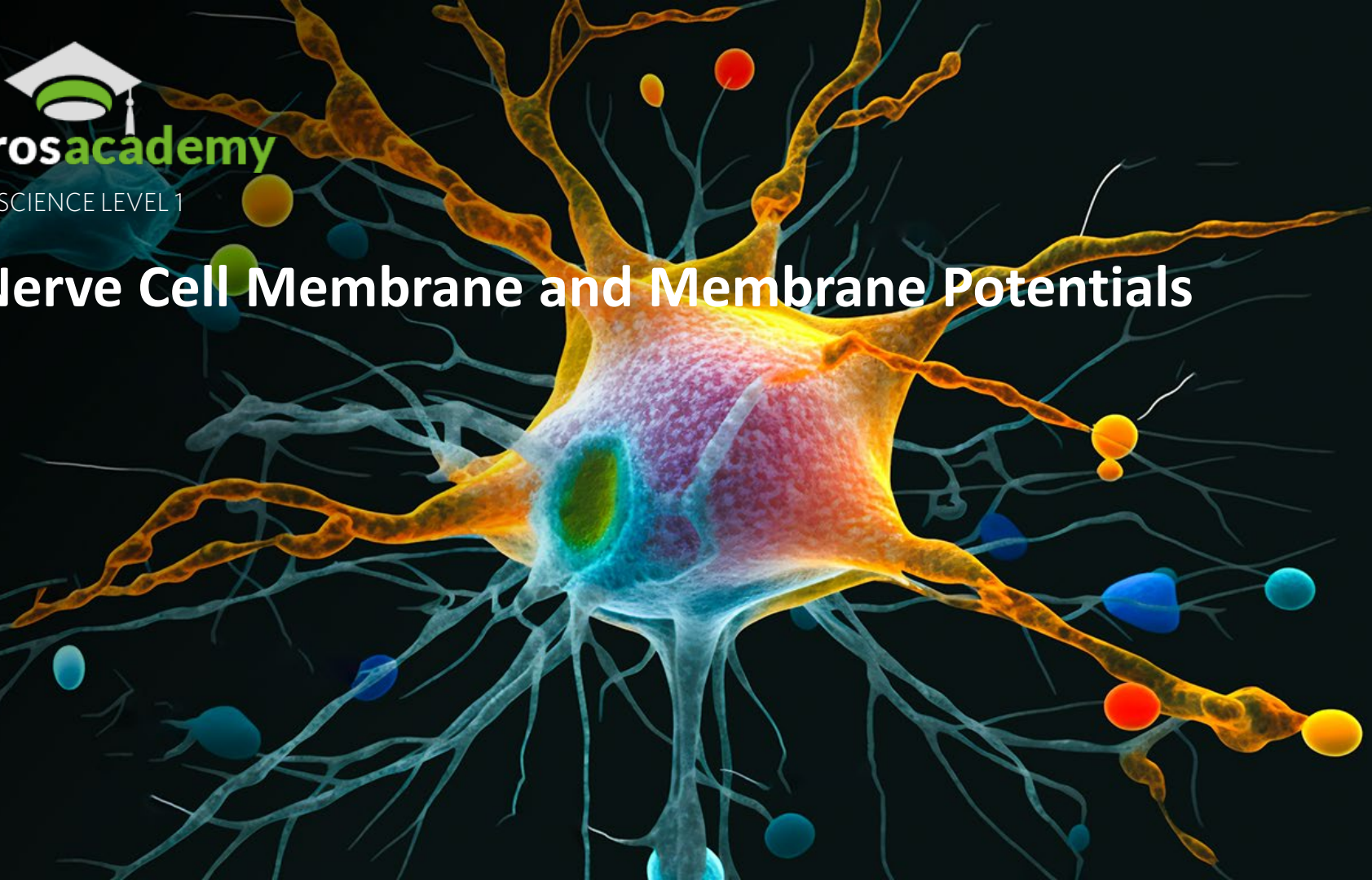


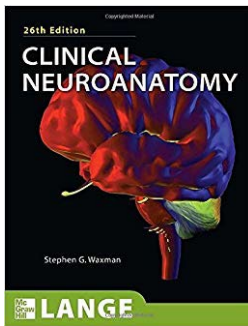
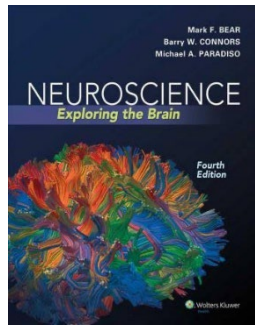


**chiroacademy**

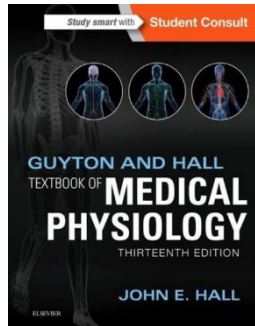
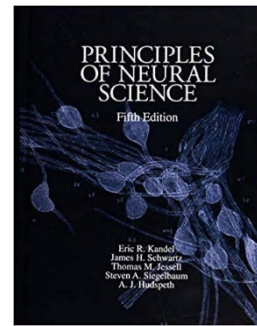
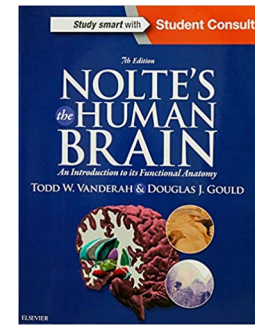
NEUROSCIENCE LEVEL 1

# 3 Nerve Cell Membrane and Membrane Potentials

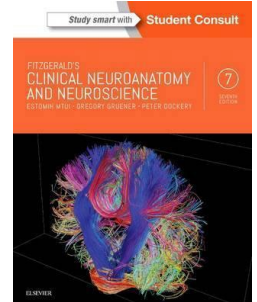
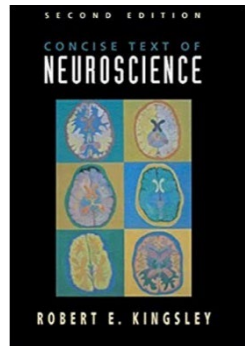
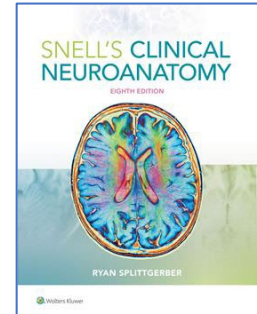




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- Kingsley R. Concise Text of Neuroscience 2<sup>nd</sup> Ed. Chapter 3 Electrochemical signalling, p.91- 108 5<sup>th</sup>
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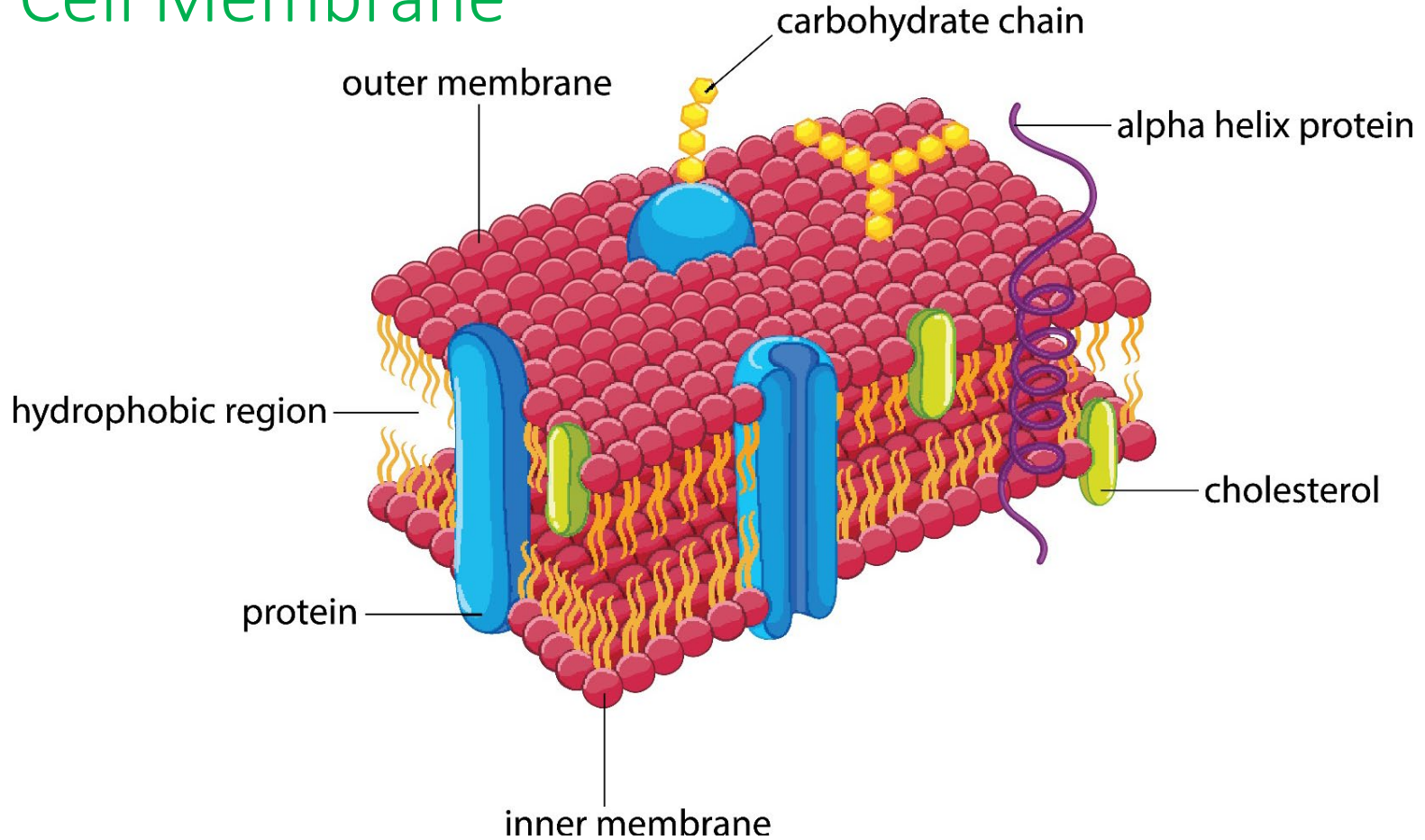
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# Good YouTube Videos on the Topic

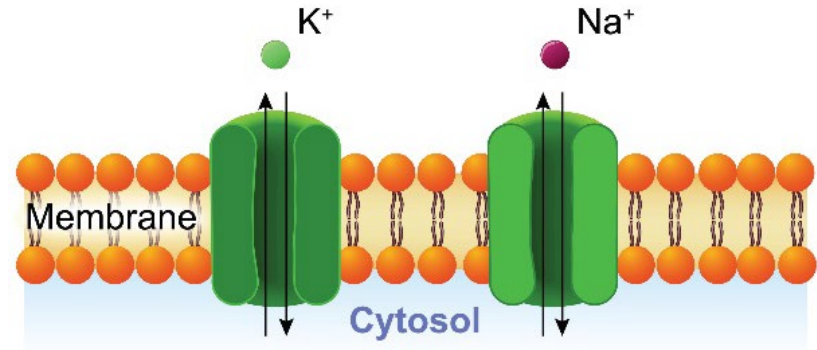
- Resting membrane potentials, graded activation of cells and covers the action potential (which is not covered in this class).
- <https://youtu.be/HYLyhXRp298>

# Bi-lipid Cell Membrane



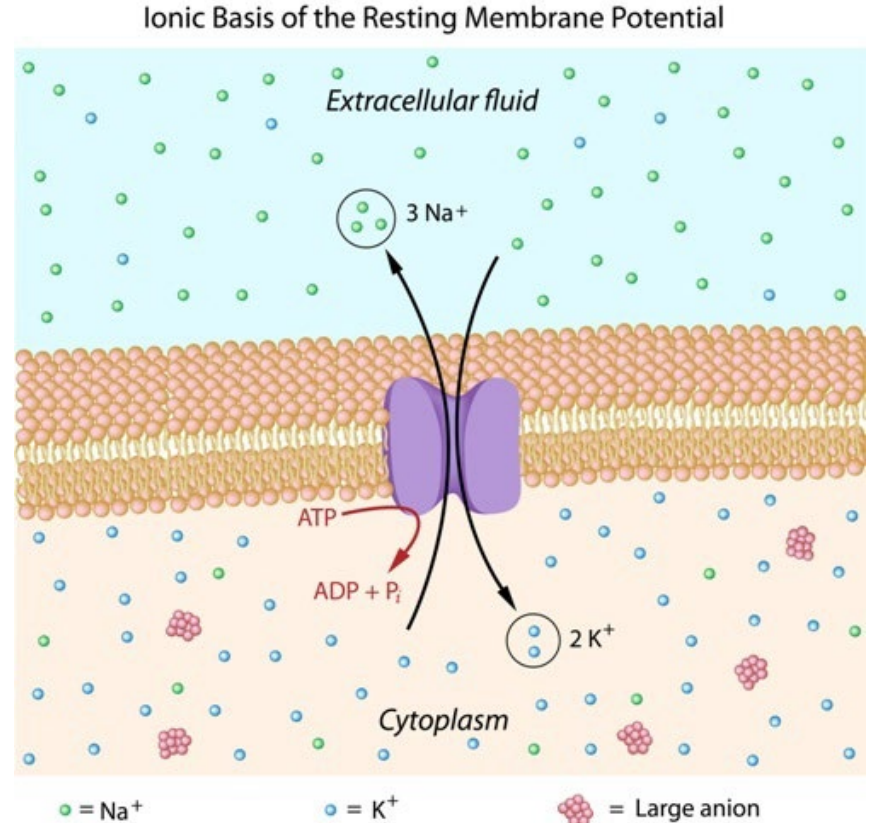
# The Resting Membrane Potential

- An imbalance of charge across a membrane is called a membrane potential.
- The major contribution to membrane potential in animal cells comes from imbalances in small ions (e.g., Na, K).
- The maintenance of this imbalance is an active process carried out by ion pumps.



# The Resting Membrane Potential

- The cytoplasm of most cells (including neurons) has an excess of negative ions over positive ions:
  - Due to active pumping of sodium ions out of the cell and;
  - Anions attach to large impermeable proteins and negatively charged organic phosphates inside cells.
- By convention this is referred to as a negative membrane potential (inside minus outside).
- Typical resting potential is -70 mV.



# Questions

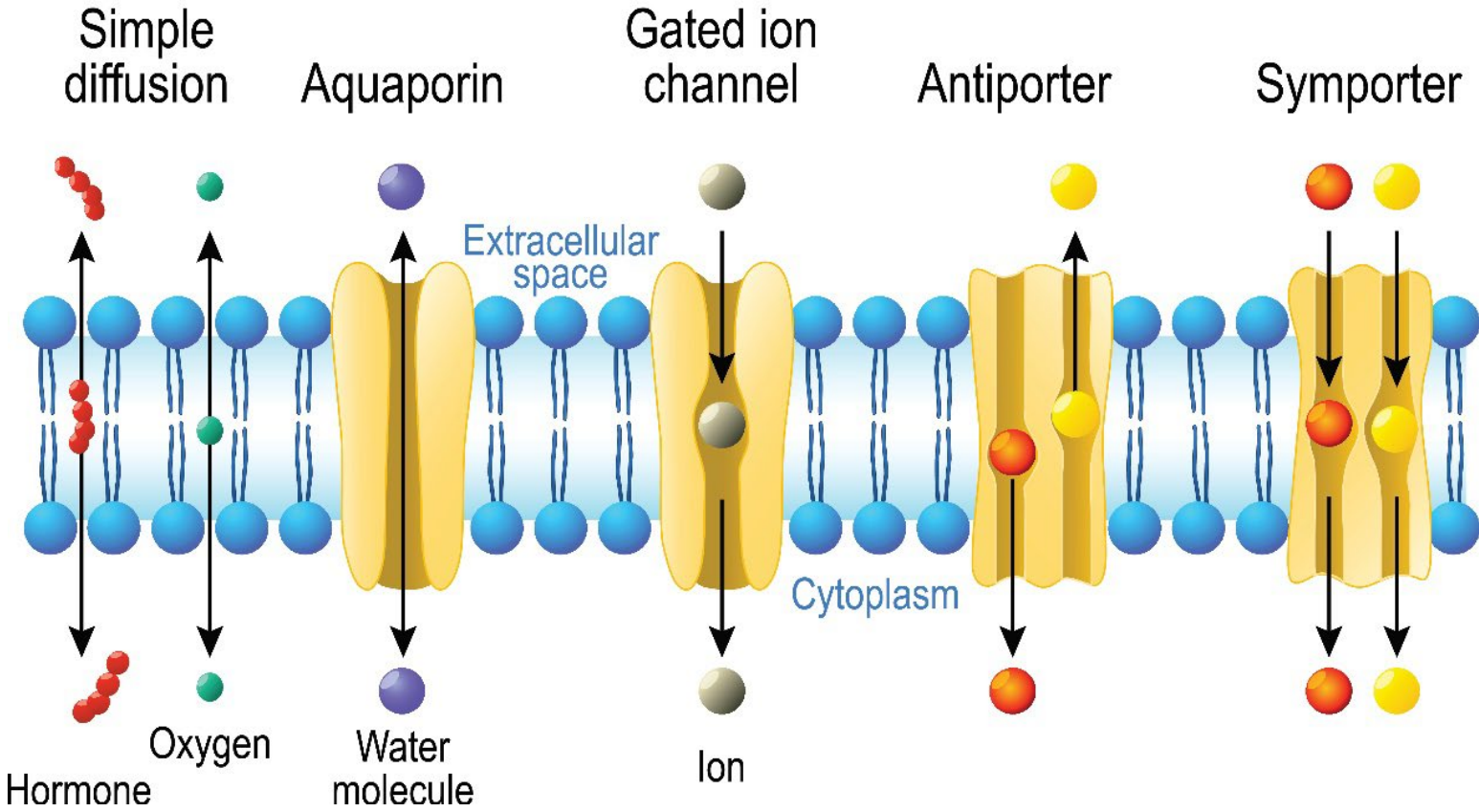


# Diffusion Through The Cell Membrane – Two Subtypes

- Simple diffusion:
  - This means that molecular kinetic movement of molecules or ions occurs through a membrane without the need for carrier proteins. The rate of the diffusion is determined by the velocity of kinetic motion, and by the number and size of openings in the cell membrane.
- Facilitated Diffusion:
  - Requires the interaction of a carrier protein with the molecules or ions. The carrier protein aids passage of the molecules or ions through the membrane in this form.

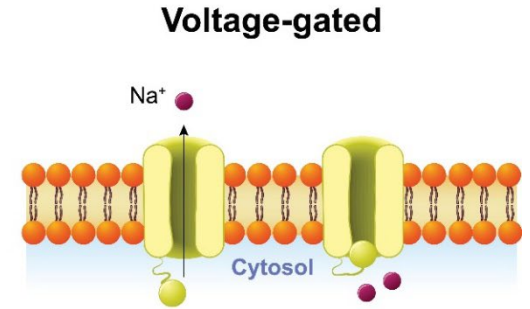
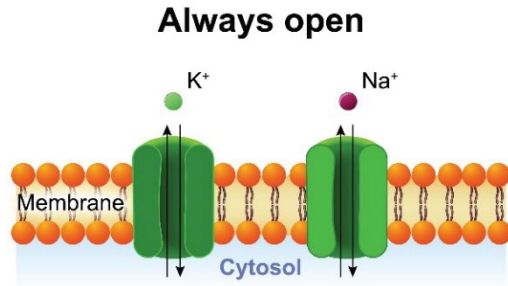
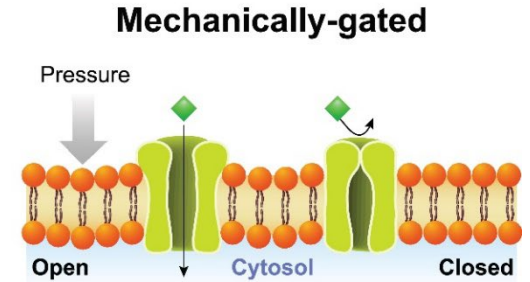
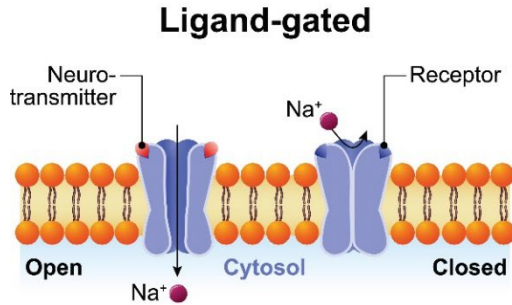
# Terminology

- **Passive Transport** is a movement of ions or molecules across cell membranes without the need of energy.
- **Simple diffusion** does NOT require a special protein channel and is an example of passive transport.
- **Active Transport** a movement of ions or molecules across cell membranes that requires energy ( in form of ATP).
- **Facilitated diffusion** (or facilitated transport) requires the assistance of transport proteins.
- **Facilitated diffusion / transport** can be Active or Passive.



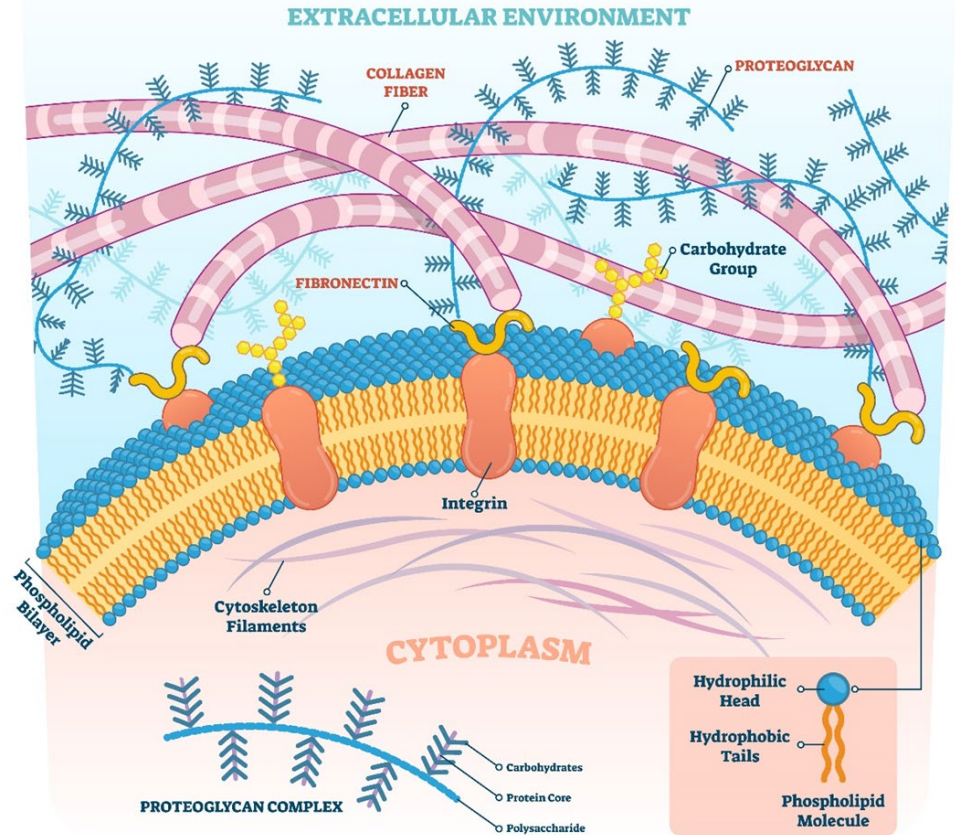
# Ion Channels

- Ion channels can switch between open and closed states.
- An ion channel can switch its state due to:
  - Change in voltage
  - Ligand (ion or molecule)
    - Ionotropic receptors
  - Stretch or pressure



# Ion Channels vs Pumps

- **Ion channels** allow ions to flow across a membrane due to electro-chemical gradients.
- **Ion pumps** require energy (ATP) to carry ions across a membrane against their electro-chemical gradients.

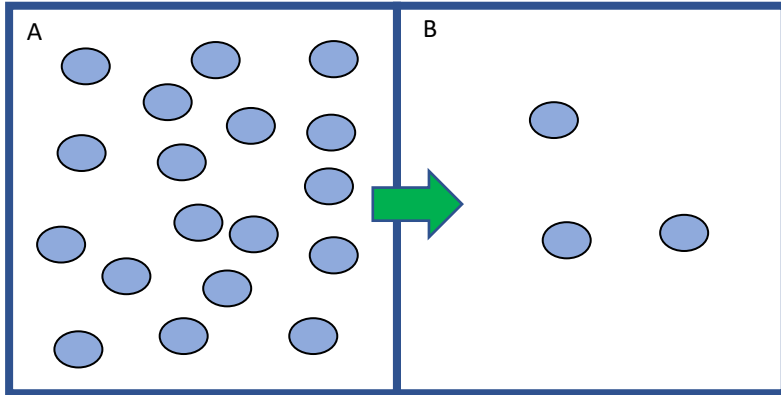


# Questions

# Two Forces Acting On Ions

1. The driving force of the **chemical concentration gradient** tends to move ions down this gradient (chemical potential).

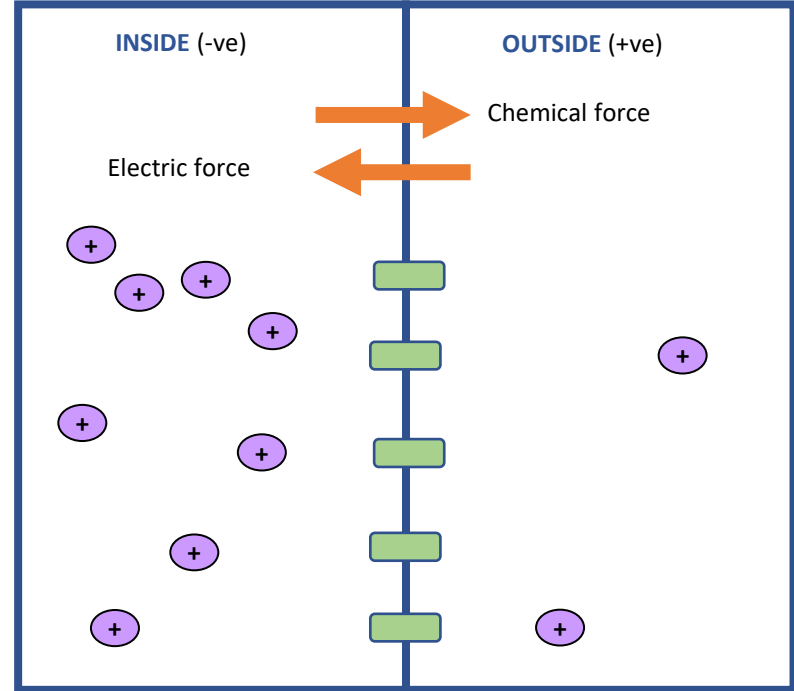
2. On the other hand the **electrostatic force** due to the charge separation across the membrane tends to move ions in a direction determined by its particular charge.



- Opposites attract
- Same charge repels
- Cations (+ve)
- Anions (-ve)

# Potassium Ions

- Potassium ions are concentrated inside the cell.
- Chemically they will tend to move out of the cell down its concentration gradient through non gated K<sup>+</sup> channels.
- However the relative positive charge outside the membrane will tend to push potassium ions back into the cell.



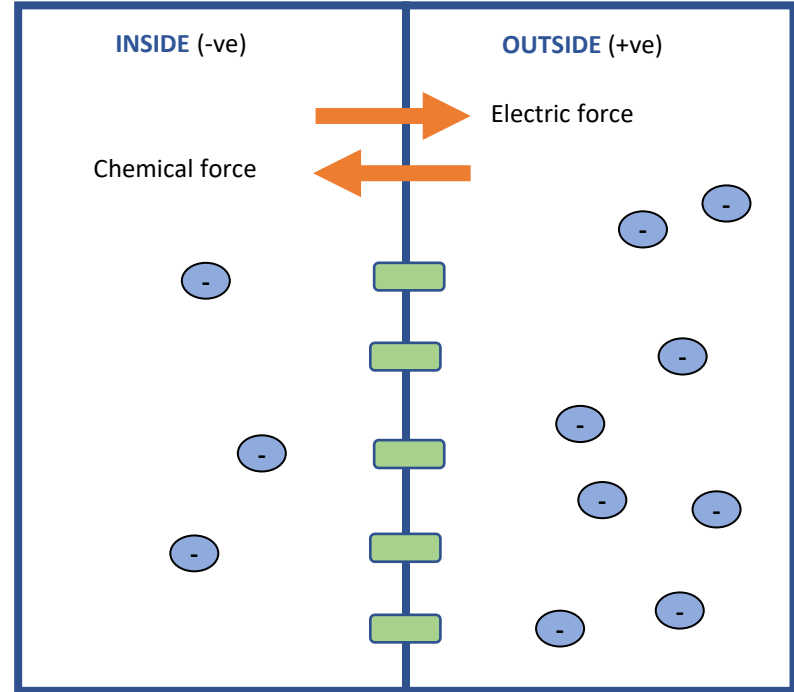


# Equilibrium Potentials

- The chemical concentration gradient pulls  $K^+$  out of the cell.
- As the inside fluid acquires more and more net negative charge, the electrical force starts to pull the positively charged  $K^+$  ions back through the channels into the cell.
- When a certain potential difference is reached, the electrical force pulling  $K^+$  ions inside exactly counterbalances the chemical gradient force of diffusion pushing them out.
- Thus, an *equilibrium* state is reached in which the diffusional/chemical and electrical forces are equal and opposite, and the net movement of  $K^+$  across the membrane ceases.
- The electrical potential difference that exactly balances an ionic concentration gradient is called an **ionic equilibrium potential**, or simply **equilibrium potential**.

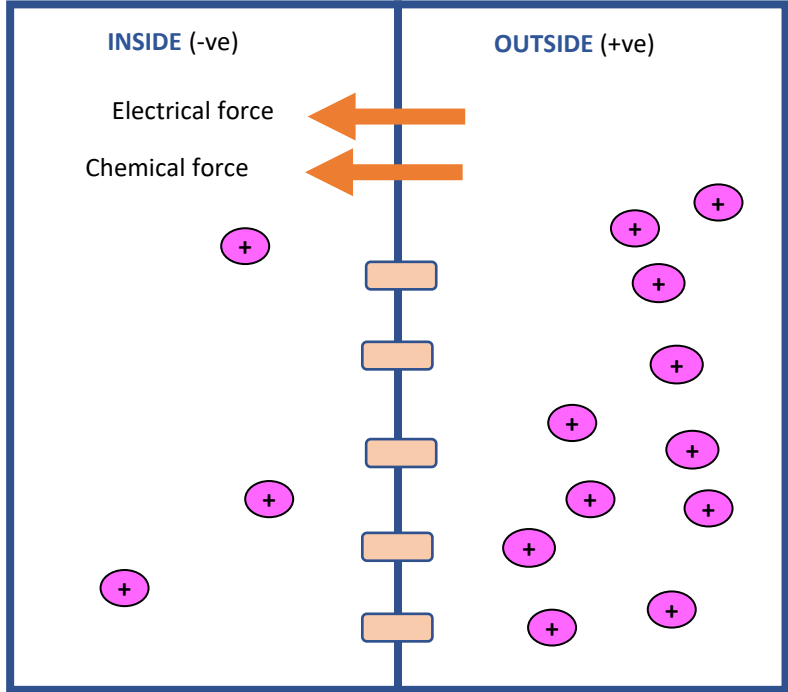
# Chloride Ions

- Chloride ions are concentrated outside the cell.
- Chemically they will tend to move inward down its concentration gradient through non gated chloride channels.
- However, the relative negative charge inside the membrane will tend to push chloride ions back out of the cell.



# Sodium Ions

- In the case of Sodium ions, both forces act together on each Na ion to drive it into the cell.
- Na is more concentrated outside than inside and therefore tends to flow into the cell down its concentration gradient.
- Na is also driven into the cell by the electrical potential difference across the membrane.
- Therefore, if the cell is to have a steady resting membrane potential, the movement of Na ions into the cell must be balanced by the efflux of K ions.

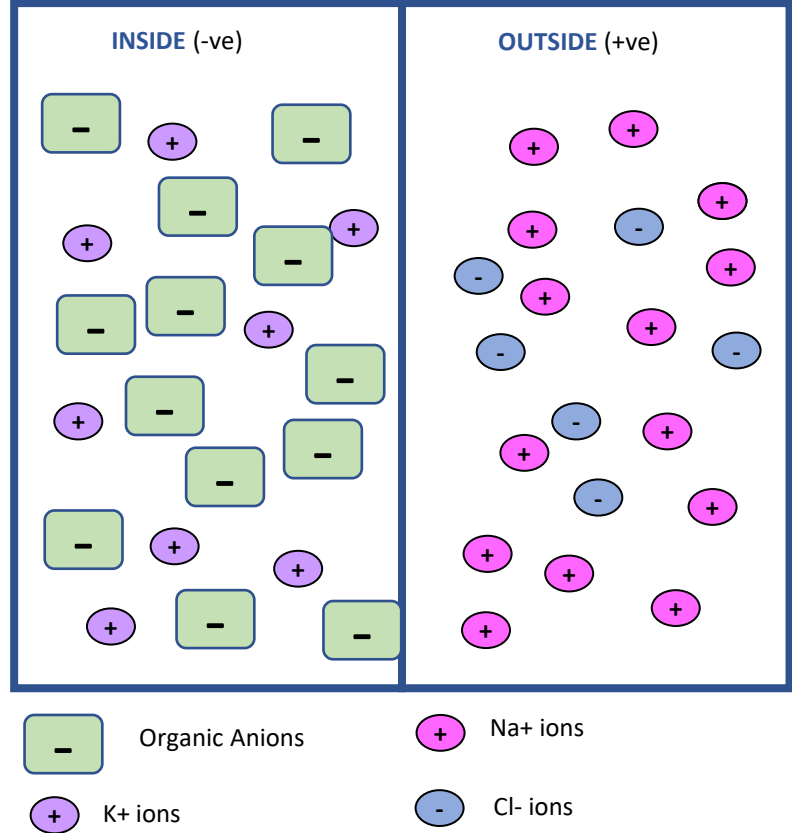


Cell Membrane



# Charge Distribution

The relative excess of positive charges outside and negative charges inside the membrane of a nerve cell at rest is maintained because the lipid bilayer acts as a barrier to the diffusion of ions, and give rise to an electrical potential difference, which ranges from about 60 to 90mV.



# Questions

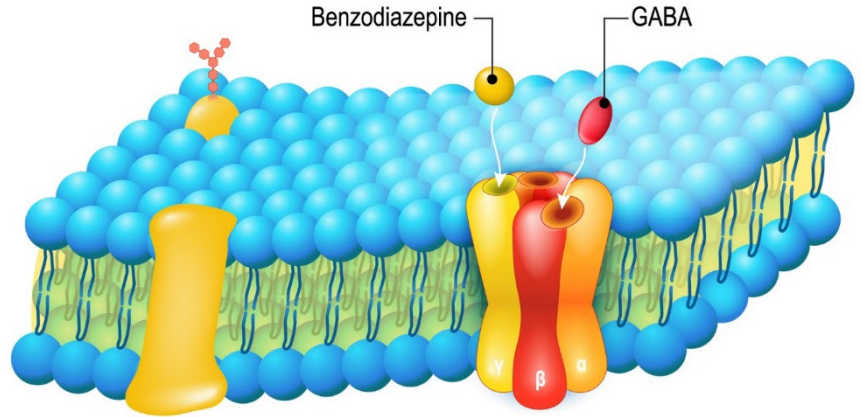
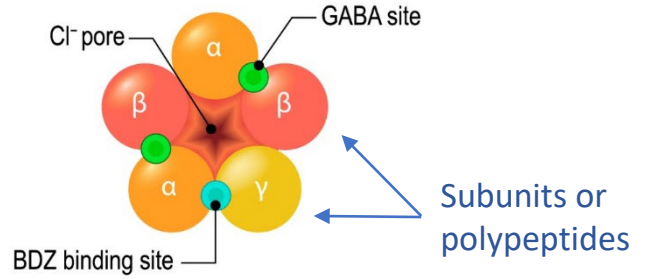
Alpha helix

# Ion Channel Structure

The basic structure of a single ion channel:

- 1° Sequence of amino acids
- 2° Alpha helix
- 3° Three-dimensional folding into polypeptide (AKA subunits)
- 4° Different polypeptides bonded together to form a larger protein

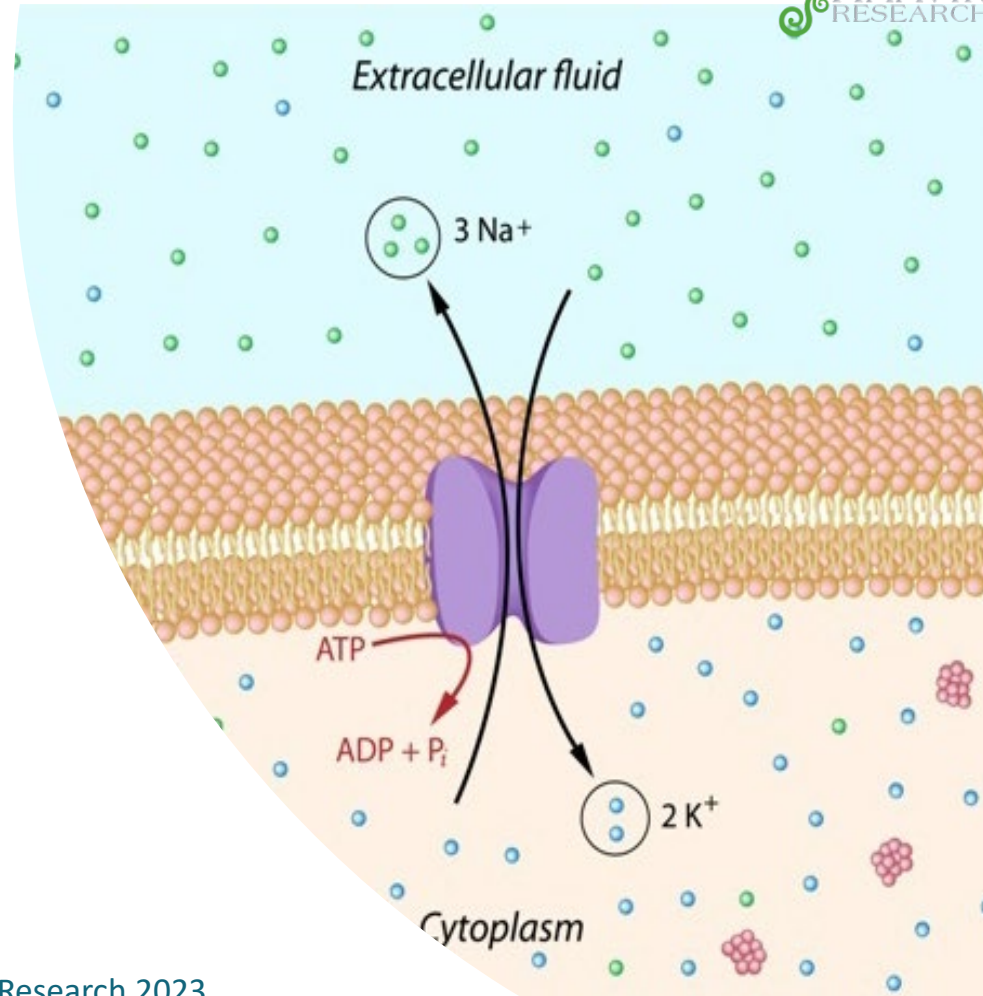
The subunits can be copies of the same protein or be a combination of quite different proteins.



# Ion Channel Pumps

## The Sodium/Potassium Pump

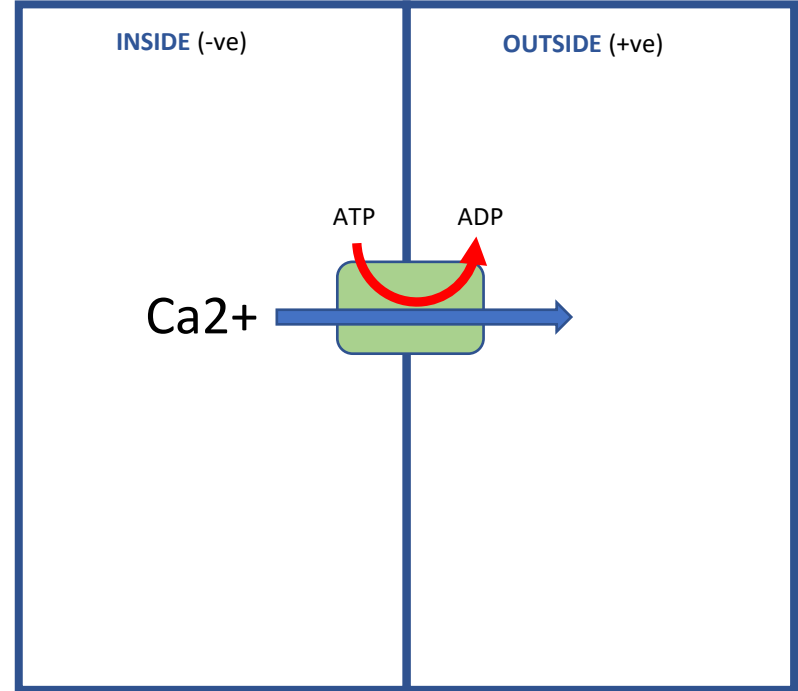
- Pumps are Protein that crosses the membrane, AND
- Requires ATP
- Example; the  $\text{Na}^+/\text{K}^+$  pump that restores normal  $\text{Na}^+$  outside cells and  $\text{K}^+$  inside cells
- By doing this it restores normal resting membrane potential



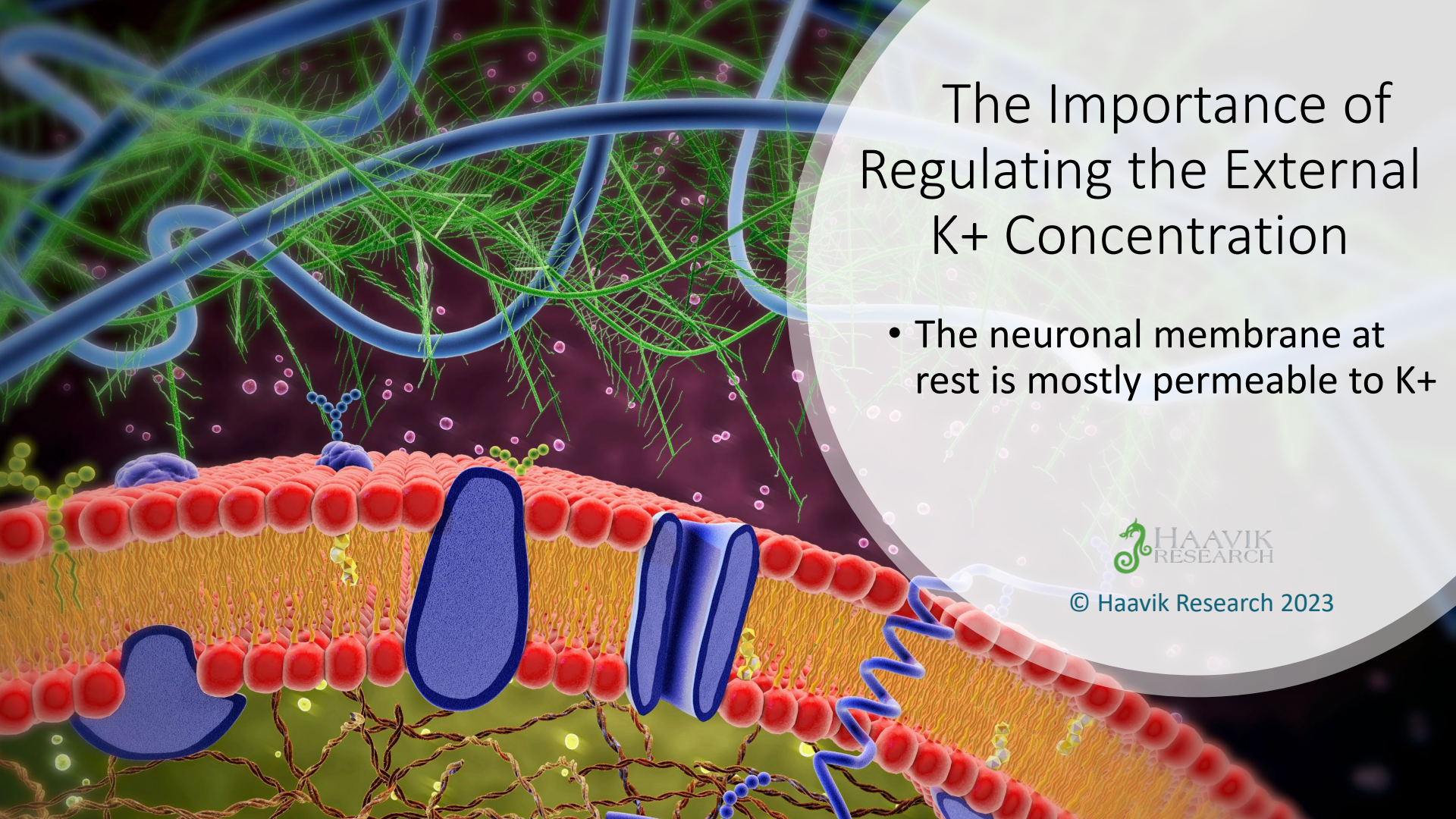
# Ion Channel Pumps

## The Calcium Pump

- The calcium pump actively transports  $\text{Ca}^{2+}$  out of the cytosol across the cell membrane.
- Ion pumps are the unsung heroes of cellular neurophysiology.
- They work in the background to ensure that the ionic concentration gradients are established and maintained.
- Without ion pumps, the resting membrane potential would not exist, and the brain would not function.







# The Importance of Regulating the External $K^+$ Concentration

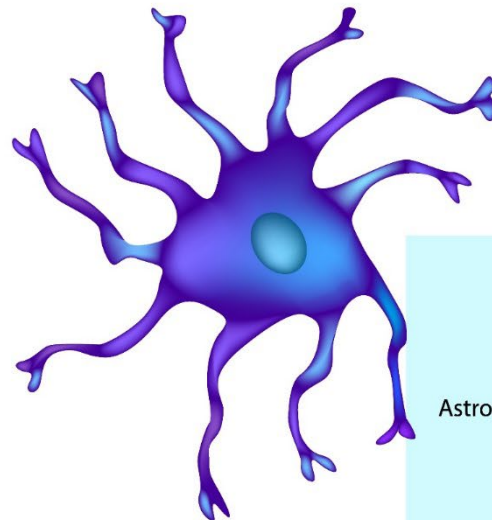
- The neuronal membrane at rest is mostly permeable to  $K^+$



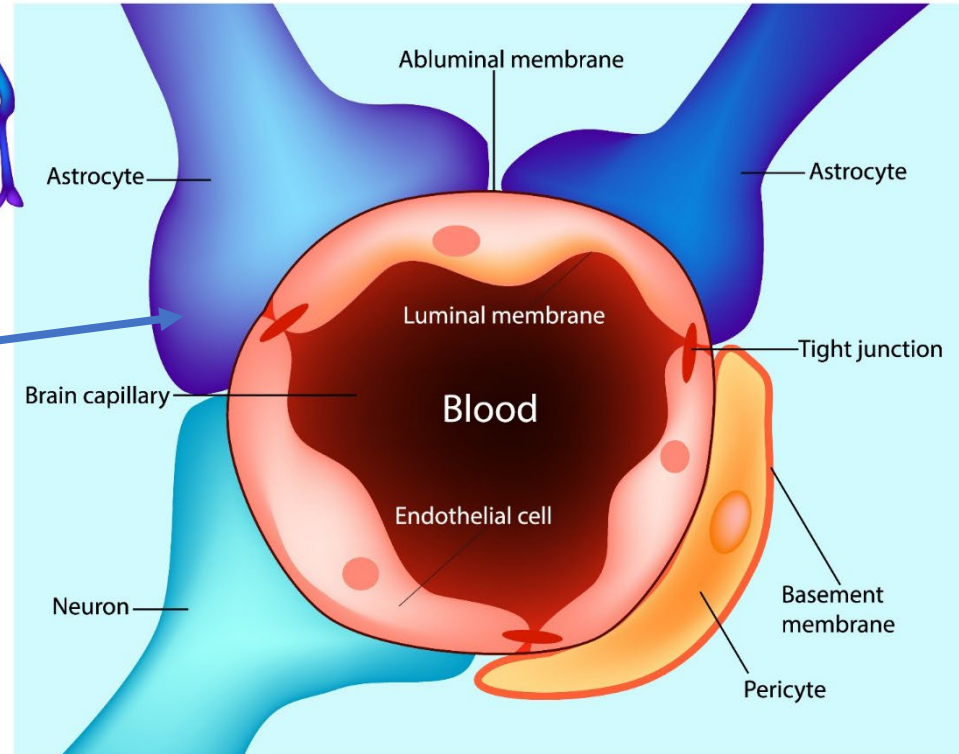
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# Astrocytes

Glial Cells Help  
Maintain The  
Membrane  
Potential



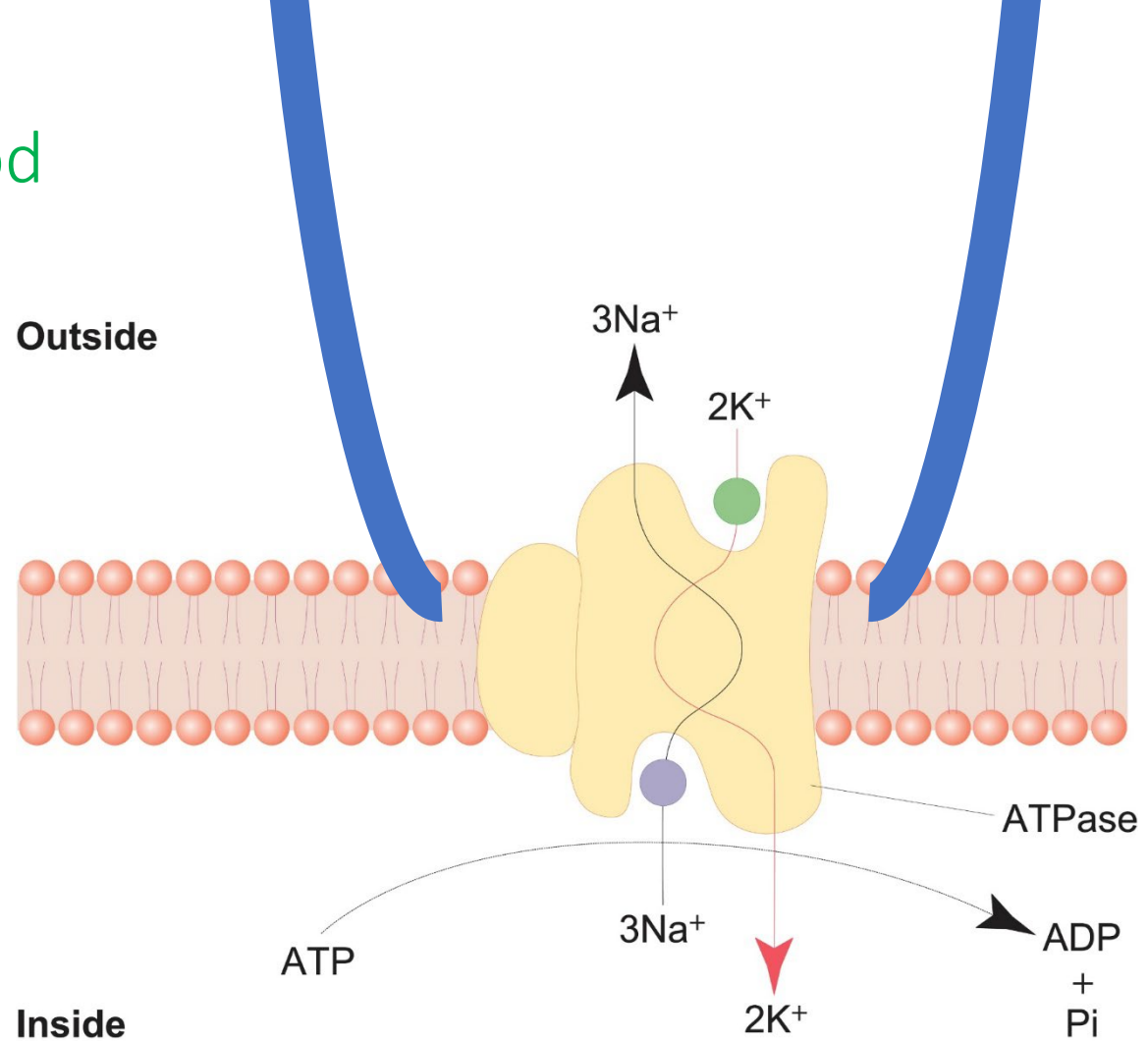
- Astrocyte Perivascular feet help maintain blood brain barrier.
- Astrocyte membranes contain  $K^+$  channels and pumps.



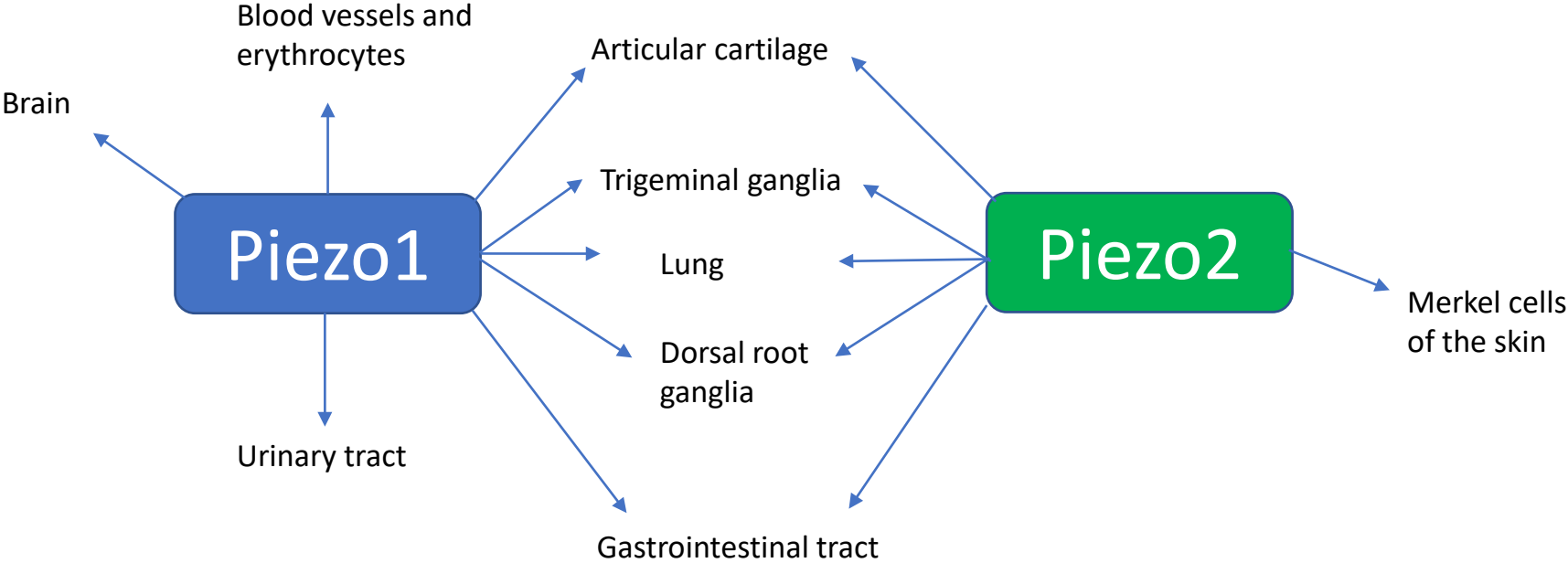
# Questions

# Patch Clamp Method

- Can study individual ion channels



# Mechanically Activated Piezo 1 and Piezo 2 Ion Channels



# Piezo1

- Major skeletal mechanosensory that regulates skeletal homeostasis.
- Plays an essential role in skeletal growth and development by affecting osteoblast-osteoclast crosstalk in response to mechanical forces.
- Plays major role in mechanical force related chronic inflammation.
- Implicated in:
  - Chronic pain
  - Chronic inflammation
  - Hypertension

# Piezo2

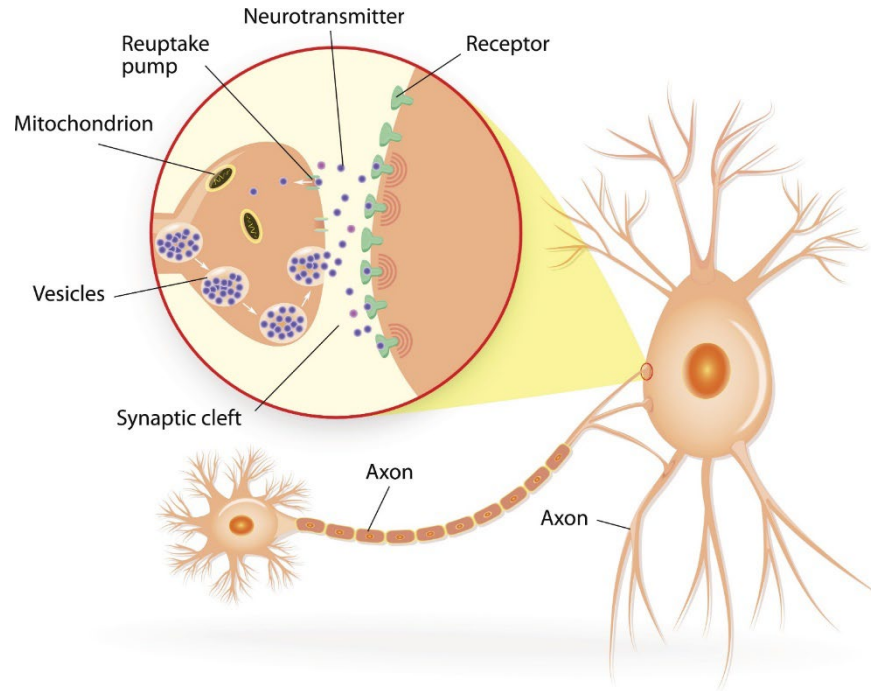
- Expressed by dorsal root ganglia (DRG) neurons, especially proprioceptive mechano-sensing neurons with muscle spindles and Golgi Tendon Organs.
- Loss of Piezo2 in proprioceptive neurons of mice resulted in severely uncoordinated body movements and abnormal limb positions.
- Thus, considered main mechanotransducer for proprioceptive signals.

# Resting Membrane Potential

- **Unequal electrolytes distribution between ECF/ICF:**
  - Diffusion of ions down their concentration gradients
  - Selective permeability of plasma membrane
  - Electrical attraction of cations and anions
- **Explanation for -70 mV resting potential:**
  - Membrane very permeable to  $K^+$ 
    - Leaks out until electrical gradient created attracts it back in
  - Cytoplasmic anions can not escape due to size or charge ( $PO_4^{2-}$ ,  $SO_4^{2-}$ , organic acids, proteins)
  - Membrane much less permeable to  $Na^+$
  - $Na^+/K^+$  pumps out 3  $Na^+$  for every 2  $K^+$  it brings in
    - Works continuously & requires a great deal of ATP
    - Necessitates glucose & oxygen to be supplied to nerve tissue



# Chemical Excitation



# Thank You



DR. HEIDI HAAVIK

ENLIGHTENING THE  
WORLD ABOUT THE  
SCIENCE OF CHIROPRACTIC



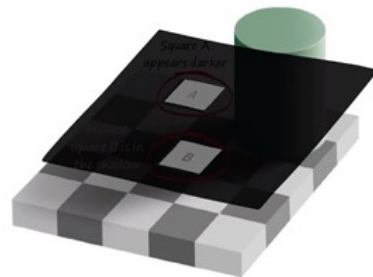
# Introduction to Chiropractic Care

The introduction to chiropractic video series is the perfect way to gain an understanding of why chiropractic care may help you and your family.



## The Beginners Guide to Chiropractic

In this first introductory video we explore what chiropractic is all about, and how it works, then we briefly explore the evidence informed effects of chiropractic care.

[View video >](#)

## How the Brain Perceives the World

Did you know that your brain and central nervous system are constantly changing? It's quite amazing - from one day to the next your brain is not the same.

[View video >](#)

# The Beginners Guide to Chiropractic

## The Beginners Guide to Chiropractic

The word chiropractic derives from the Greek words "cheir", meaning hand, and "praktikos" meaning skilled in or concerned with. The origin of the word chiropractic can be traced back to [D.D. Palmer](#) who coined it in 1895 when he founded chiropractic.

Chiropractic care is really about total health and wellbeing

### What does a Chiropractor do?

A chiropractor is a healthcare professional who specializes in the health and [function of the spine](#) and nervous system. Because of this focus on the spine, many people think chiropractors can only help with problems such as back pain, [neck pain](#) and [headaches](#). They can often help with these issues but there is much more to chiropractic than just pain.

This is the first video in our animated series "Introduction to Chiropractic". In this video, we outline what a chiropractor does, then we briefly explore the effects of care. It is a perfect one to watch for anyone that is curious about chiropractic care, and how it can help their family.

### Video References

1. Rosner AL. Chiropractic Identity: A Neurological, Professional, and Political Assessment. *J Chiropr Humanit* 2016;23(1):35-45.
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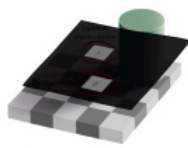




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### How the Brain Perceives the World

Did you know that your brain and central nervous system are constantly changing? It's quite amazing - from one day to the next your brain is not the same.

[View video >](#)



### Break the Pain Cycle

Did you know that pain is created in your brain to let you know that something is not ok within your body? Feeling pain is good because it is actually helpful and informative.

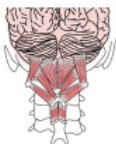
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### Chiropractic Care and Migraines

Did you know that 1 in 6 people in the world experience migraines regularly? The World Health Organisation consider them to be the most debilitating of all neurological disorders.

[View video >](#)



### Chiropractic Affects your Brain

Your brain receives information about your body from the environment and your organs. Did you know that the muscles in your body are also sensory organs?

[View video >](#)



### What is that Pop?

If you have been adjusted before by a chiropractor you may have noticed a strange popping sound. Don't worry - it is just the formation of gas within a joint.

[View video >](#)



### Lower Back Pain

Scientists have worked out that at any one time, over 500,000,000 people around the world are suffering from low back pain and it is now the leading cause of disability worldwide.

[View video >](#)



### Growing Pains

We've all heard of growing pains right? But did you know that what we call growing pains aren't associated with growing? So they're not actually growing pains at all.

[View video >](#)



### Pain and the Immune System

Research studies have shown that the way you feel pain all depends on what's going on for you - and most importantly - what you think and feel about the situation.

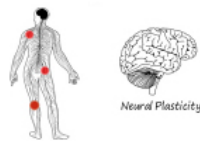
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### Chiropractic and Headaches

Headaches are a sign that something is not right. Your brain will create for you the sensation of pain if it thinks there is something wrong or if there is a potential problem.

[View video >](#)



### Pain is Created in Your Brain

Did you know that the scientists now know that the feeling of pain is something your brain decides that you should experience - if it believes that there is a problem?

[View video >](#)



### Chronic Pain

Chronic pain is the second-most common reason people see a doctor and miss work. More than one-third of people with chronic pain become disabled by their pain to some degree.

[View video >](#)




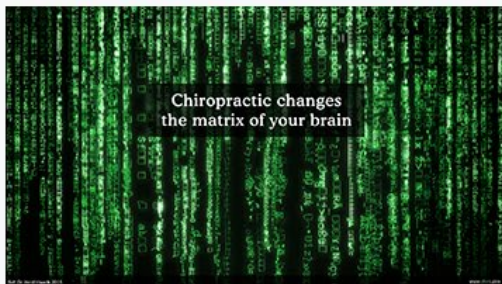


# Print & Digital Assets

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To download the digital assets, simply click on the corresponding button below the image.




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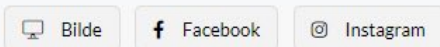
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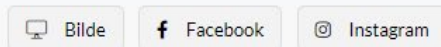


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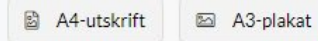
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# Chiropractic Research

Research summary articles to read, download and print (members only) all backed by the latest scientific research studies.



## Chronic Pain

Chronic pain that has persisted for more than 3 months is no longer protective, nor informative. So, what is chronic pain and what can you do about it?

[Read more »](#)



## Pain is in the Brain

Sometimes pain persists long after tissue damage has actually healed. When pain persists for more than three months we call this chronic pain.

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## Neck Pain

Up to half the world's population suffers from neck pain at some stage. For some, one big problem is that it just keeps coming back, or becomes chronic.

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# Neck Pain

# Pain is Created in the Brain

# Understanding Pain

# Maintenance Care

# The Opioid Epidemic

# Lower Back Pain

...that 50% of patients visit a chiropractor to maintain their health and well-being!

Up to half of all people around the world suffer from neck pain at some stage in their lives. For some people, one problem with neck pain is it just becomes chronic, and may even increase their risk of other health problems.

**Chiropractic care is an effective care option, and it's also cost-effective.** We know from many research studies that chiropractic care is an effective care option, and it's also cost-effective compared to other common treatments for neck pain.

**We've all heard about the opioid epidemic, but what are opioids and why are they such a big problem?** Opioids are basically a type of pain killing drug. No-one likes pain right? Why wouldn't you want to take drugs to help relieve it?



**Do you think Heroin (an opioid drug) is good for you?** In case you're unsure how to answer that question lets discuss some of the actual side effects from taking heroin - nausea, vomiting, itching, insomnia, infections, abscesses, constipation, liver, kidney and lung disease, mental problems, problems with sexual function, and death. Not just a few deaths, Heroin kills thousands of people every single year and it is a highly addictive drug!

**Did you know that pain is not just damage to feel pain.** The interesting thing is that you can have damage to feel pain, and you can have pain and not feel any pain.

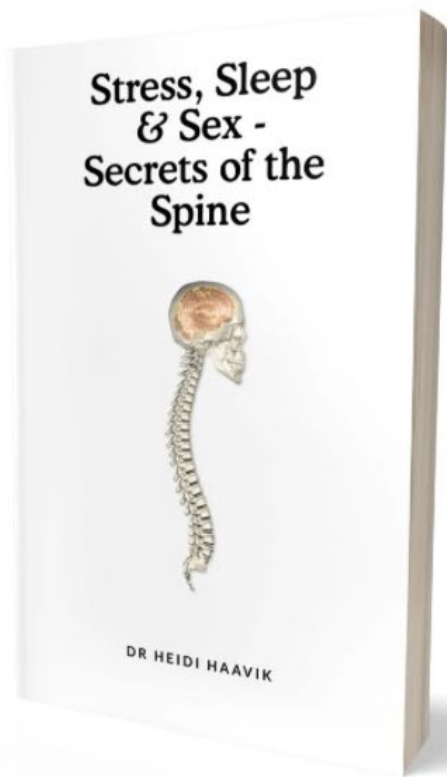


**Do you suffer from lower back pain? It is now the leading cause of disability worldwide.** Back pain guidelines recommend seeing a chiropractor or other form of healthcare before e. medications such as relaxants or opioid based pain relief.

**Back pain can be frustrating and debilitating.** With so many suffering from back pain, when doctors don't know what's causing the pain, as most of the time back pain isn't due to something like a fracture or an infection. It's often due to a change in the way your back is moving and functioning which changes the way your brain senses what is going on in your back.



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# Questions