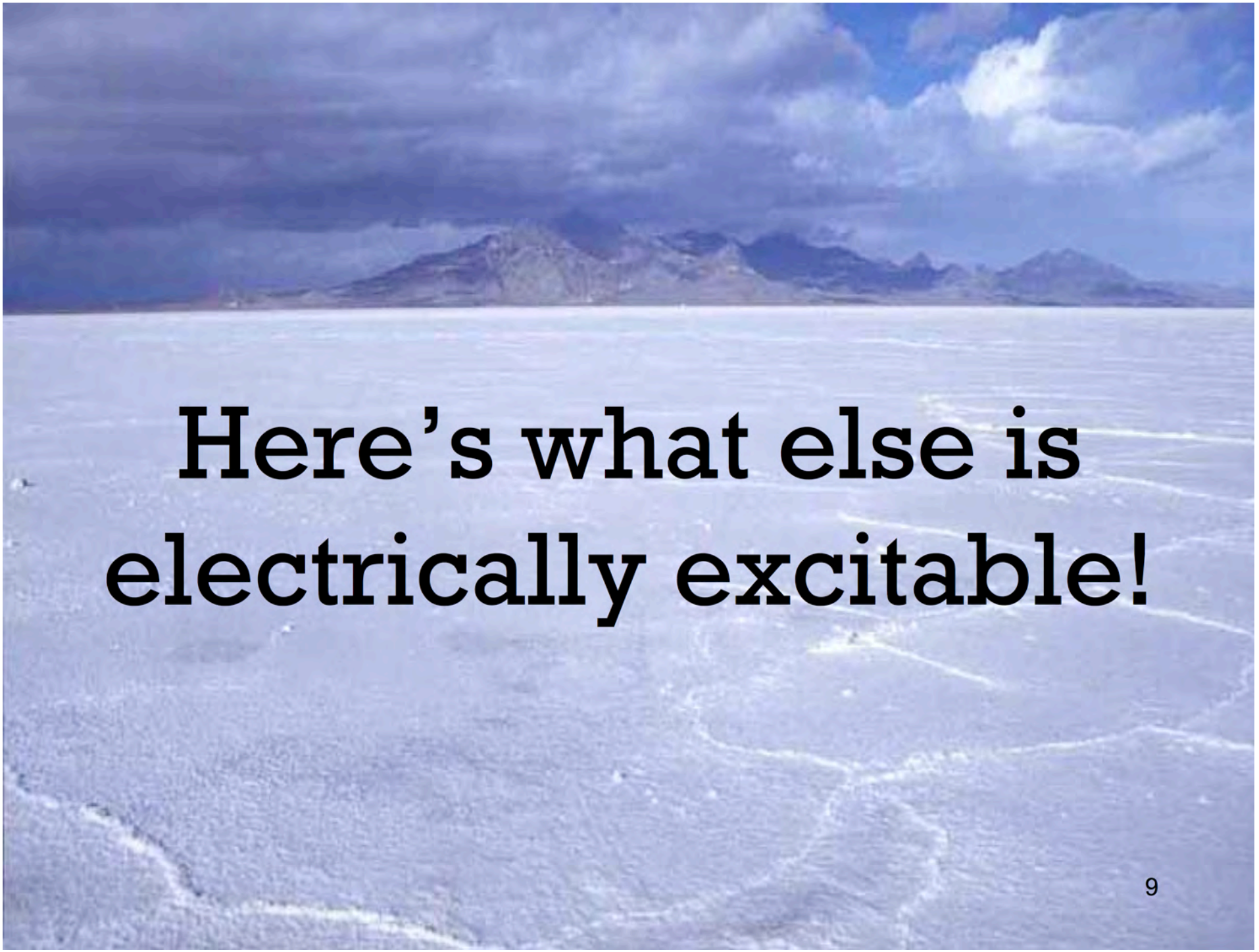
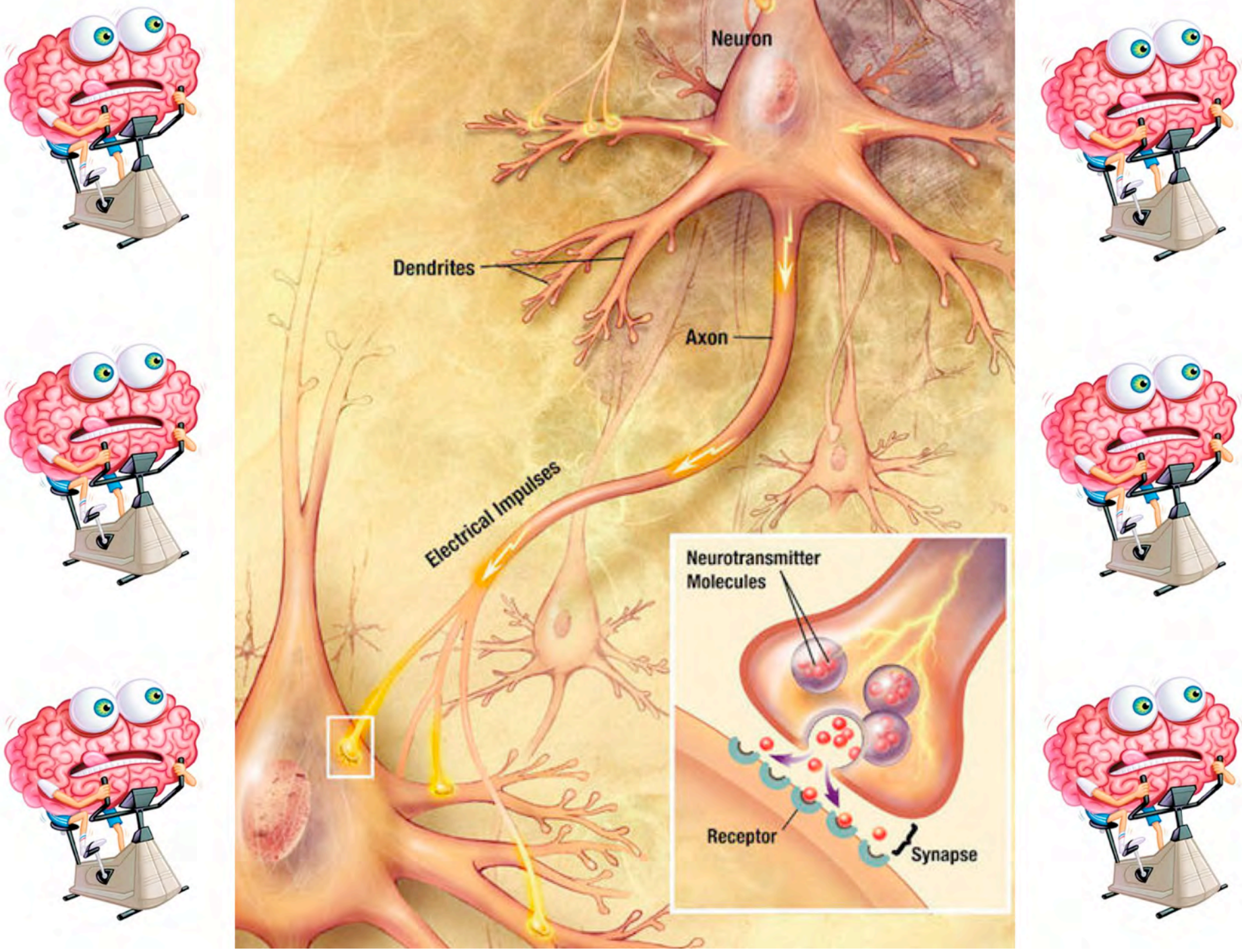
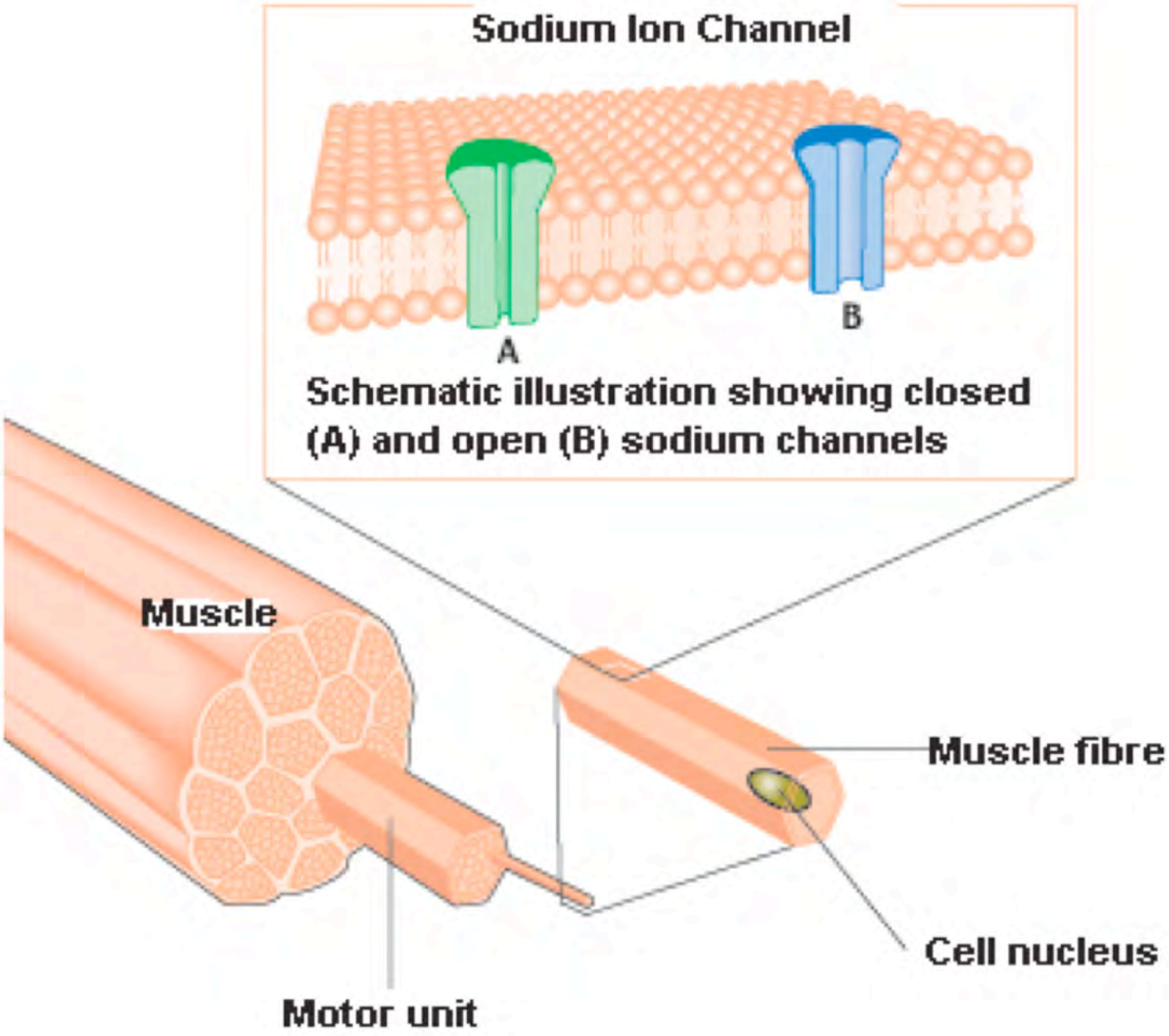
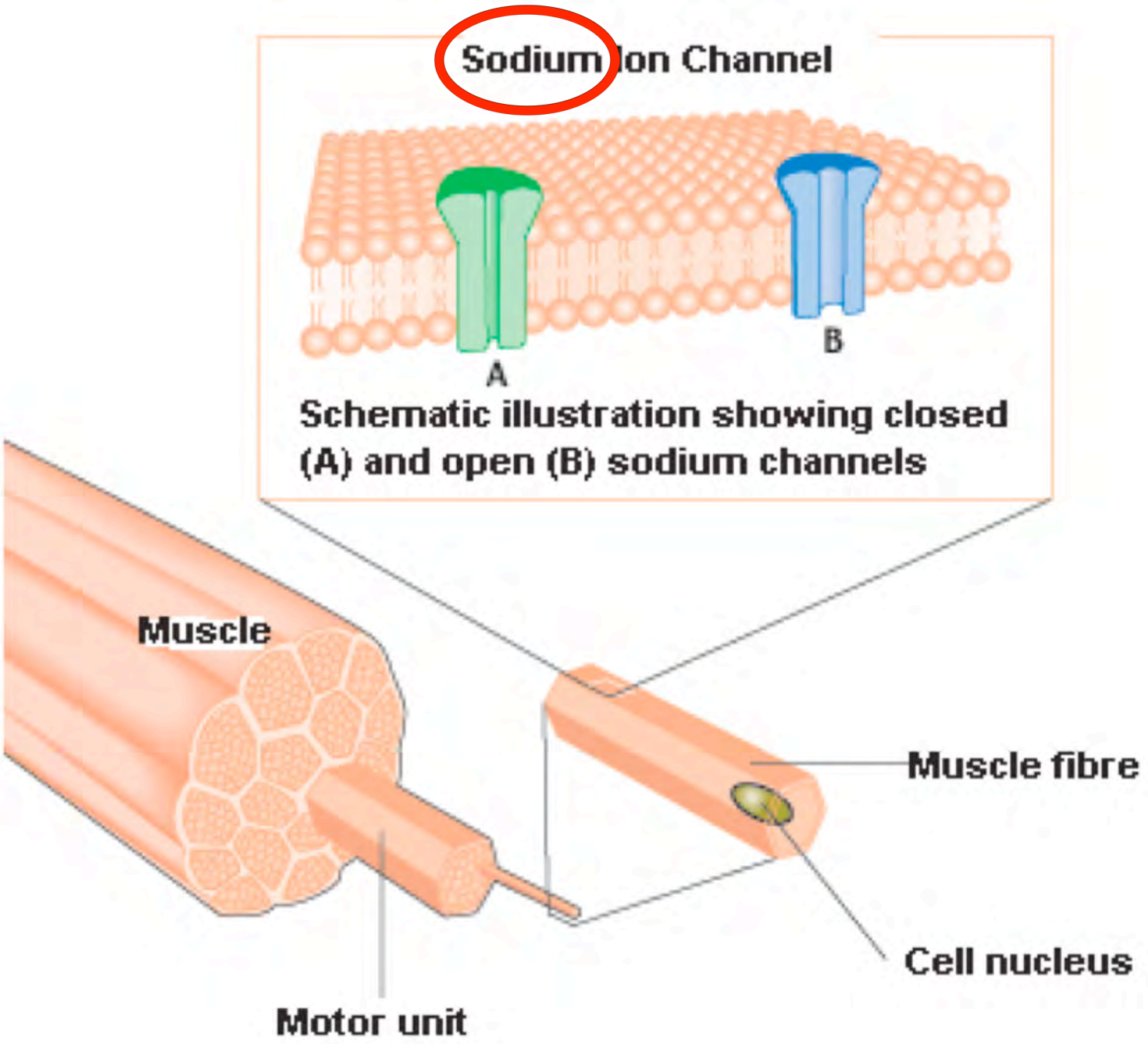


This *solution* is now electrically excitable!


Here's what else is
electrically excitable!


Neuron
Dendrites
Axon
Electrical Impulses
Neurotransmitter Molecules
Receptor
Synapse


Sodium Ion Channel
A
B
Schematic illustration showing closed (A) and open (B) sodium channels
Muscle
Muscle fibre
Cell nucleus
Motor unit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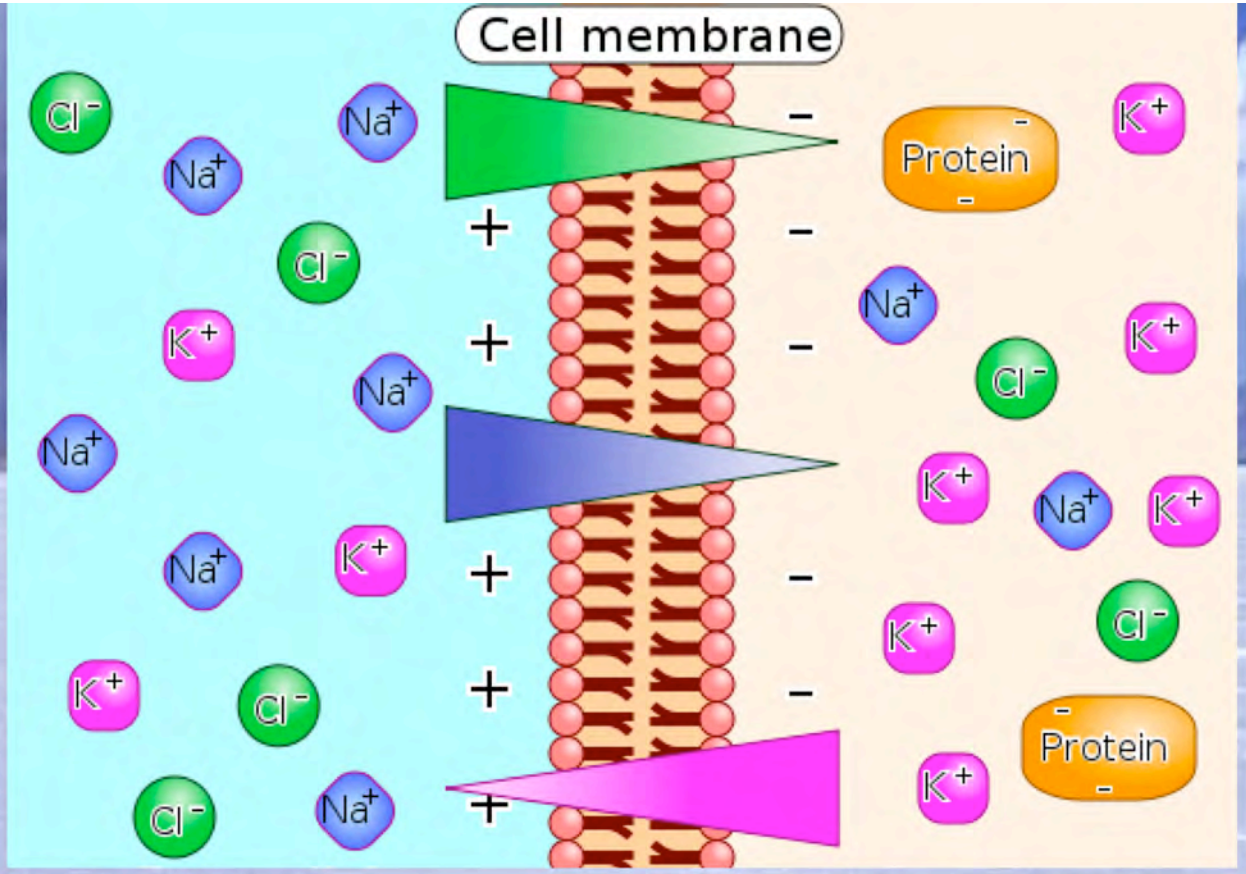
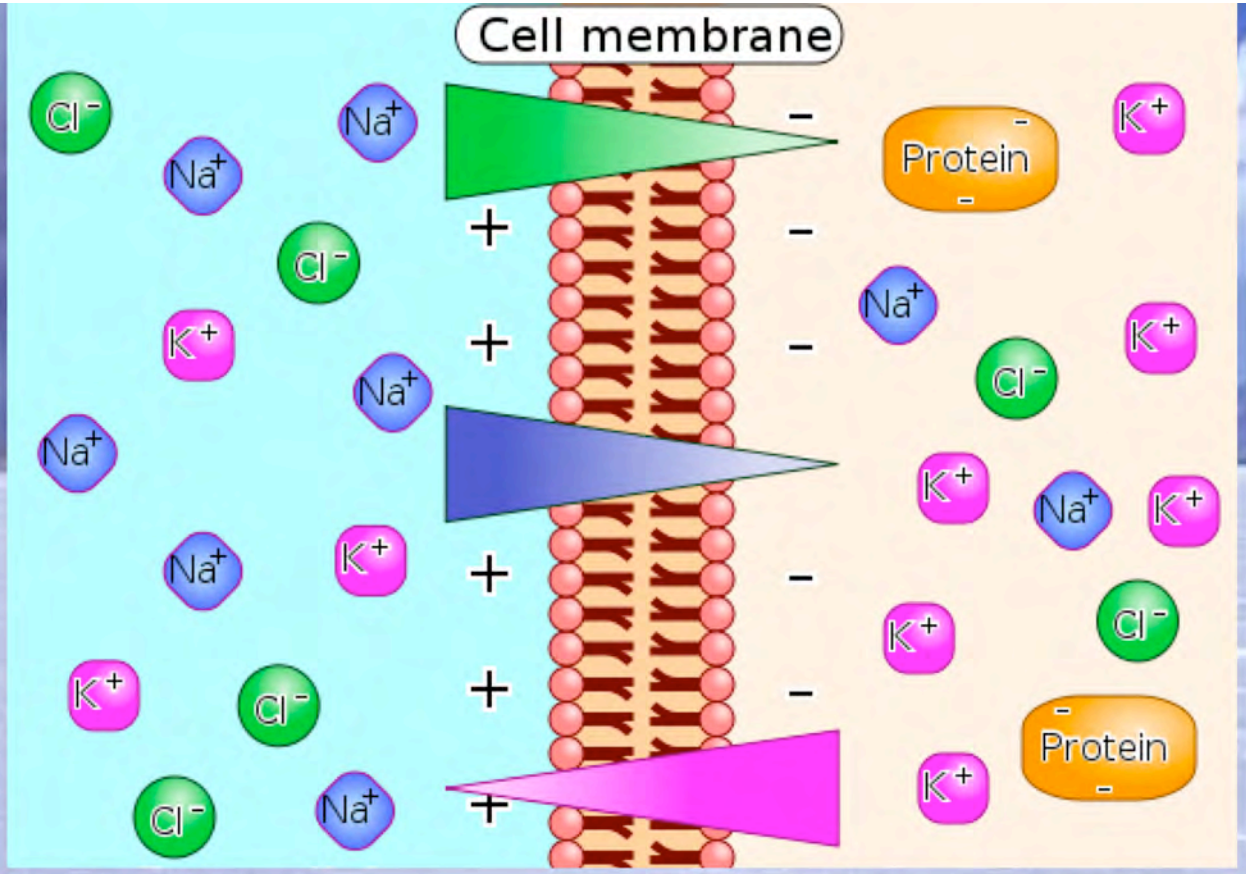


In fact, almost all cells (animal or plant) have sodium (Na) and chloride (Cl) near the cell walls/membranes.



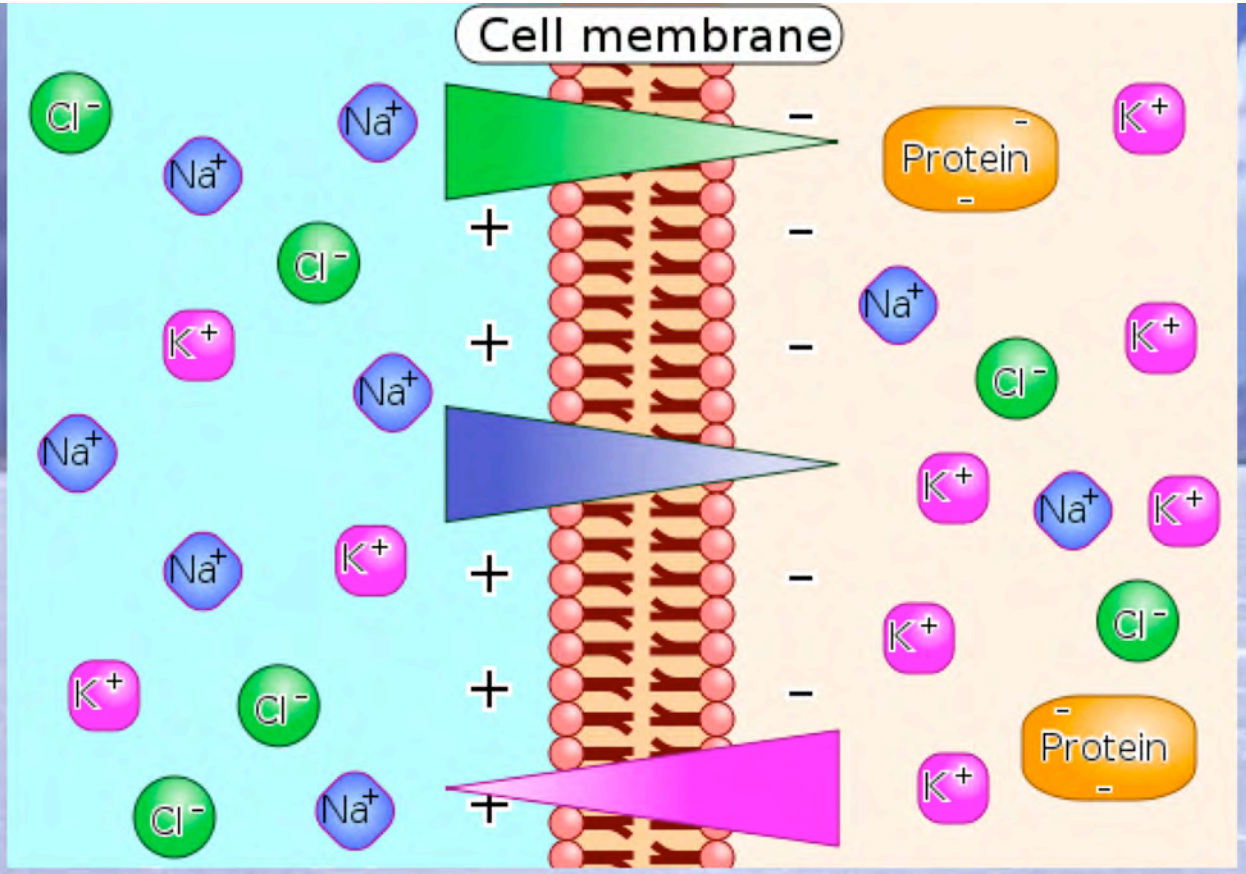
In fact, almost all cells (animal or plant) have sodium (Na) and chloride (Cl) near the cell walls/membranes.

Did you know…?

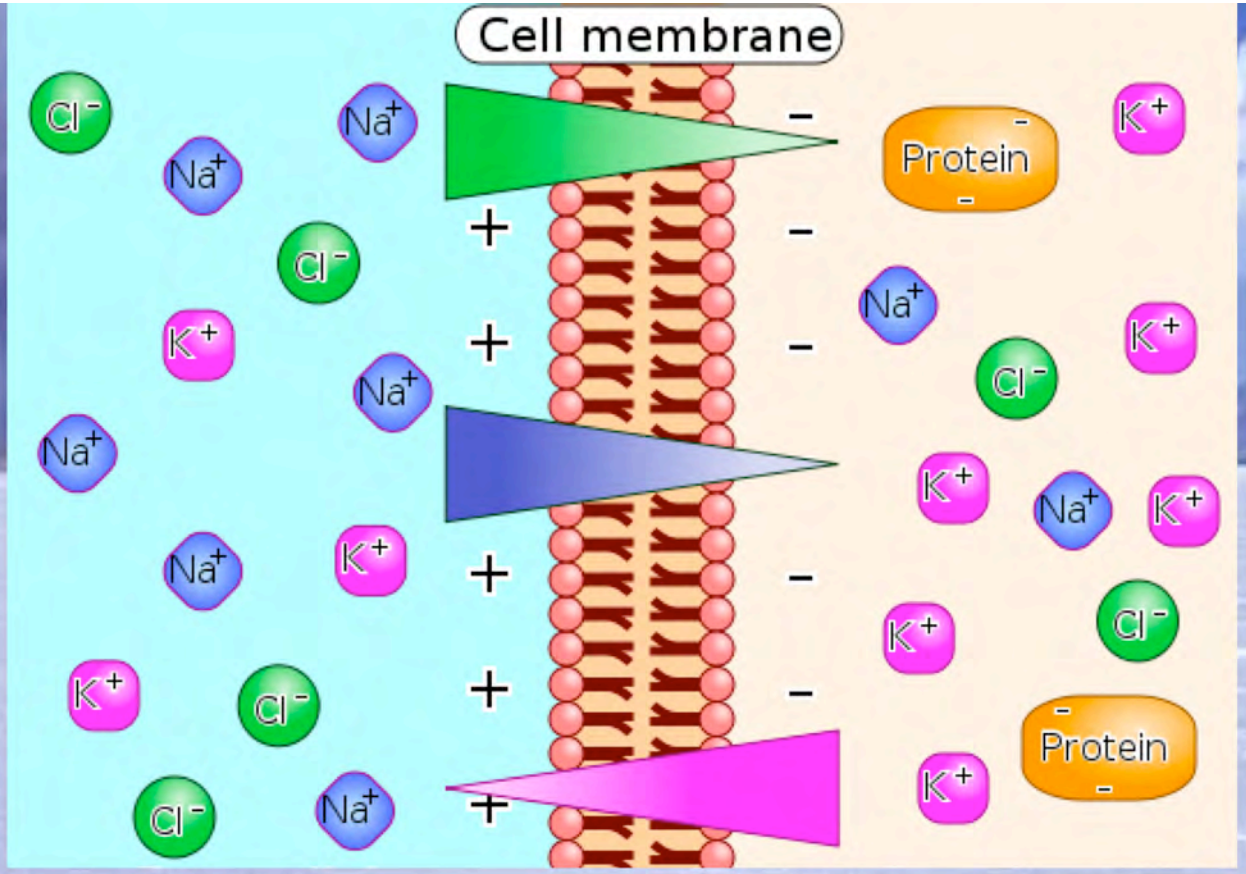
Human blood is 0.9% NaCl!

How salty is that?

Fresh water is <0.05% NaCl.
Saltwater is about 3% on average.



Salinity of blood =
salinity of most ***extracellular*** spaces



Salinity of blood =
salinity of most ***extracellular*** spaces

Plants don't have brains or muscles.

So what is the purpose of having sodium (Na) and chloride (Cl) inside and outside the cell walls?

What Does Salt Stress Look Like?

International Rice Research Institute, 2006

Major symptoms are :

- White leaf tip followed by tip burning (salinity)

- Leaf browning & death (sodicity)
- Stunted plant growth
- Low tillering
- Spikelet sterility

(Papery) Spikelet sterility is an effect of salinity at reproductive stage

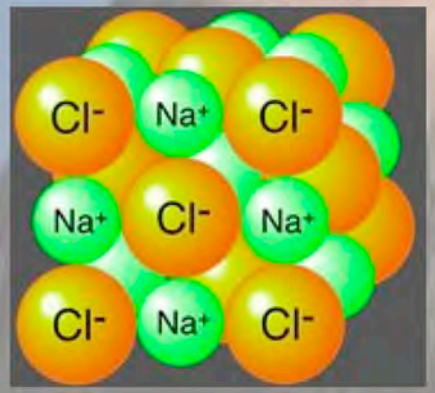

Low harvest index
Less florets per panicle
Less 1000 grain weight
Low grain yield
Change in flowering duration
Leaf rolling
White leaf blotches
Poor root growth
Patchy growth in field

The Body & Salt: Why do we need it again?

REMEMBER THIS?

Now, for a little chemistry…

What if a salt is dissolved in water…?



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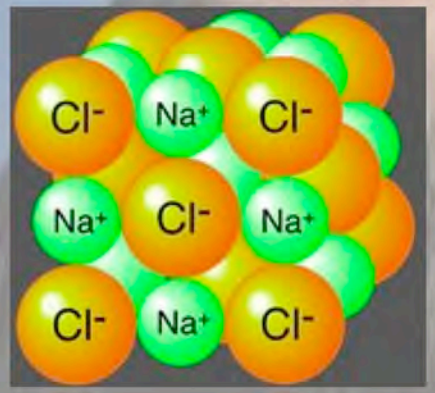

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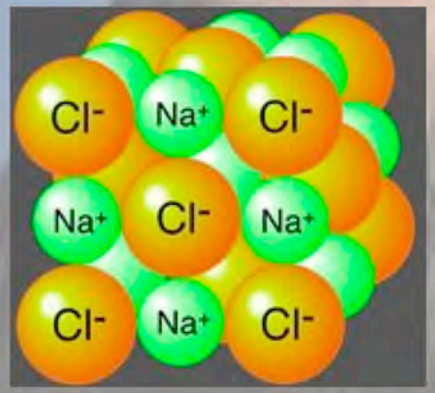

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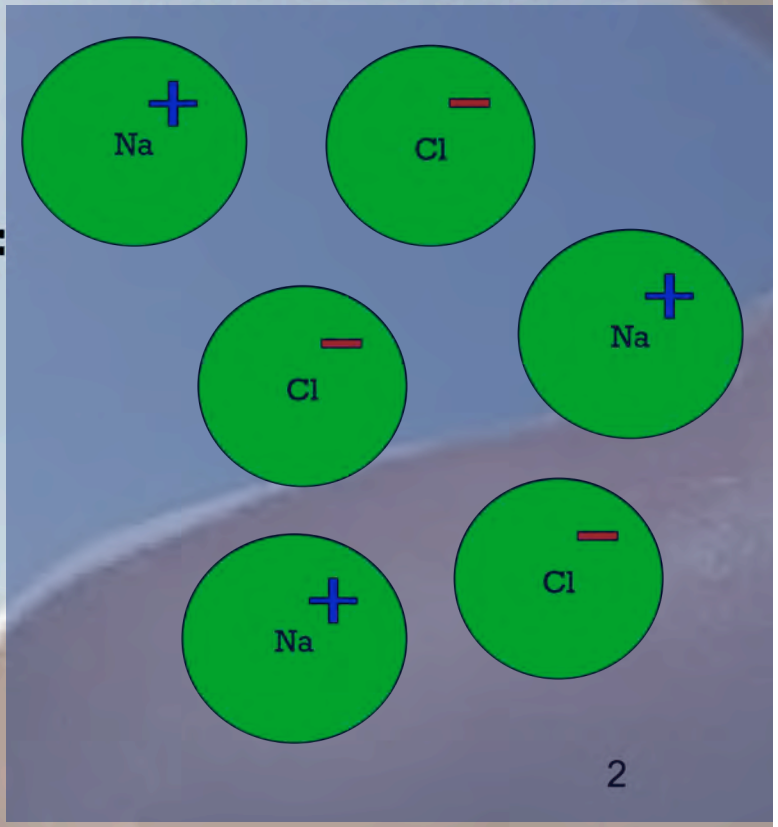

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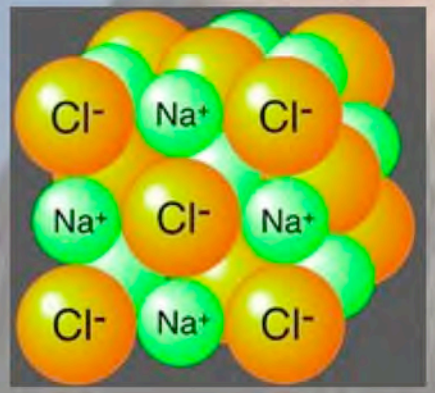

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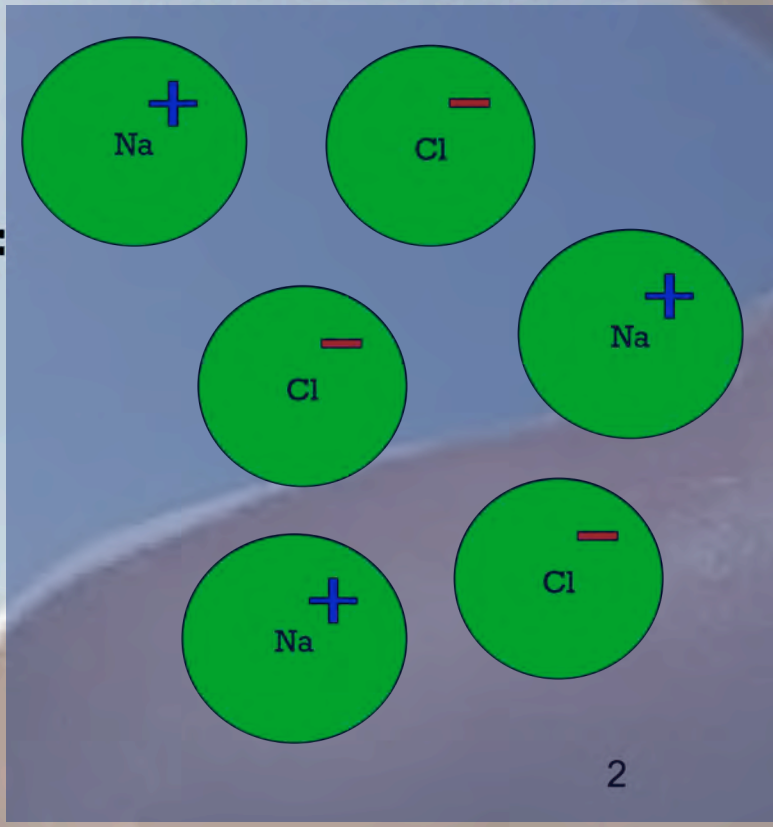
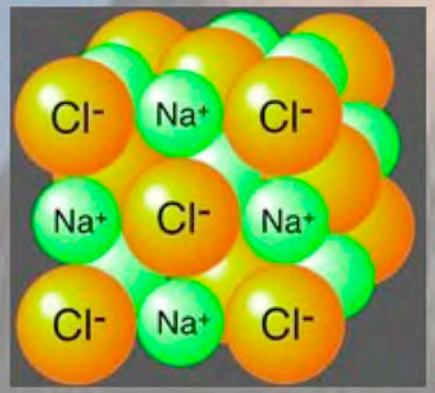


This *solution* is now electrically excitable!

This is called an ***electrolyte.***



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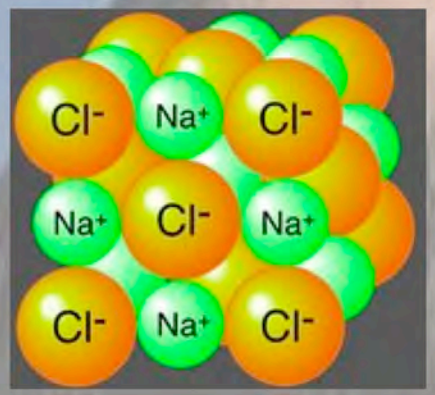

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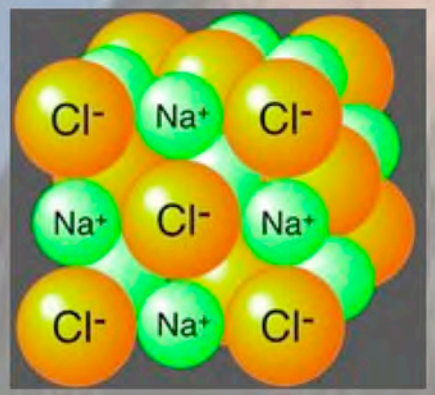

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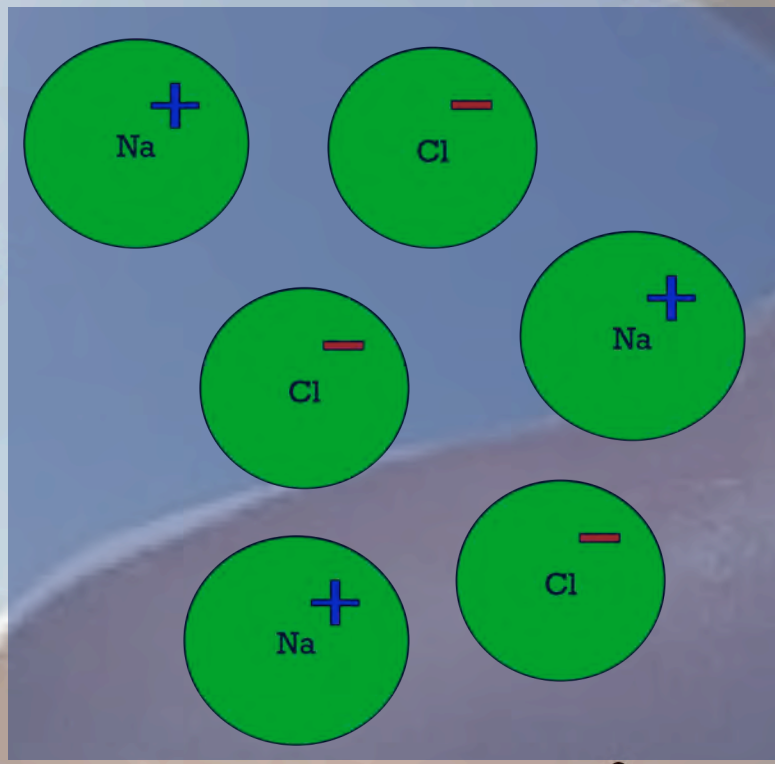
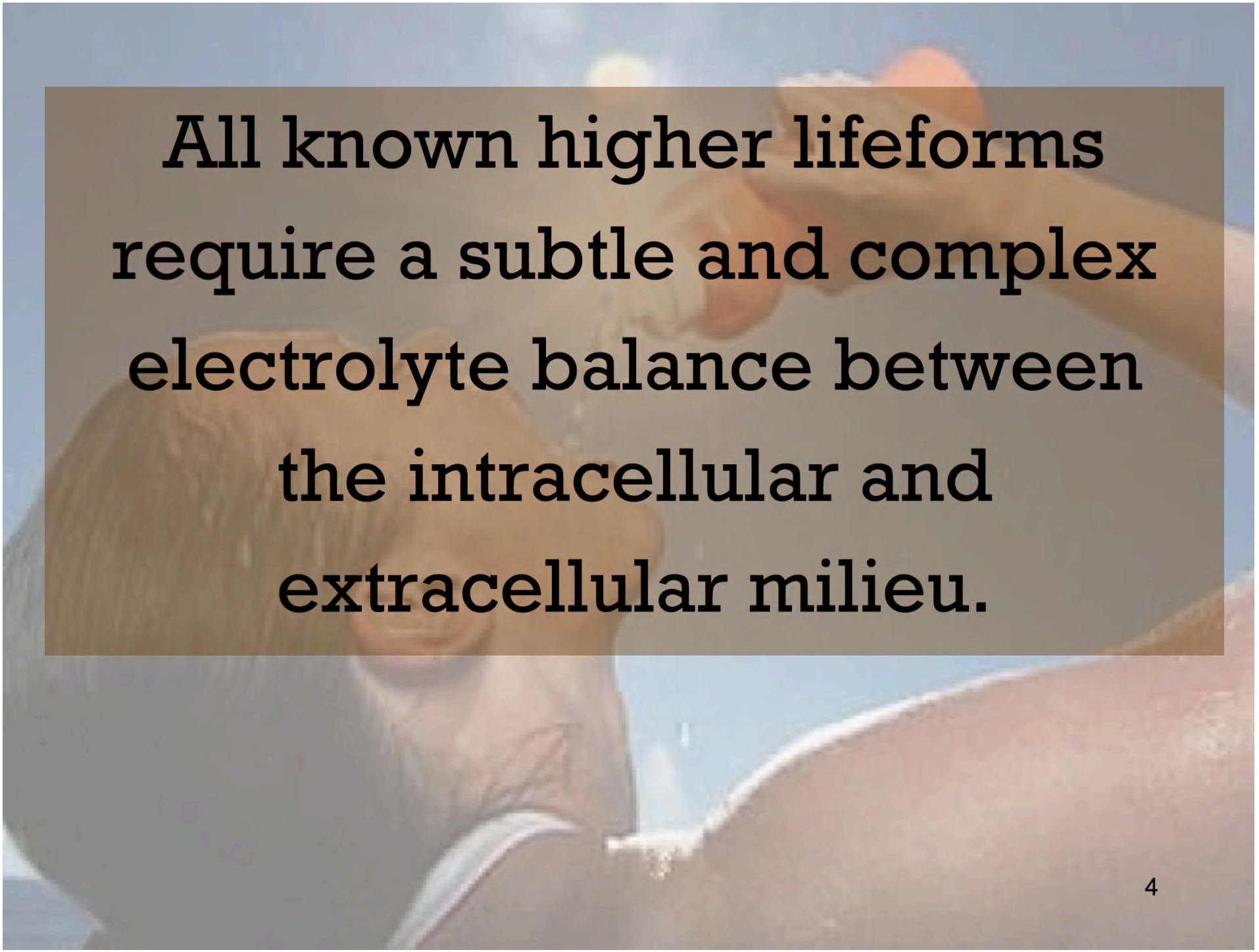


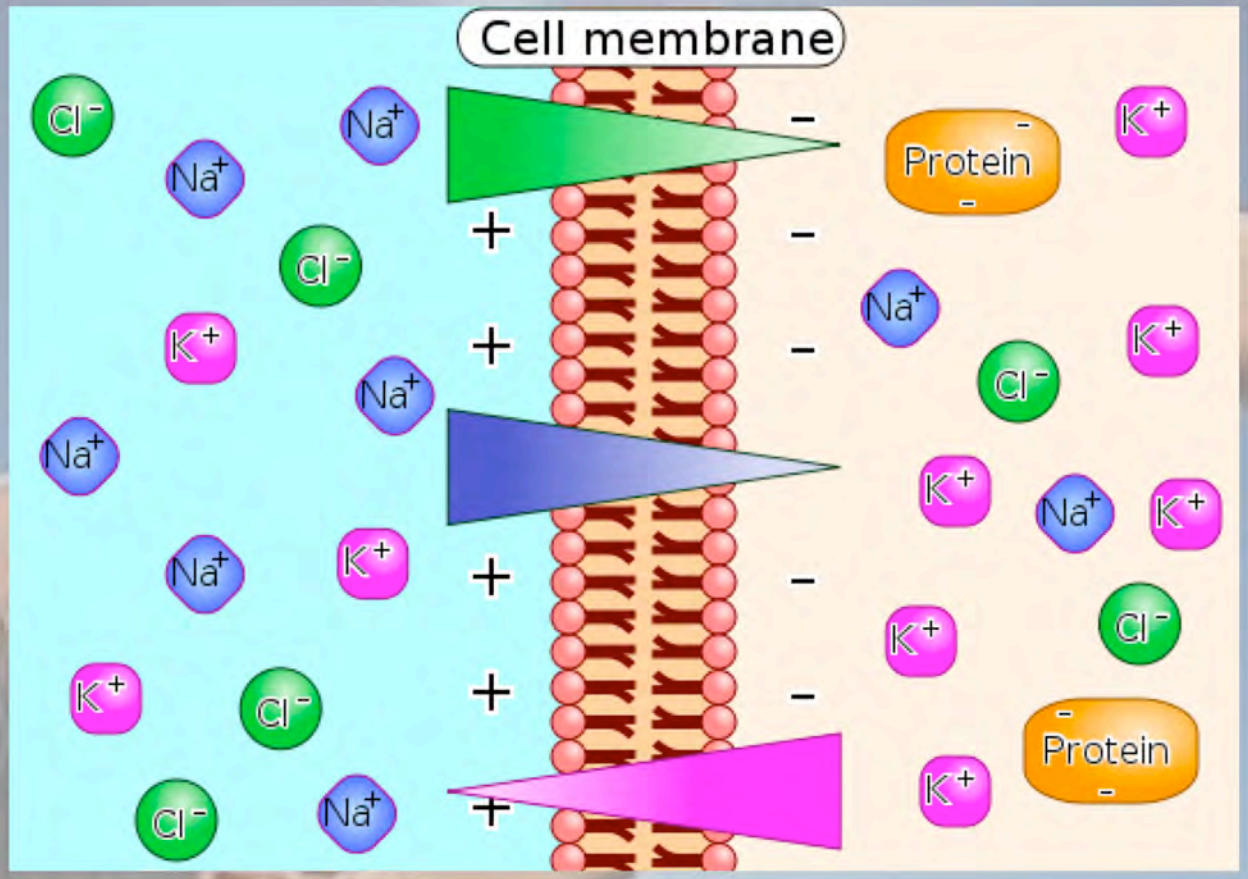


All known higher lifeforms require a subtle and complex electrolyte balance between the intracellular and extracellular milieu.

All known higher lifeforms require a subtle and complex electrolyte balance between the intracellular and extracellular milieu.

W H A T…?


Remember this…..



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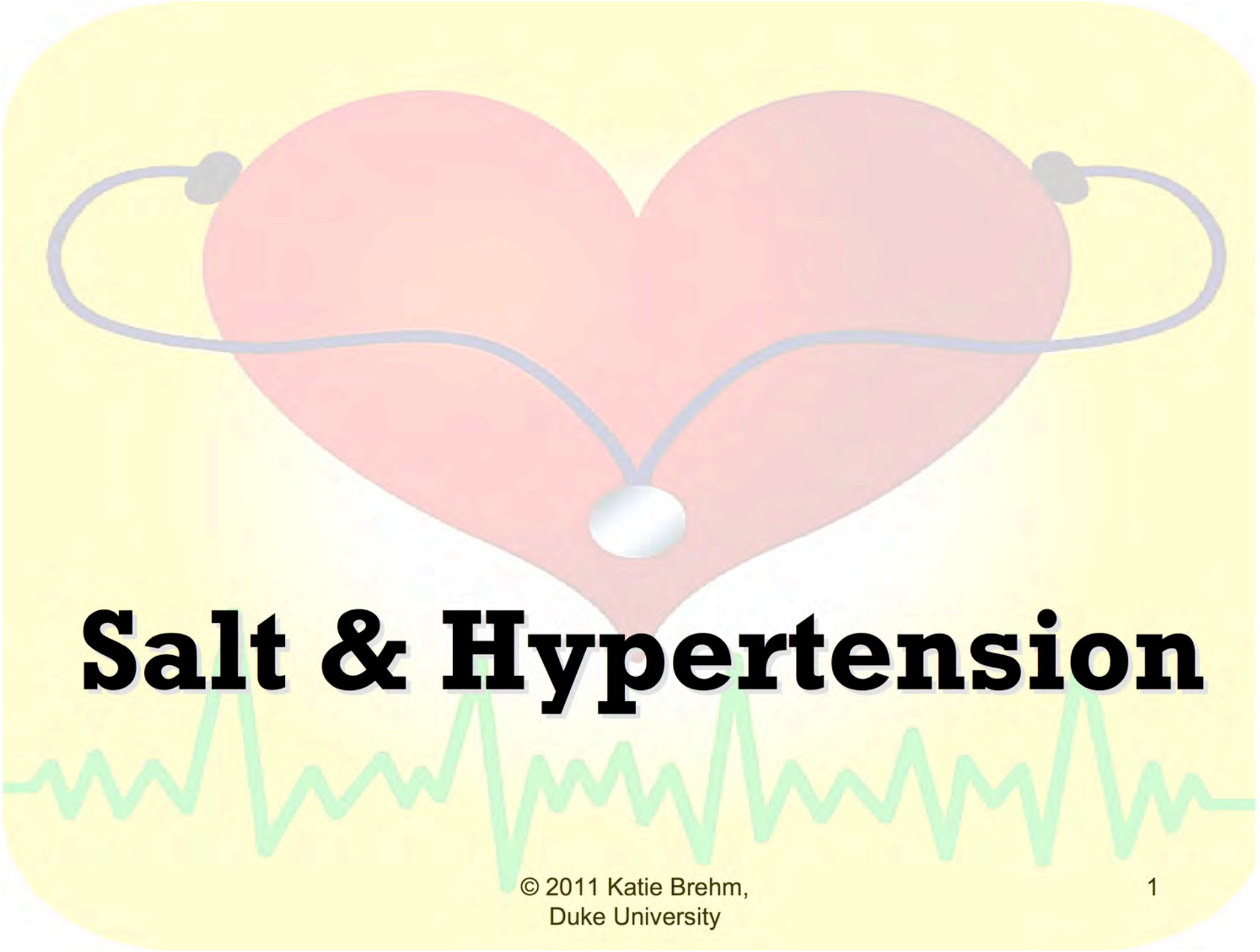
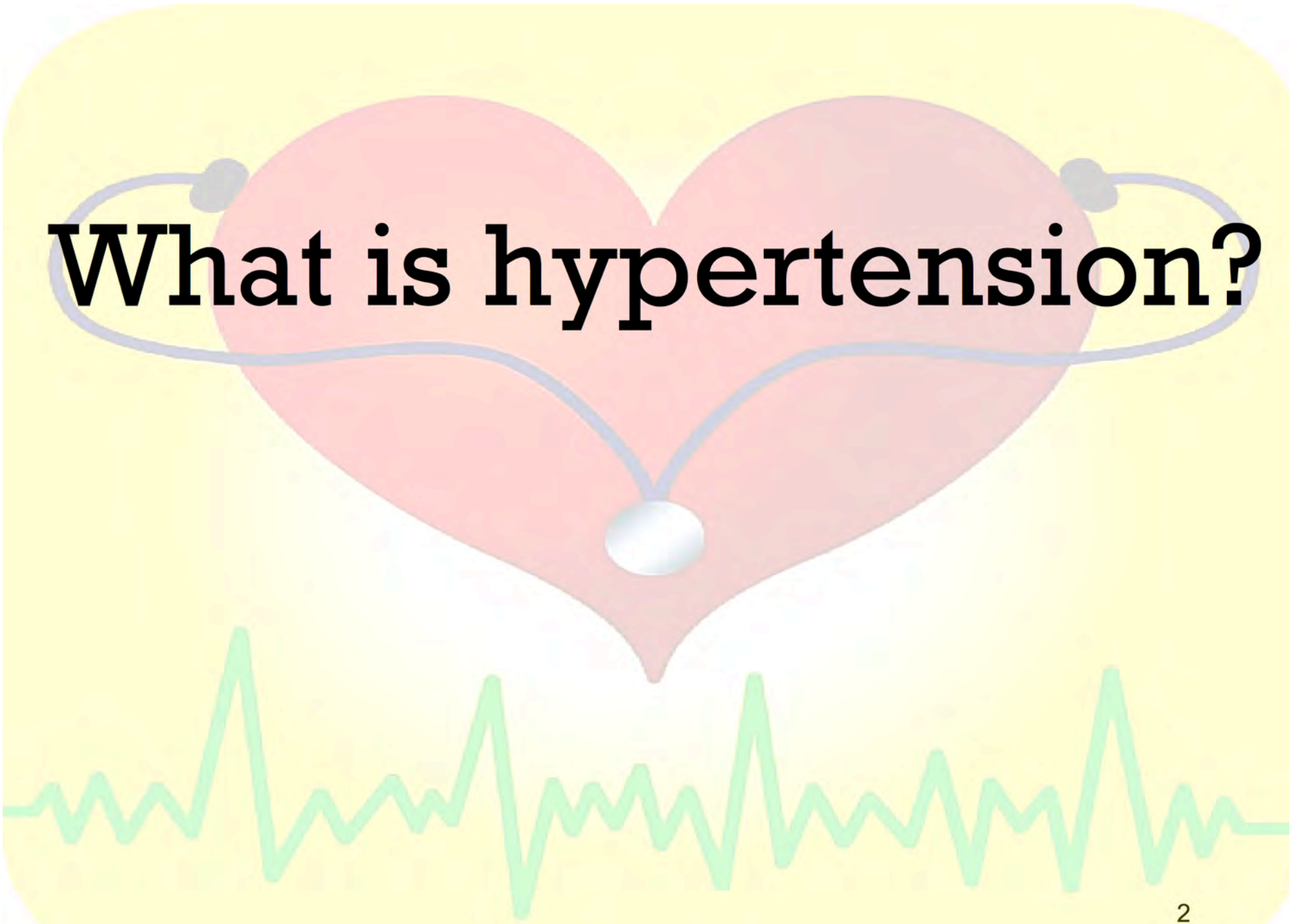


Salt & Hypertension

What is hypertension?

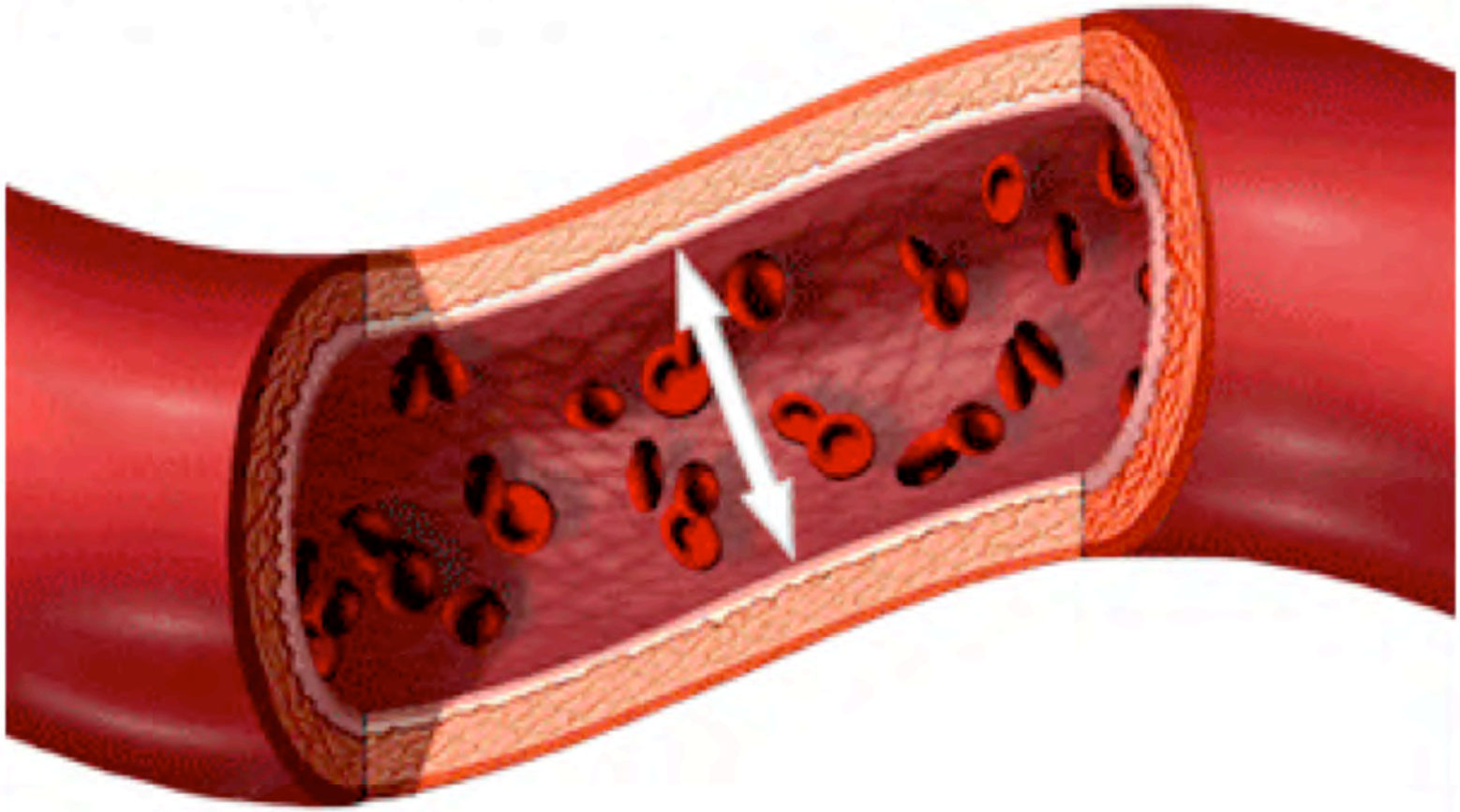


What is hypertension?

hy·per·ten·sion /hīpərˈtenSHən/ *Noun*
Abnormally high blood pressure.

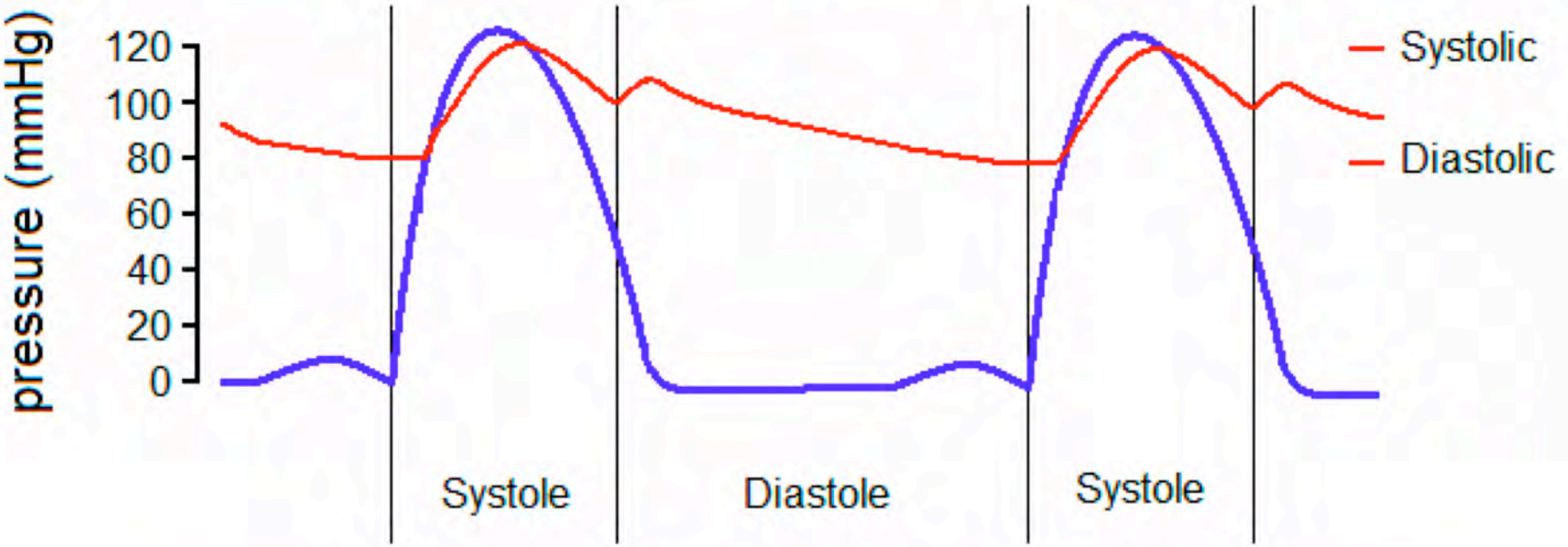
What is blood pressure?

Blood pressure is the measurement of force applied to artery walls



What is blood pressure?

During each heartbeat, BP varies between a maximum (systolic) and a minimum (diastolic) pressure.



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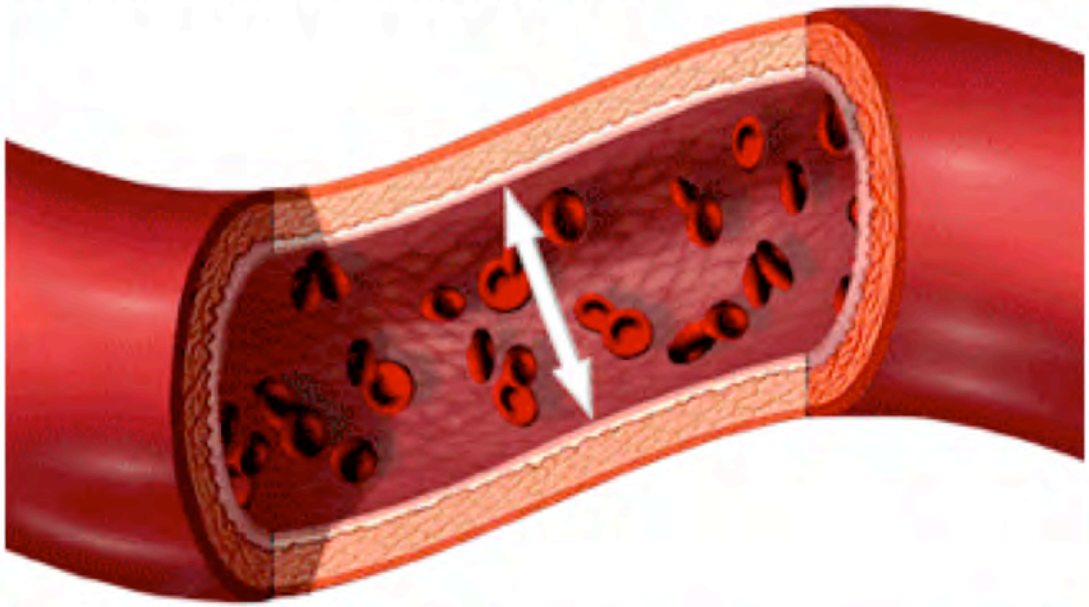

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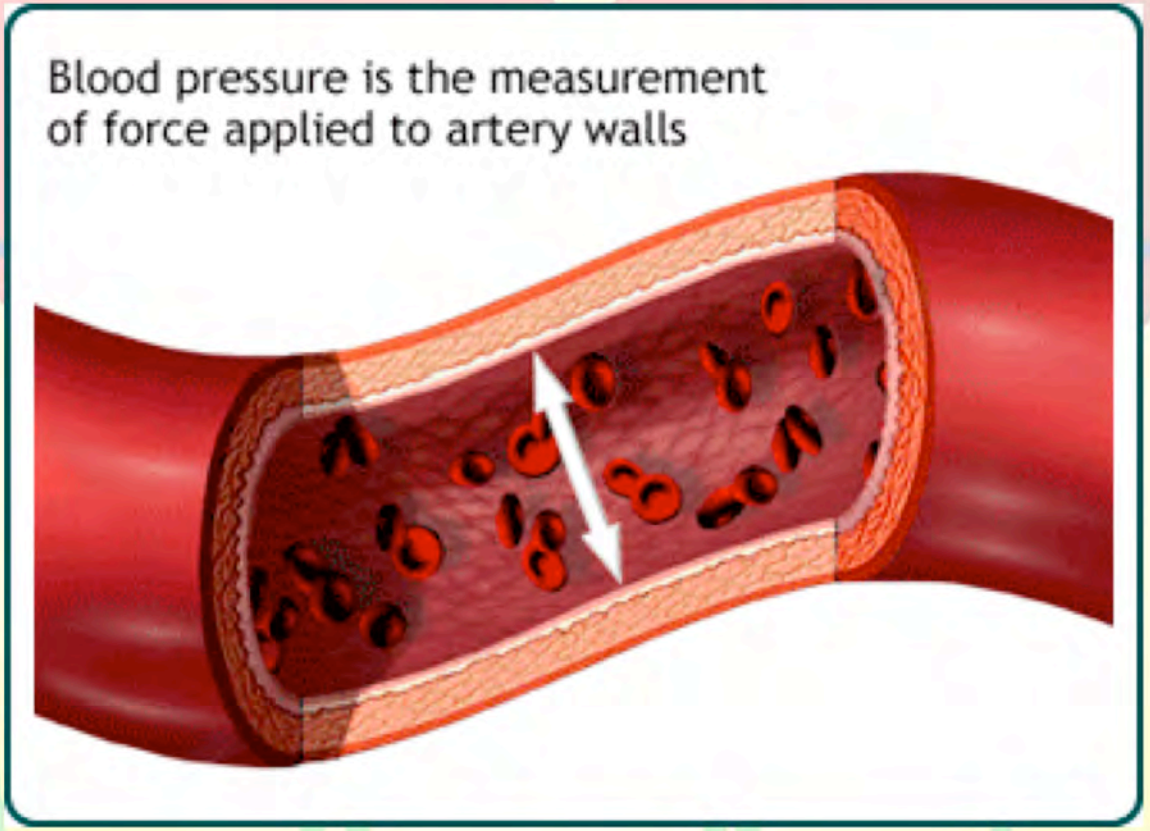
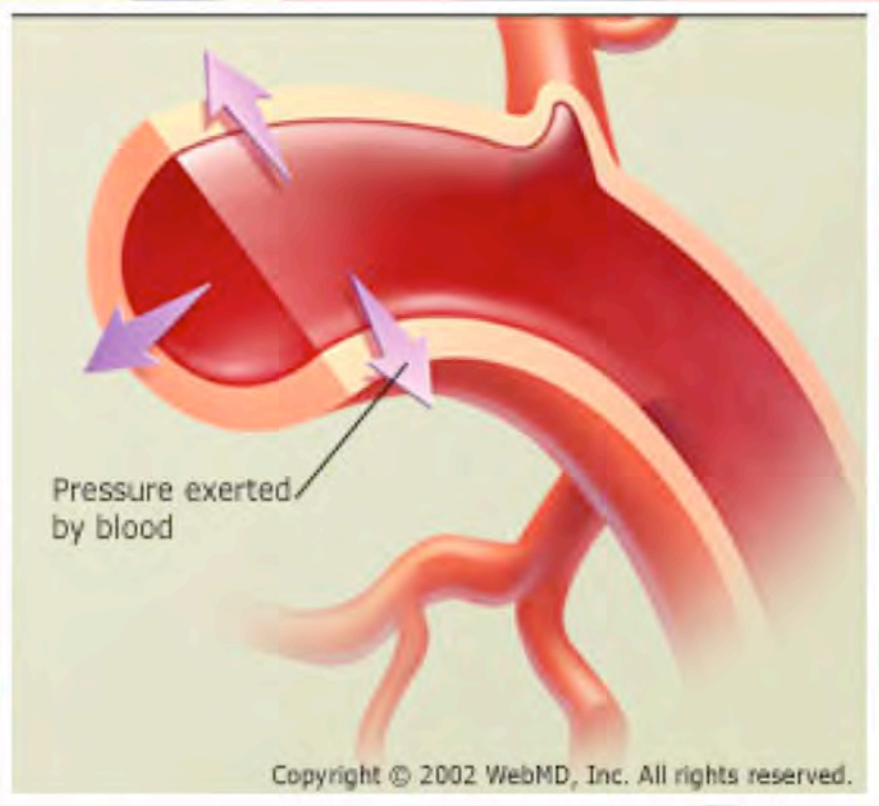


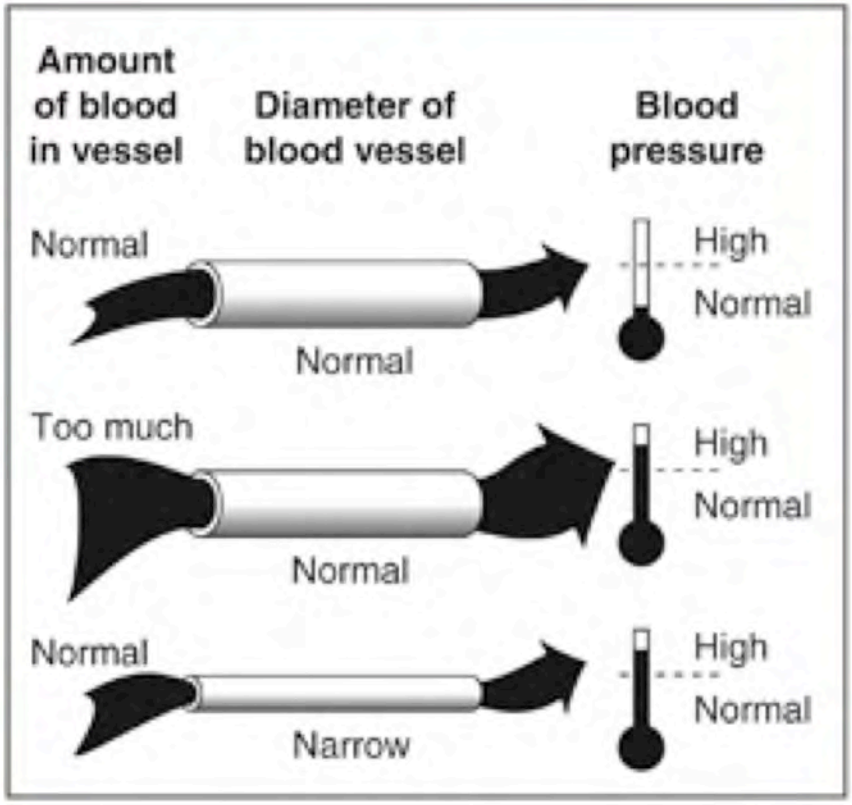
What substance flows through arteries and applies force?


lonelyplanetimages.com

Which river is applying the *most* pressure to the river banks?

It's the same for the blood in your arteries.





Sources: http://qwikstep.eu/ http://kidney.niddk.nih.gov/kudiseases/pubs/highblood/

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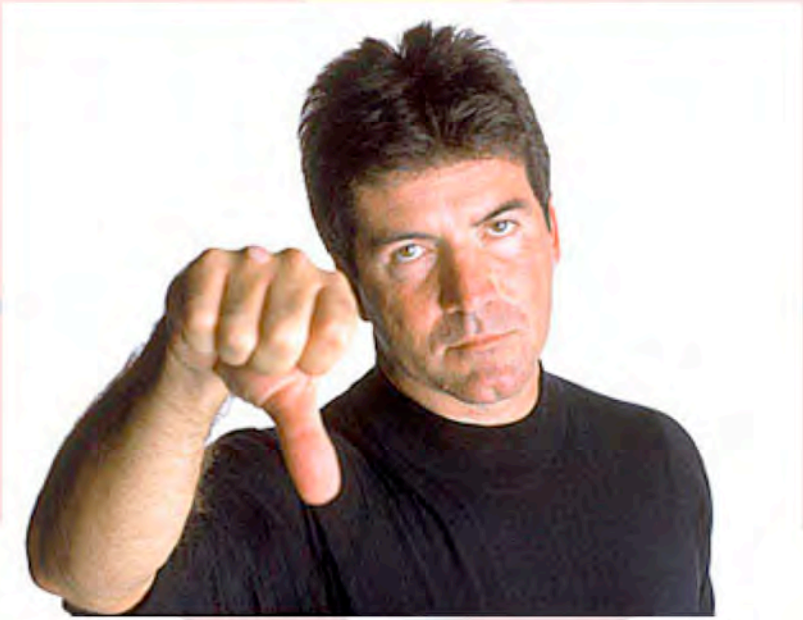
2. Excess salt attracts water. It's ***osmosis***, remember?!?

3. More water in your blood increases the volume moving through your arteries.

More blood is better, right?

WRONG!



You aren't getting more blood.
You get watery blood!

AND your arteries have to work harder.

Your arteries are partially made of muscle cells.

What happens when you work your muscles?

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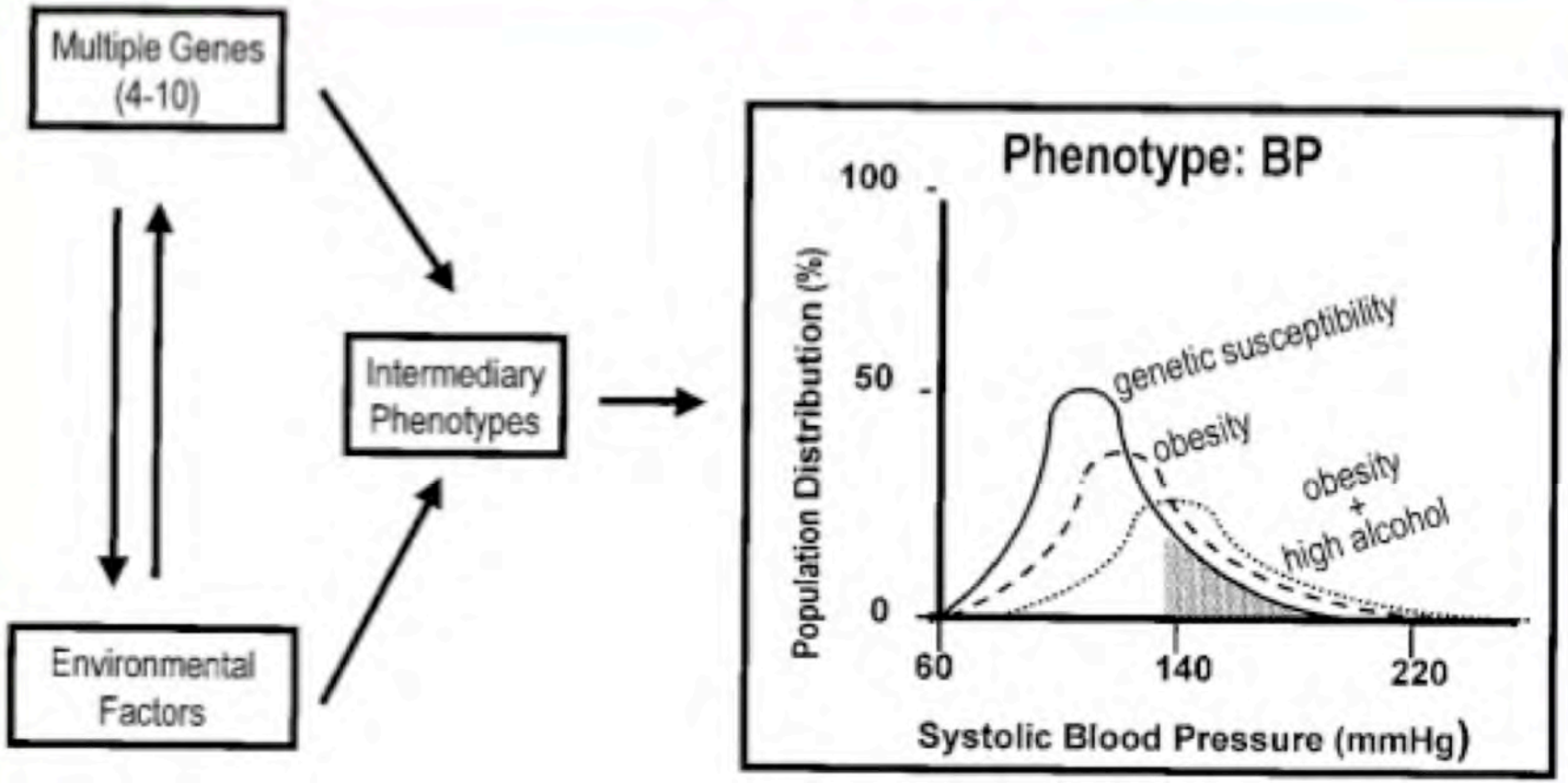
What happens when you work your muscles?

- **Hypertension (high blood pressure) has many consequences, including**
  - **Heart, vessels: stress on and thickening of vessel walls, heart works harder to pump, enlargement/stiffening of left ventricle, aneurysm, heart failure, …**
  - **Brain: TIA, stroke, dementia, mild cognitive impairment, …**
  - **Kidney: scarring, aneurysm, failure, …**
  - **Eyes: blood vessel damage, vision impairment, nerve damage, …**
  - **Misc: sexual dysfunction, bone loss (calcium excretion), snoring, sleep apnea, sleep deprivation, …**

Source: http://online.santarosa.edu/presentation/page/?48546

But the story is not that simple…

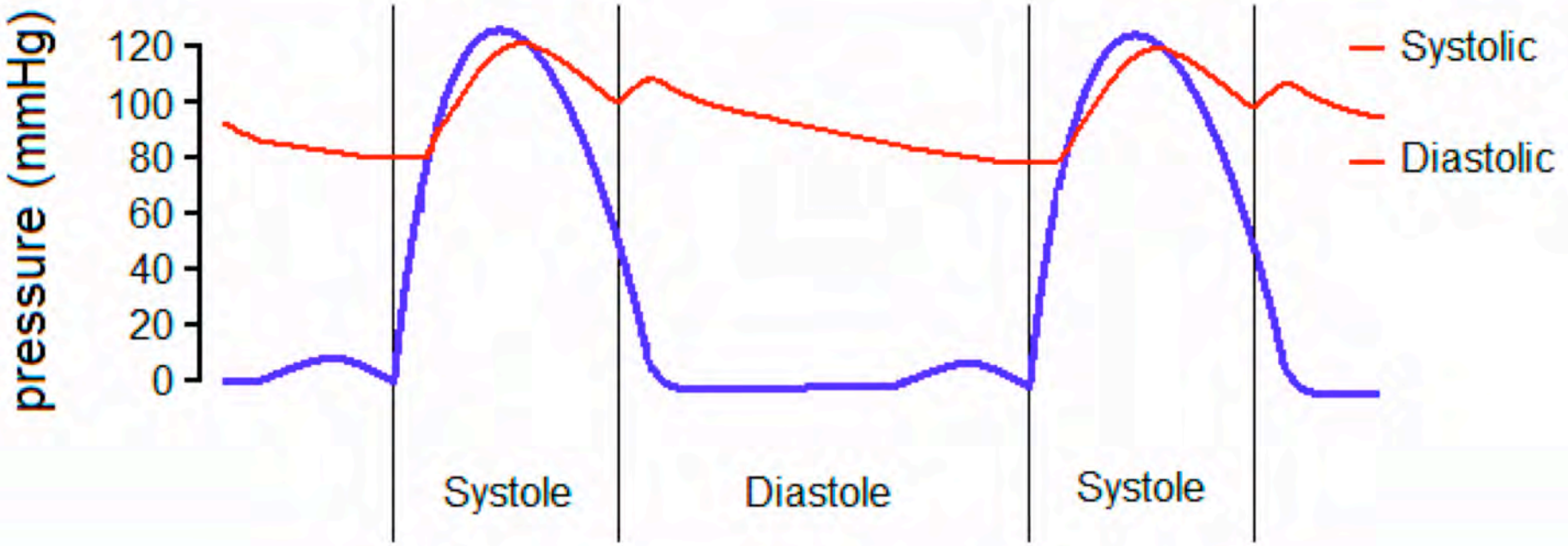


Source: Carretero, O. and Oparil, S., **Essential Hypertension : Part I: Definition and Etiology,** *Circulation* 2000;101;329-335

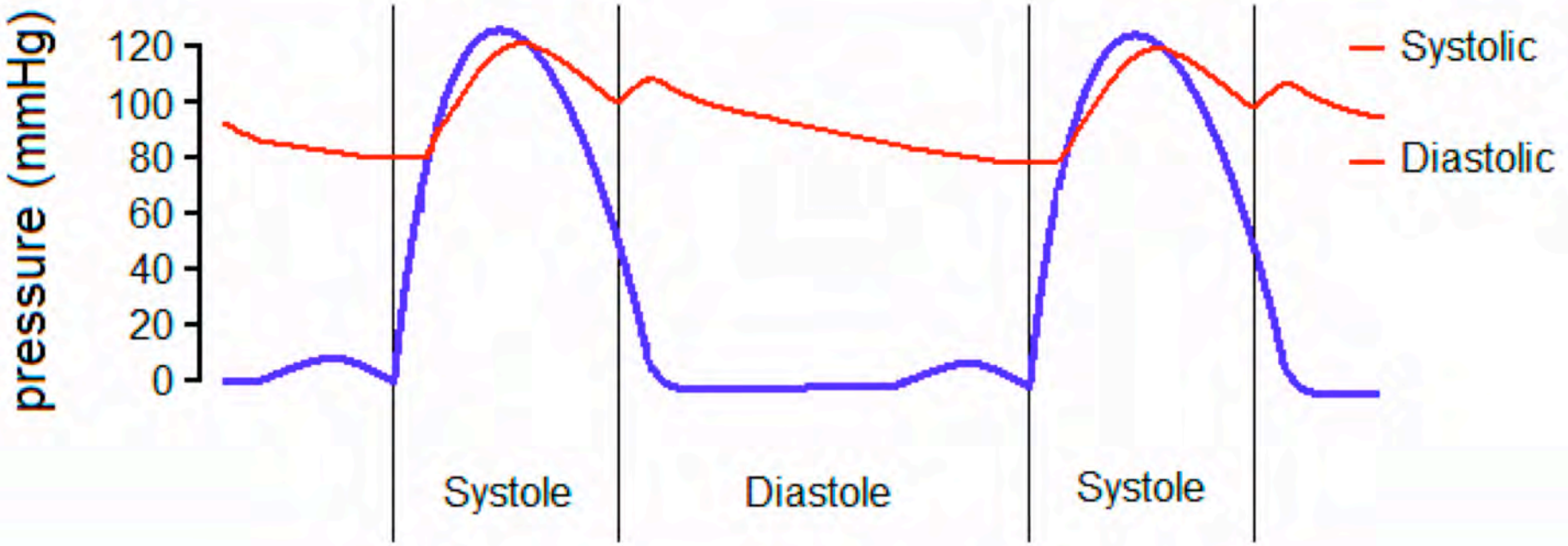
So if hypertension is "abnormally high" BP, what's normal?

So if hypertension is "abnormally high" BP, what's normal?

hy·per·ten·sion /hīpərˈtenSHən/ *Noun*
Abnormally high blood pressure.


pressure (mmHg)
120
100
80
60
40
20
0
Systole
Diastole
Systole
Systolic
Diastolic

120/80 mmHg



120/80 mmHg

millimeter (mm) of mercury (Hg) = Torr, a unit of pressure

Now that we know the problems, let's think solutions!

2. What are the options to fight salt related problems?

Worldwide, the research to overcome salt related problems is based on two approaches;

1. Change the growing environment (make it normal) suitable for the normal growth of plants; or

2. Select the crop and/or change genetic architecture of the plant so that it could be grown in such areas.

Source: Abdelbagi M. Ismail, International Rice Research Institute, 2006
http://www.knowledgebank.irri.org/ricebreedingcourse/Breeding_for_salt_tolerance.htm

Now imagine you are a rice farmer….

Your land has been contaminated by high salinity…

You have to keep growing crops in order to live…

What are YOU going to do?

Remember your choices…

1. Change the growing environment (make it normal) suitable for the normal growth of plants; or

2. Select the crop and/or change genetic architecture of the plant so that it could be grown in such areas.

Remember your choices…

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Remember your choices…

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How do you change genetic architecture, you ask?

The Search for Favorable Traits

Where should we look?

What species thrive in saline conditions?

Regulating Body Fluids in Sea Creatures

All organisms must maintain roughly constant salt concentration in internal body fluids.

"***electrolyte balance***"

Invertebrates and sharks -- no problem! The salinity of their body fluids is similar to that of sea-water.

Source: Steve Hurst, University of Illinois at Urbana-Champaign http://ijolite.geology.uiuc.edu/02sprgclass/geo117/lectures/Lect35.html

For bony fish, body fluids are less saline than seawater, so water diffuses out of the cells.

How do fish stay hydrated?

Source: Steve Hurst, University of Illinois at Urbana-Champaign http://ijolite.geology.uiuc.edu/02sprgclass/geo117/lectures/Lect35.html

For bony fish, body fluids are less saline than seawater, so water diffuses out of the cells.

How do fish stay hydrated?

Adaptations:

- Drink a lot of sea water
- Excrete salt ions through gills and urine

Source: Steve Hurst, University of Illinois at Urbana-Champaign http://ijolite.geology.uiuc.edu/02sprgclass/geo117/lectures/Lect35.html

Where else should we look?

Something a little closer related to our rice crop…

Predominant salt-tolerance mechanisms operating in plants

4. Sequestration of the toxic ions to vacuole or cell wall – cell level compartmentation

3. Excretion of salt through salt glands, salt-hairs or bladders – in most halophytes

2. Transporting the toxic ions to stem, leaf sheath or older leaves – plant level compartmentation

1. Restricting the entry of toxic ions at root level - Exclusion

Source: Abdelbagi M. Ismail, International Rice Research Institute, 2006
http://www.knowledgebank.irri.org/ricebreedingcourse/Breeding_for_salt_tolerance.htm

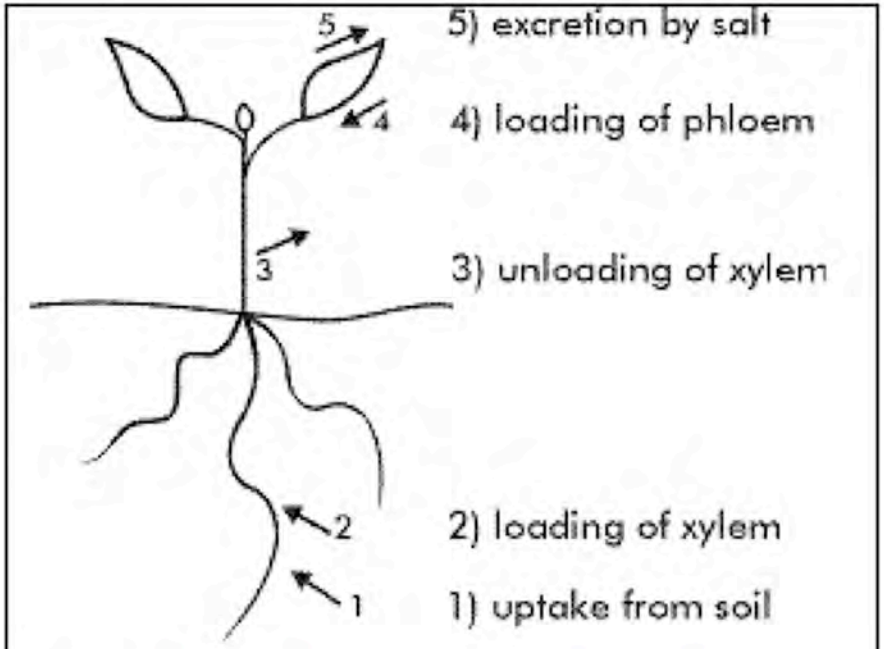
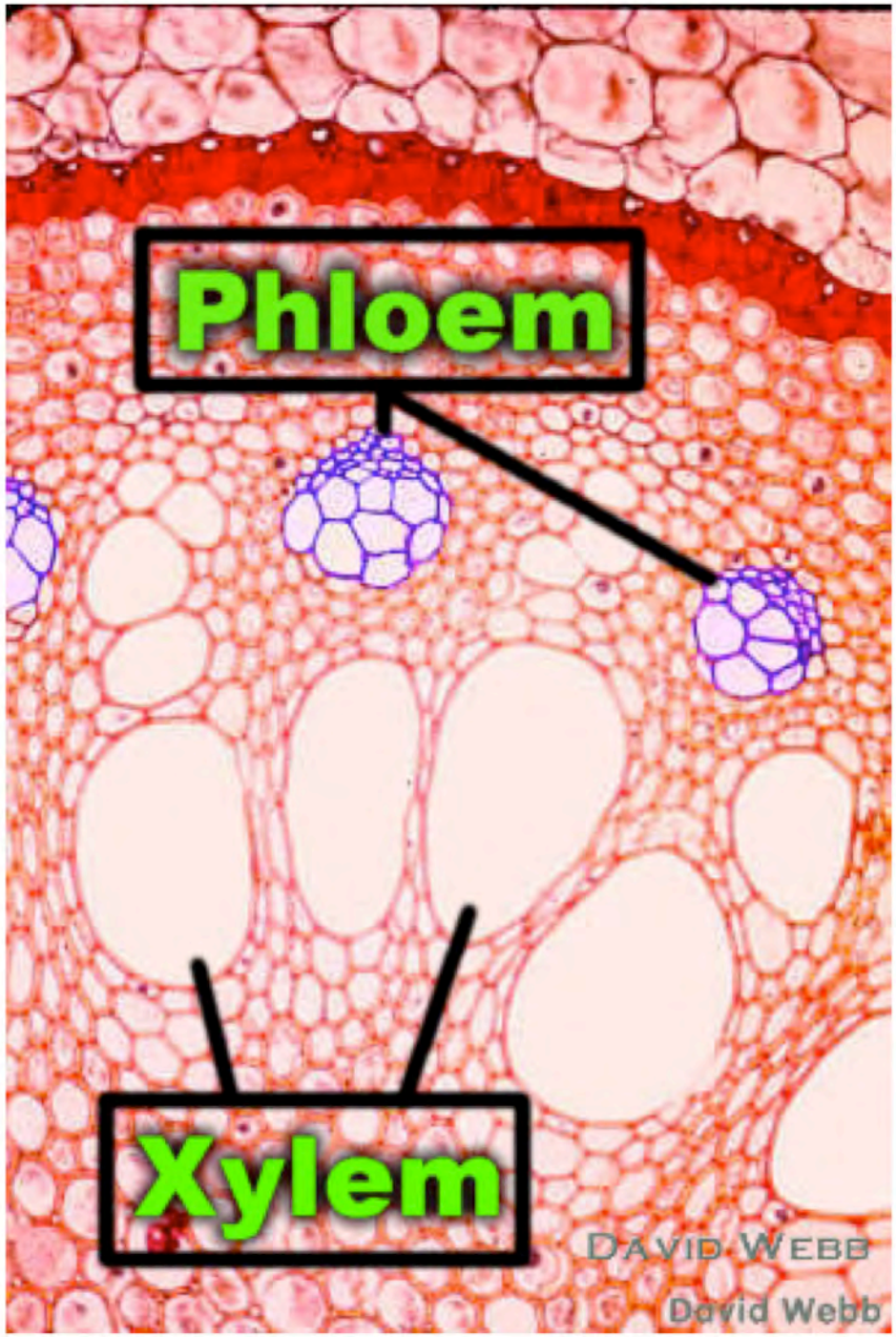
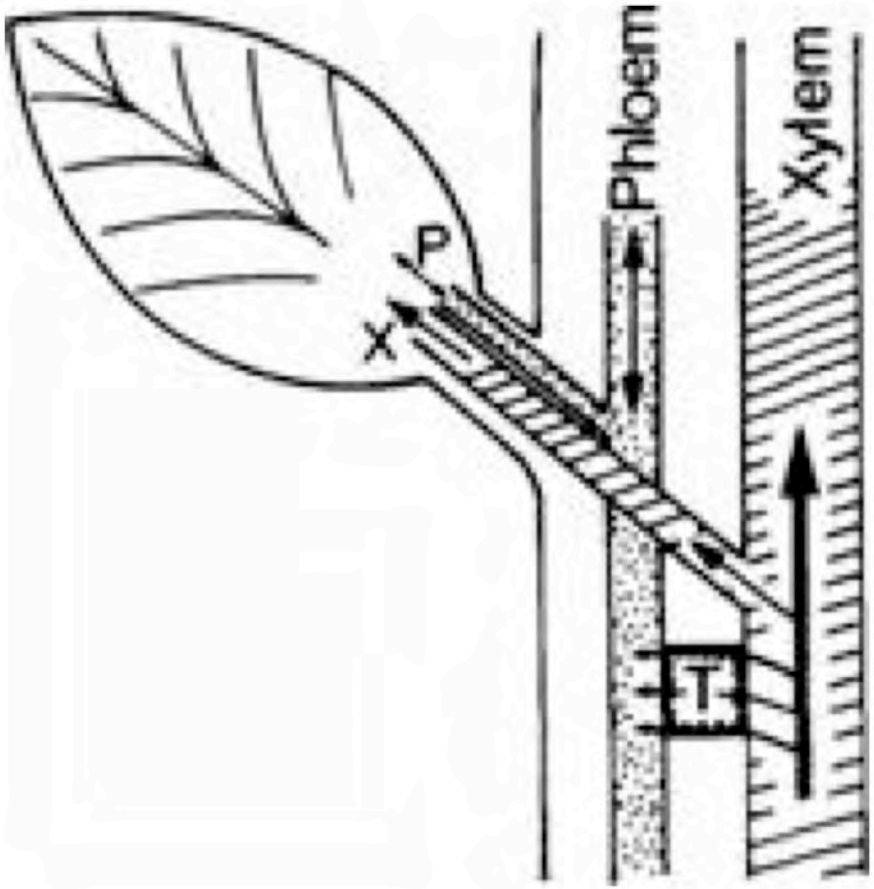


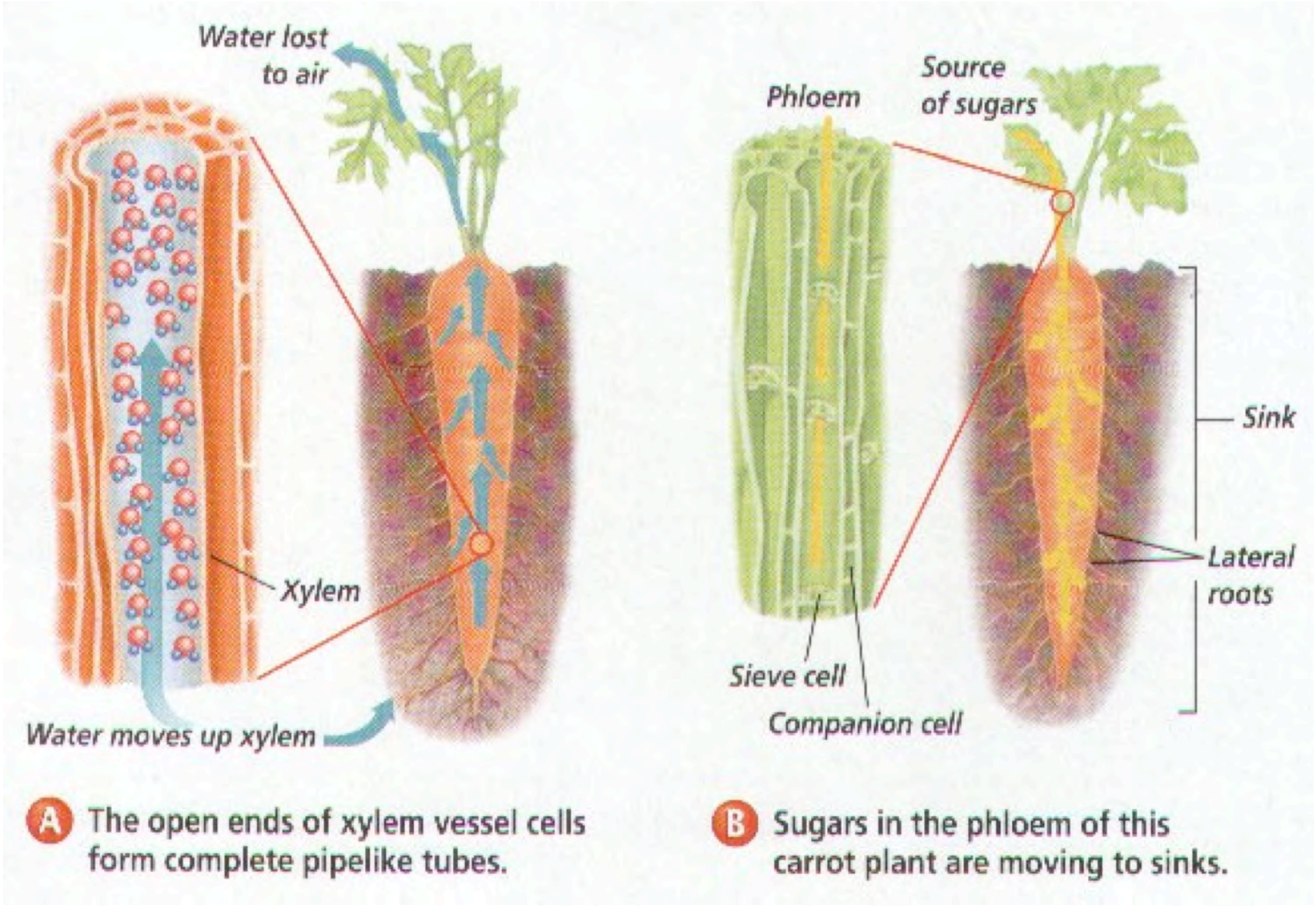
Figure 6. Control points at which salt transport is regulated. These are: 1. selectivity of uptake from the soil solution, 2. loading of the xylem, 3. removal of salt from the xylem in the upper part of the plant, 4. loading of the phloem and 5. excretion through salt glands or bladders. For a salt tolerant plant growing for some time in a soil solution of 100 mM NaCl, the root concentrations of Na^+ and Cl^- are typically about 50 mM, the xylem concentration about 5 mM, and the concentration in the oldest leaf as high as 500 mM (Munns et al., 2002).

Source: Dr. Rana Munns, CSIRO Division of Plant Industry, Canberra ACT, Australia
http://www.plantstress.com/Articles/salinity_i/salinity_i.htm





Marshner, 1986



Source: Holt, Rinehart, & Winston http://www.biologyjunction.com/plant_taxonomy_bi.htm

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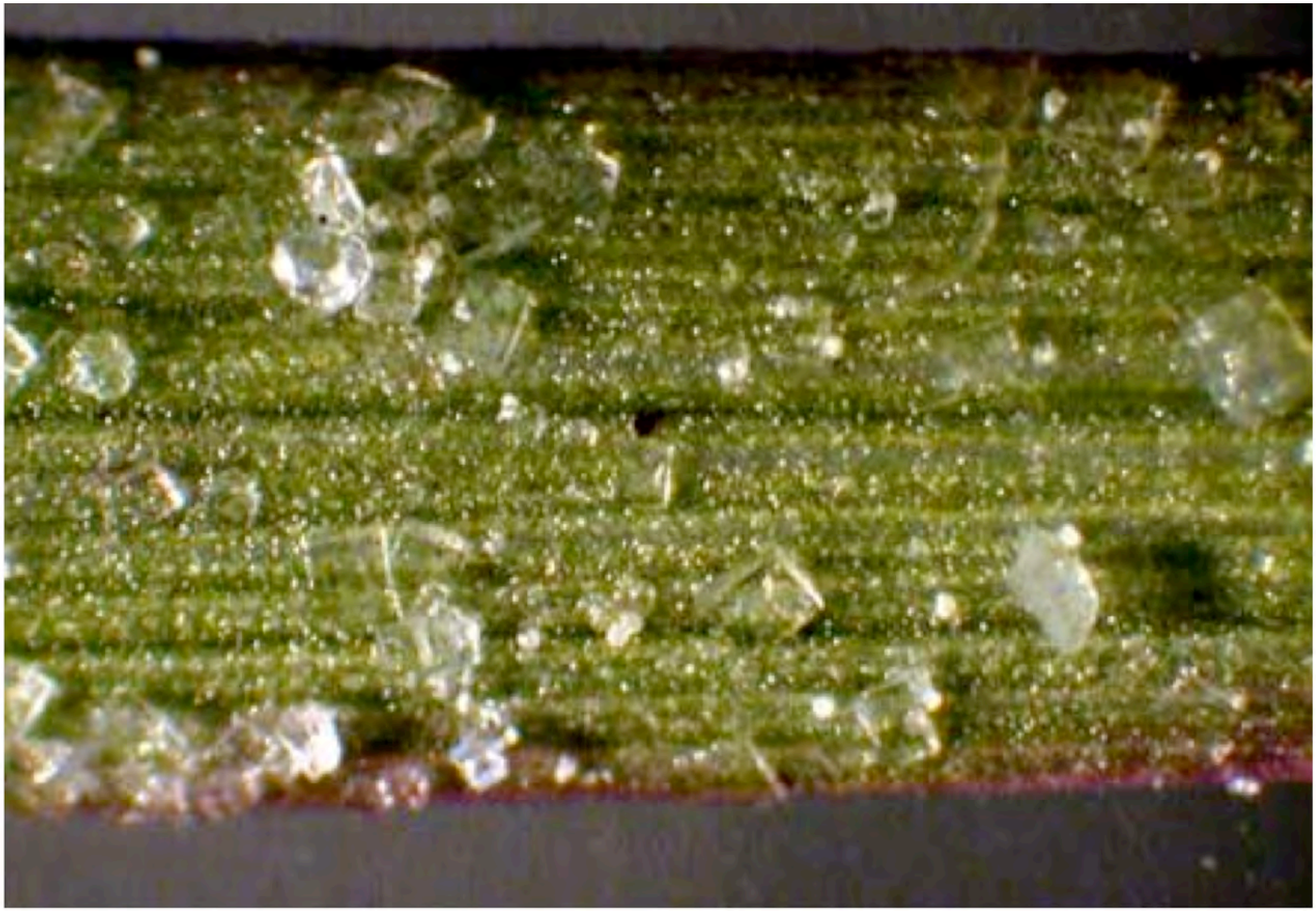

Distichlis blade with salt crystals

Source: Justin Kitzes, 2003, Monterey Bay Aquarium Research Institute
http://www.mbari.org/staff/conn/botany/seagrass/justin/salt_extrusion.htm

Source: Monterey Bay Aquarium
http://www.montereybayaquarium.org/animals/AnimalDetails.aspx?enc=LeWQvjcLBGQWY220CN93ow==

Source: Sandy Richard, 2008 http://www.flickr.com/photos/9428166@N03/2687271906/

Genetic Engineering for salinity tolerance:

1. *Find favorable trait*
2. *Find gene that controls favorable trait*
3. *Transgenic manipulation*
4. *Voila! Grow, eat & be merry!*

Not so fast….

Let’s see what others have to say.