

Effect of cold atmospheric pressure plasma on diabetic wound healing



Nature and Life
Science, Human
Biology

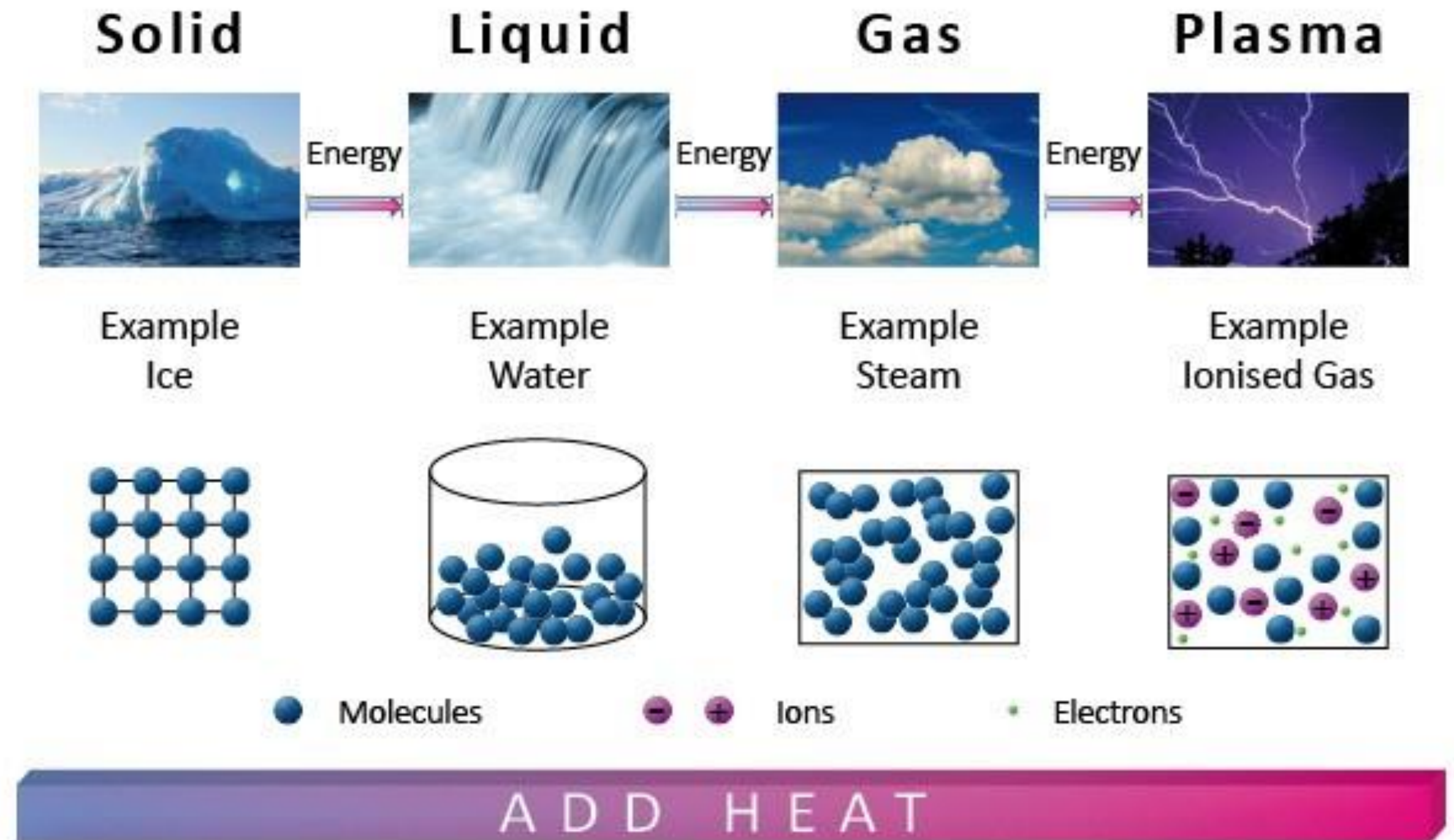
Introduction

plasma

Diabetic
wound
healing

1. What is plasma

- ❖ A plasma is an ionized gas.
- ❖ fourth state of matter.
- ❖ Actually, plasma consist of a mixture of molecular gases, contains many different neutral and charged particles. A group of identical particles in plasma called species.

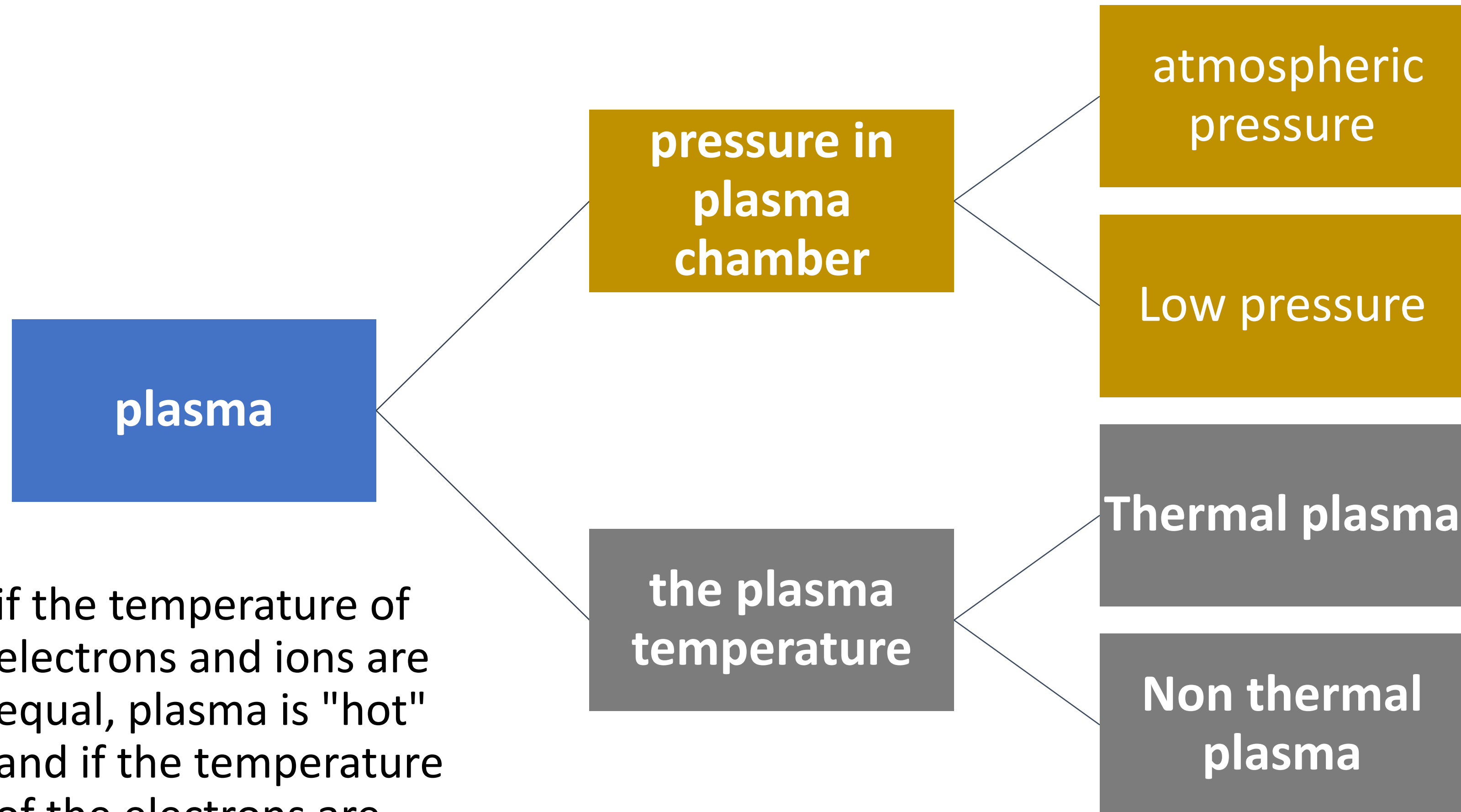




2. Nature example of plasma

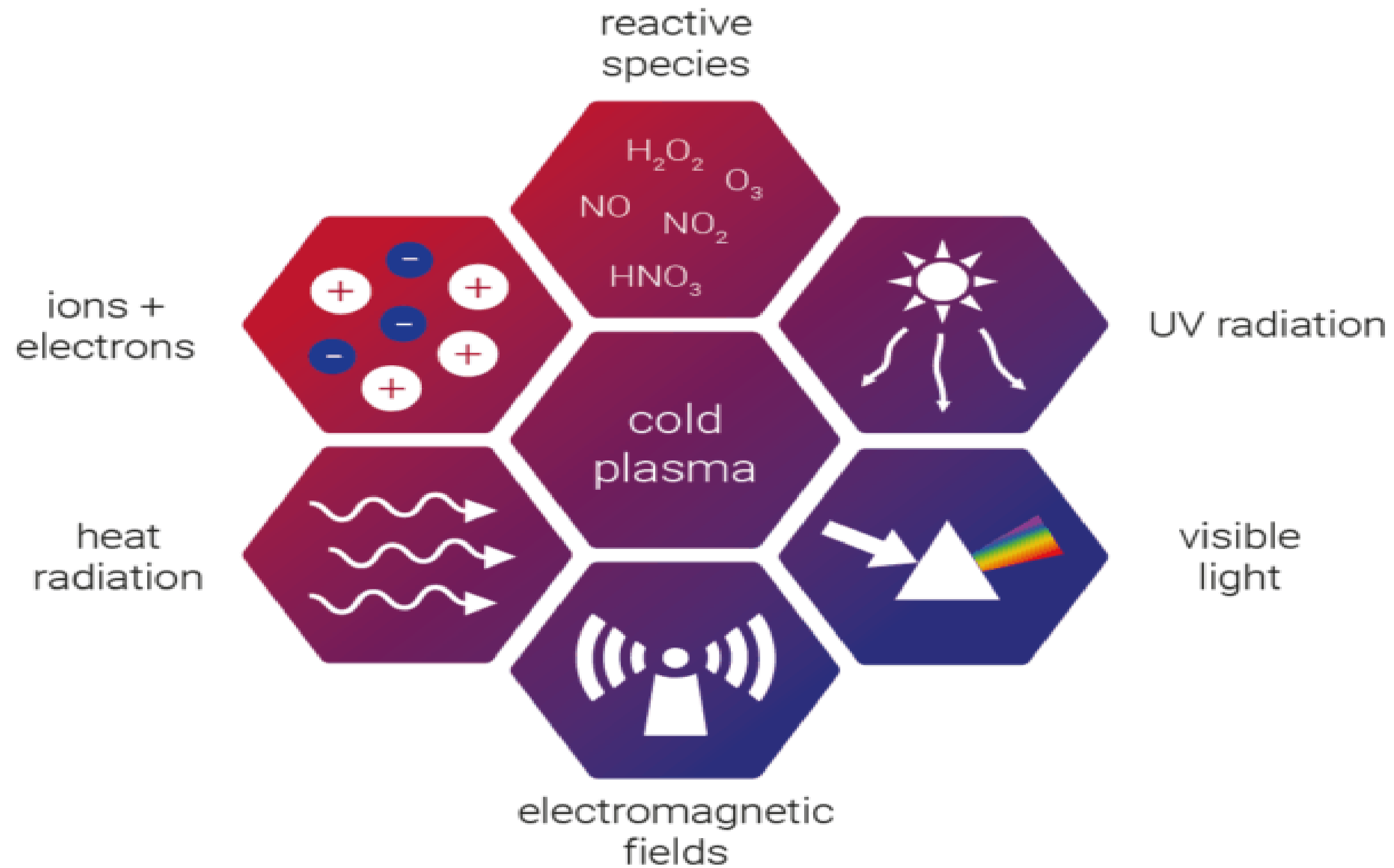


3. Classification of plasma



if the temperature of electrons and ions are equal, plasma is "hot" and if the temperature of the electrons are

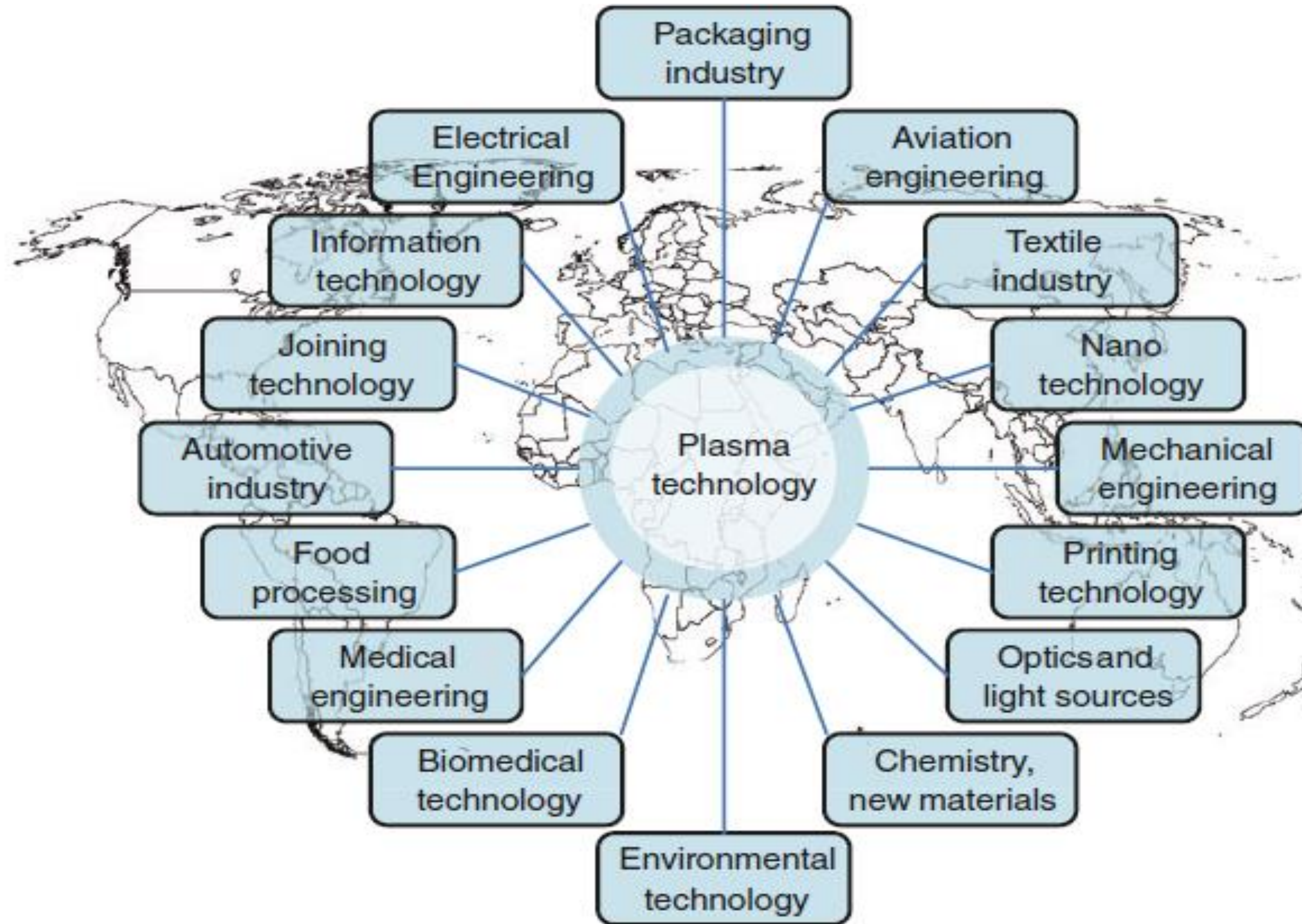
4. Cold atmospheric plasma (CAP)



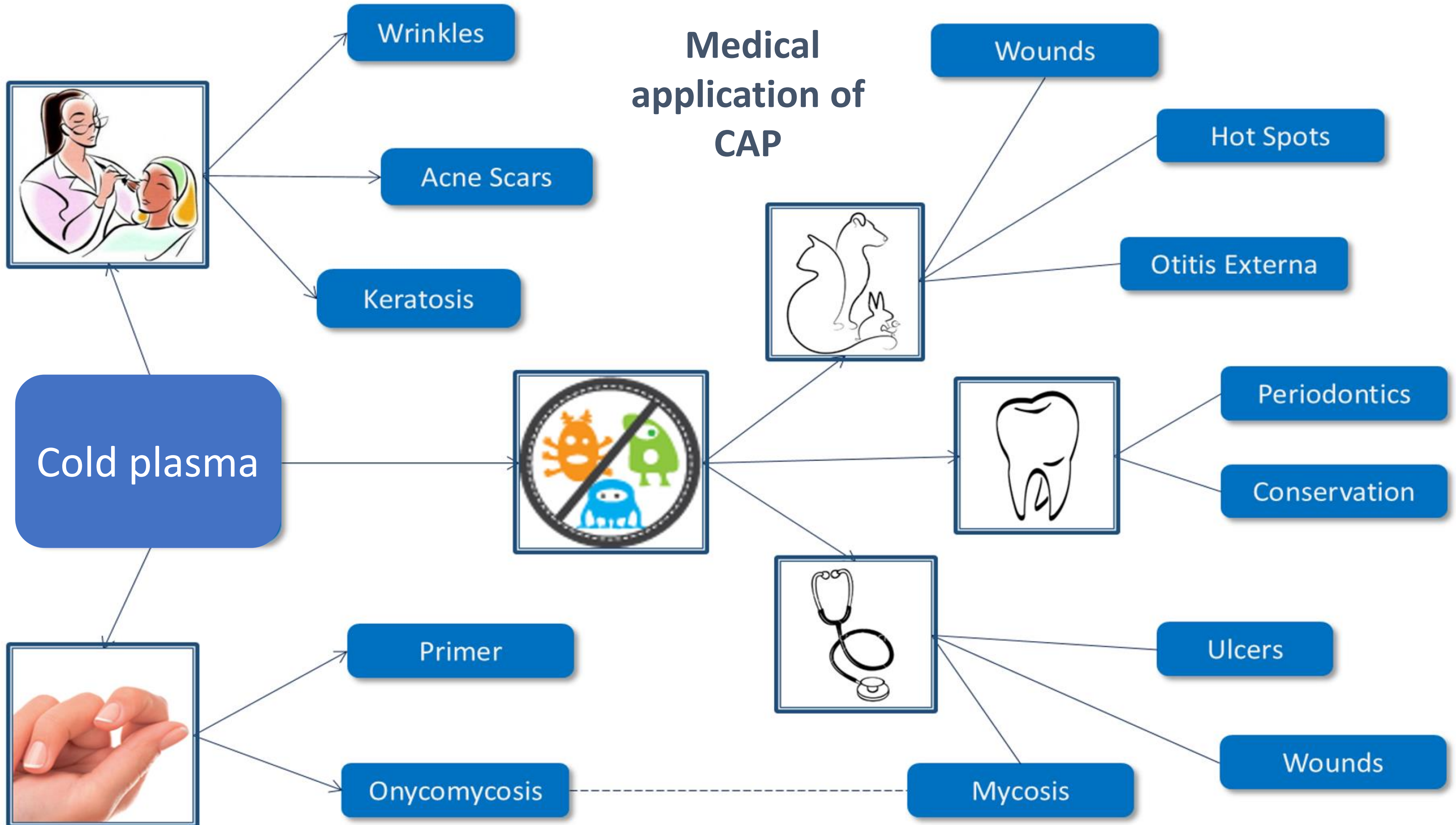
**Components, by which physical plasmas can
interact with their surroundings**

	Direct plasma	Indirect plasma	Hybrid
Plasma sources	Floating electrode dielectric barrier discharge (FE-DBD)	Plasma jet, plasma bullet, plasma gun, plasma needle, plasma torch (i.e. MicroPlaSter)	Surface micro discharge (SMD), barrier coronal discharges
Mode of production and properties	The sample to be treated functions as the second electrode, current flows through the sample	Plasma is produced in between two electrodes and transported to the sample via gas flow	The mode of production of direct plasmas is coupled with properties of indirect plasmas: ‘Hybrid’ plasmas contain a grounded electrode - i.e. here the sample does not function as the second electrode
Gas	Air	Noble gas/air	Air
Distance between device and treated sample	~ mm	~ mm - cm	~ mm
UV radiation	Relatively weak	Relatively high	Relatively weak
Plasma density on the sample	high	Low (strongly depends on the distance)	Low (strongly depends on the distance
Site of production of reactive species	RONs are produced in the plasma	RONs are produced by mixing plasma and gas/air	RONs are produced in the plasma
Produced plasma species	Charged particles (D) Short lifetime species (D) Long lifetime species (D)	Charged particles (L) Short lifetime species(H) Long life time species (D)	Charged particles (H) Short lifetime species(H) Long lifetime species (D)

application fields of plasma technology

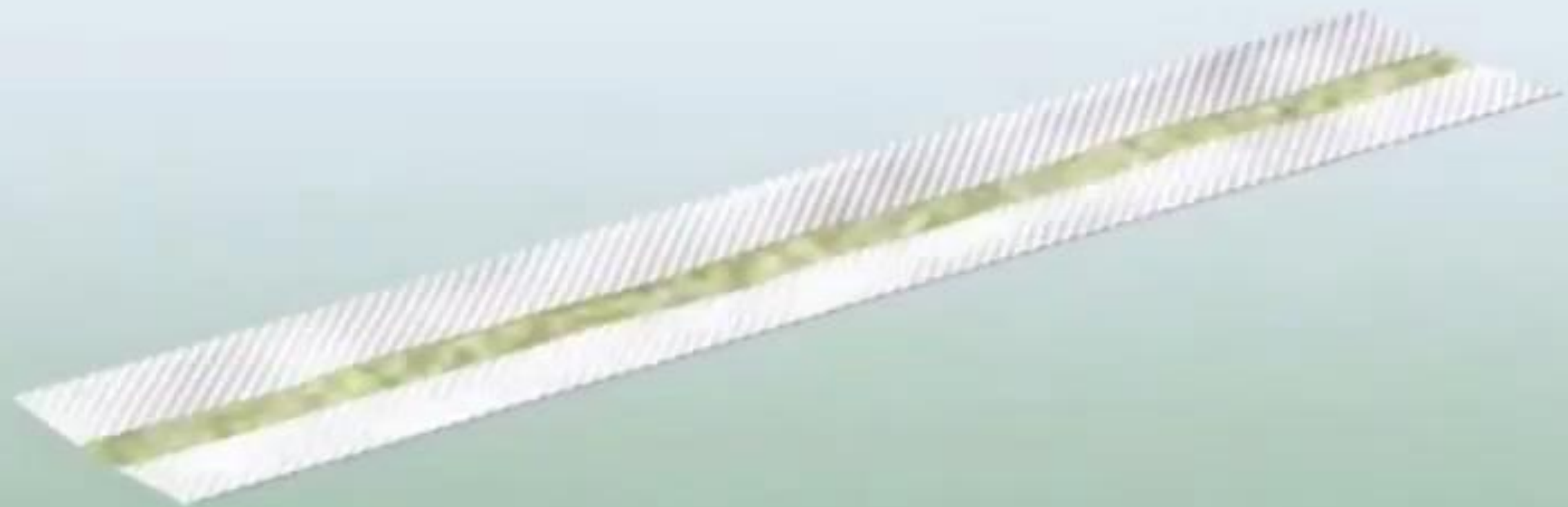


Medical application of CAP



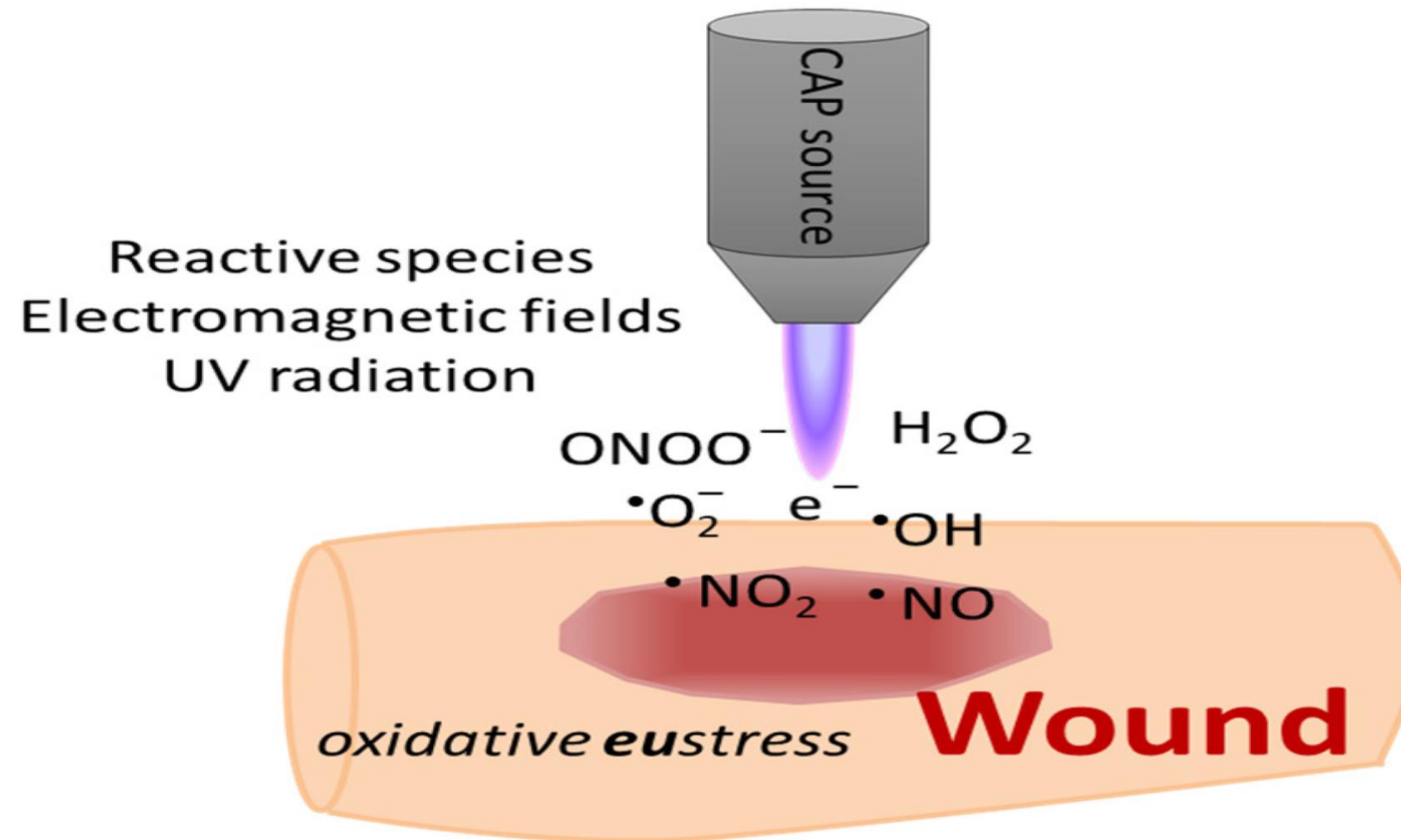
Medical application of CAP





Effect of plasma doses on tissue

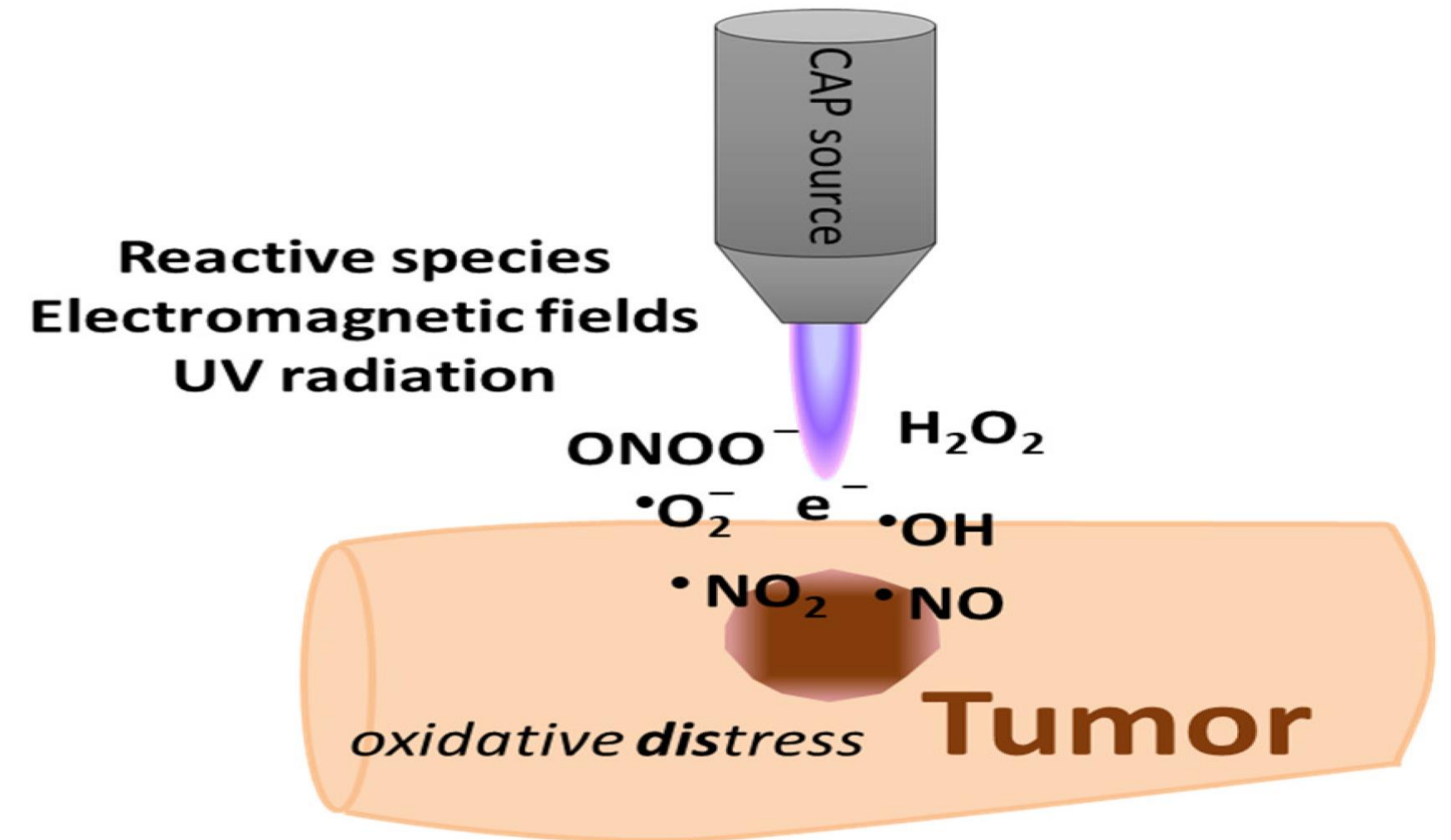
Low intensities /
moderate treatment time



- Disinfection
- Proliferation
- Angiogenesis
- Cell migration / EMT
- Re-epithelialization

Wound Healing

High intensities /
prolonged treatment time



- Apoptosis
- Necrosis
- Senescence
- Immune response

Cancer Cell Death

Medical devices of CAP



PlasmaDerm® FLEX 9060

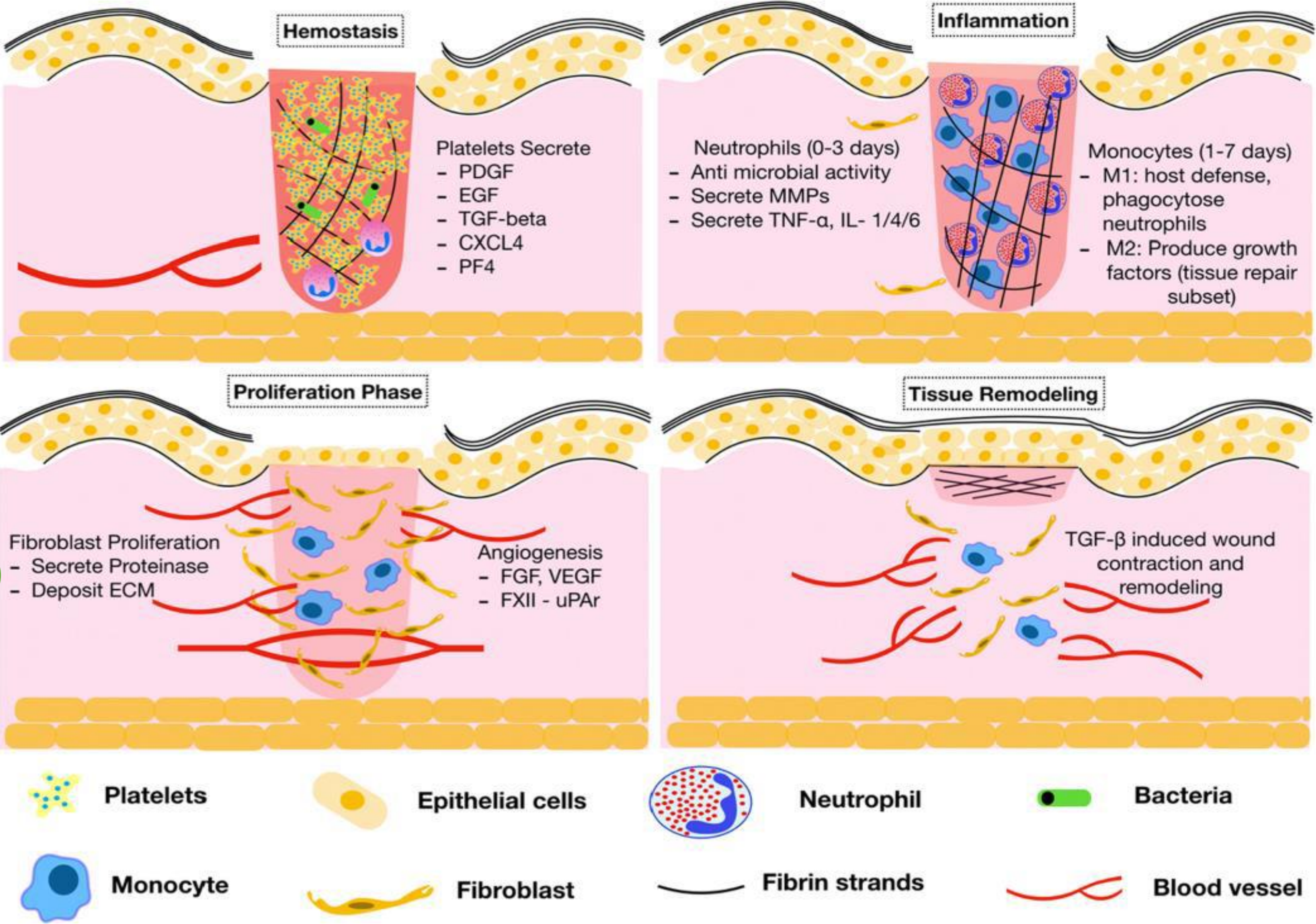


**kINPen® MED by neoplas tools GmbH
(Greifswald,
Germany)**



PlasmaDerm® FLEX 9060

Phases of wound healing



Coagulation and Hemostasis

Inflammation

Re-epithelialization

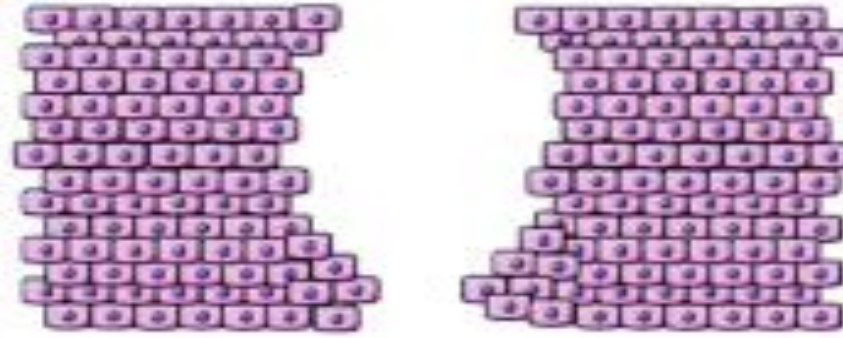
Remodeling

Phases of wound healing

1 Intact tissue



2 Tissue damage



3 Platelet aggregation



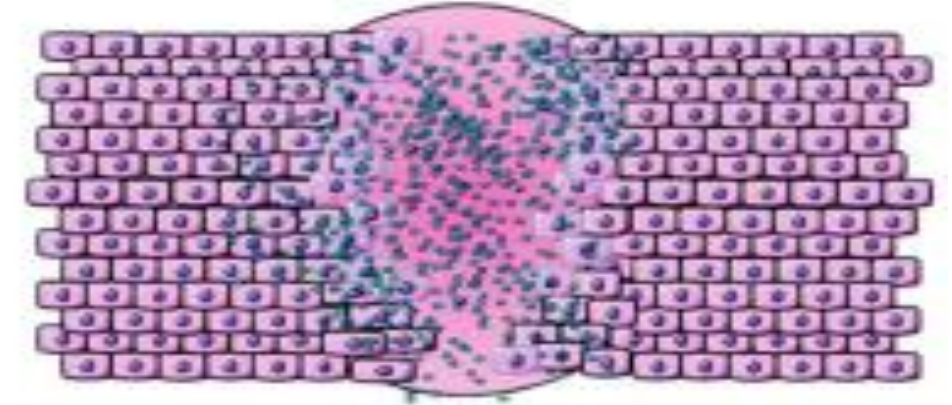
4 Hemostatic plug formation and immune cell infiltration



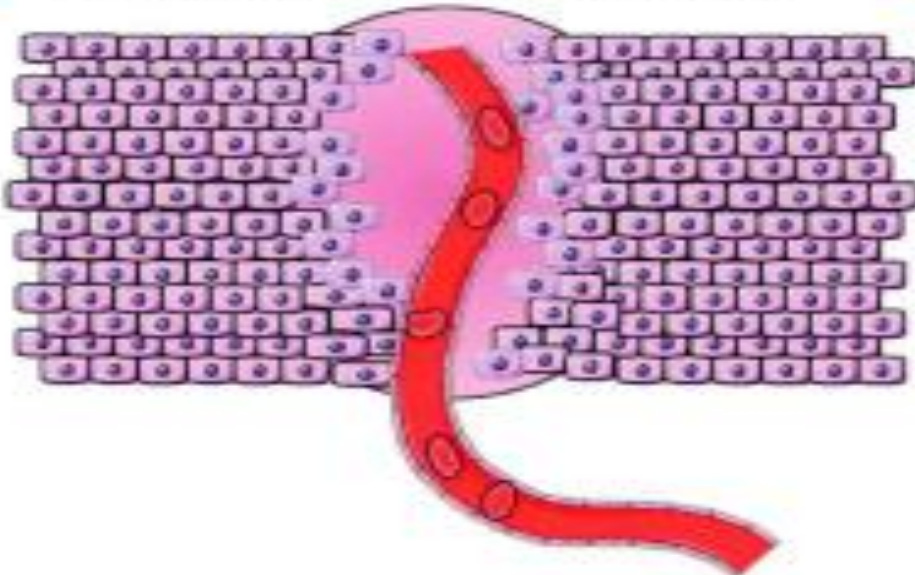
5 Cytokine release & ROS generation



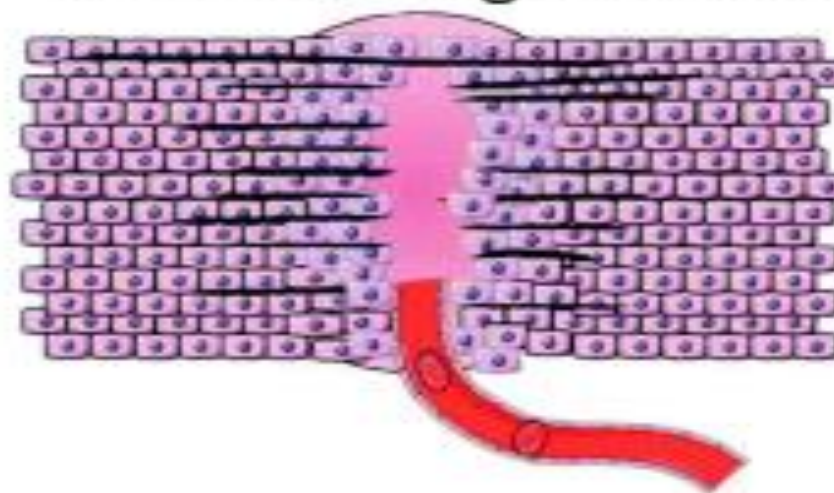
6 VEGF release & proliferation



7 Angiogenesis and neovascularization



8 Collagen conversion and vascular regression



9 Wound closing



Phases of wound healing

The above phases are made up of following substages:

- **Hemostasis** In order to stop the bleeding, a rapid mechanism of constricting blood vessels to limit blood loss is needed. This is what is referred to as hemostasis.
- **Inflammation** The body reacts to the injury in the form of inflammation. Although this is an important stage in the wound healing process, if it is stretched for a long time, it can actually prevent regeneration.
- **Proliferation and Migration** During inflammation, the body releases several kinds of cells, which further migrate and proliferate. While migration is a carefully coordinated movement of cells in a specific order, proliferation enhances hemostasis, as cells further constrict the blood vessels.
- **Angiogenesis** The intact blood vessels undergo constriction to control blood loss, while the broken ones need to be repaired or completely replaced with new ones. Angiogenesis or the process of formation of new blood vessels involves the synthesis of many complex chemicals and marks the beginning of the Remodelling phase. The following animation depicts the process of angiogenesis.
- **Re-epithelialization** After regrowing the veins, it's time to regrow the skin. The epidermis is made up of cells called keratinocytes which are forged and replenished during this stage. Re-epithelialization involves the creation of several layers which provide protection and prevent fluid loss.
- **Synthesis** This is not a very clearly demarcated stage as the synthesis of new skin and veins often happens almost simultaneously. The blood clotting factors (proteins) are essential throughout the process of wound healing.

Diabetic wound healing

wound infection

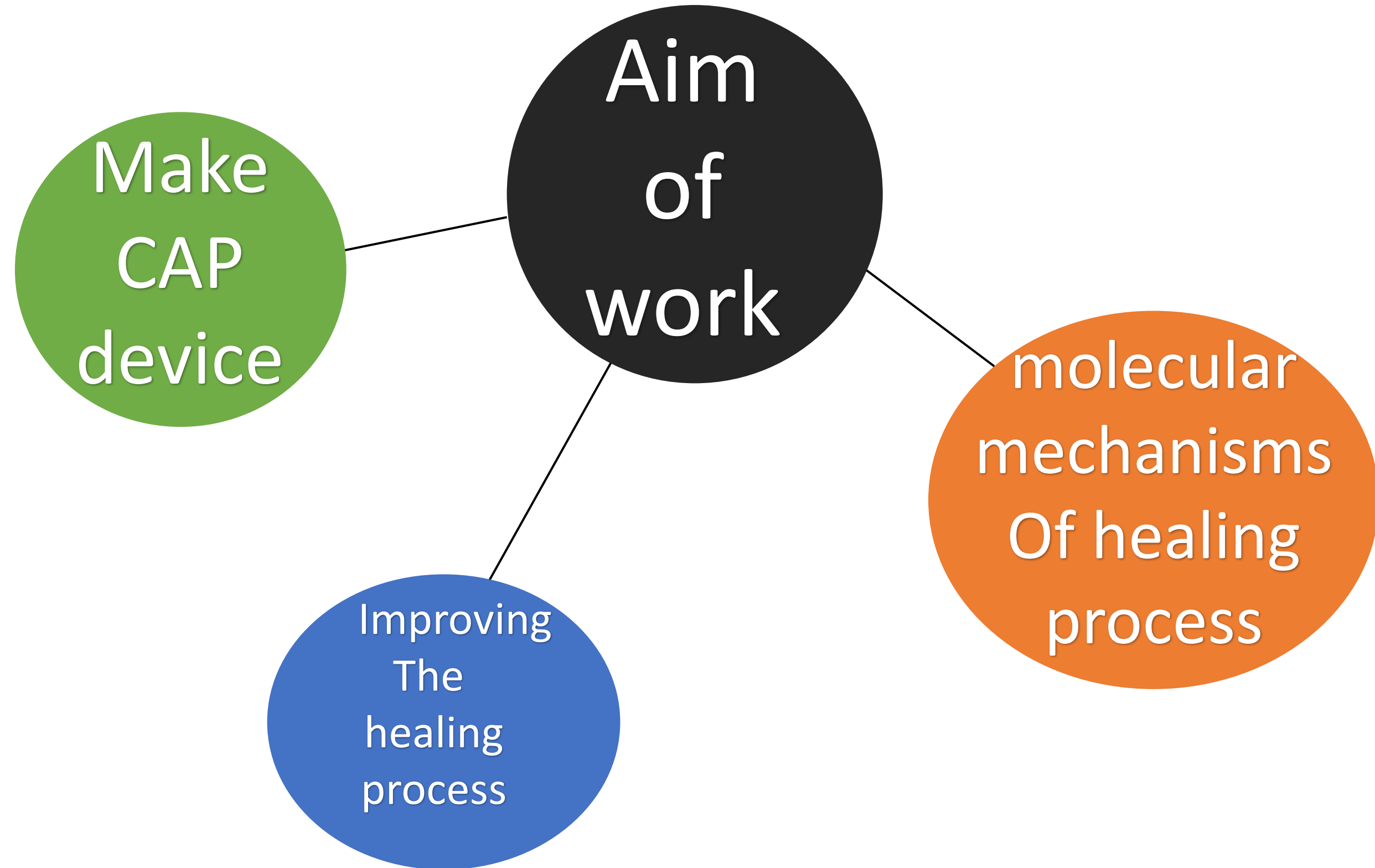
hyper-inflammation

apoptosis and pyroptosis

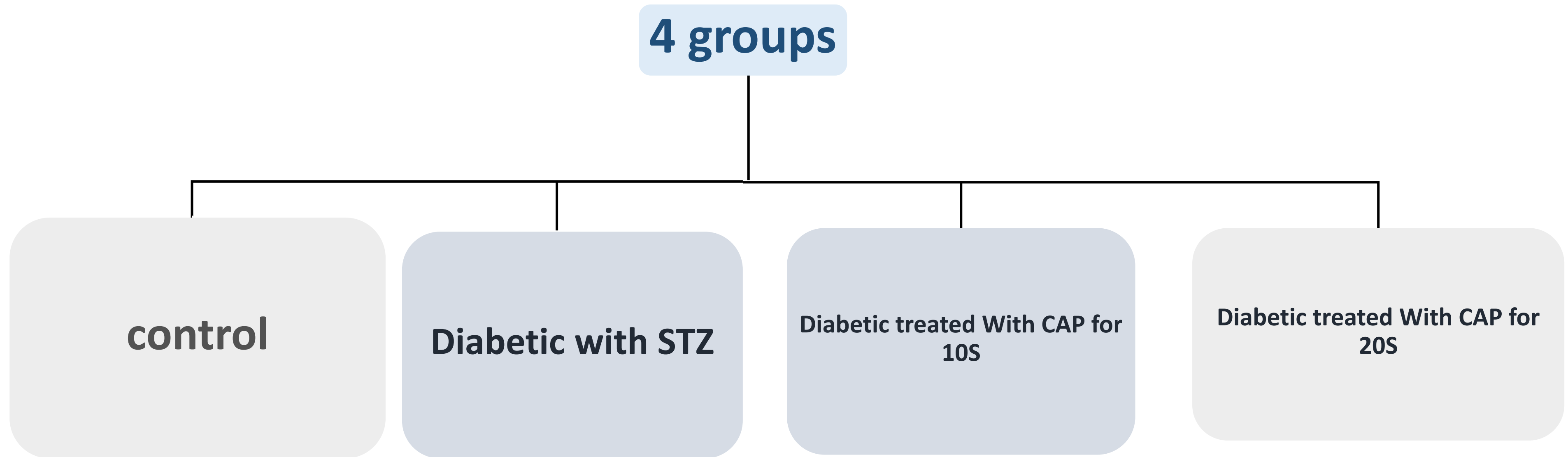
dysregulated cellular functions

reduced angiogenesis

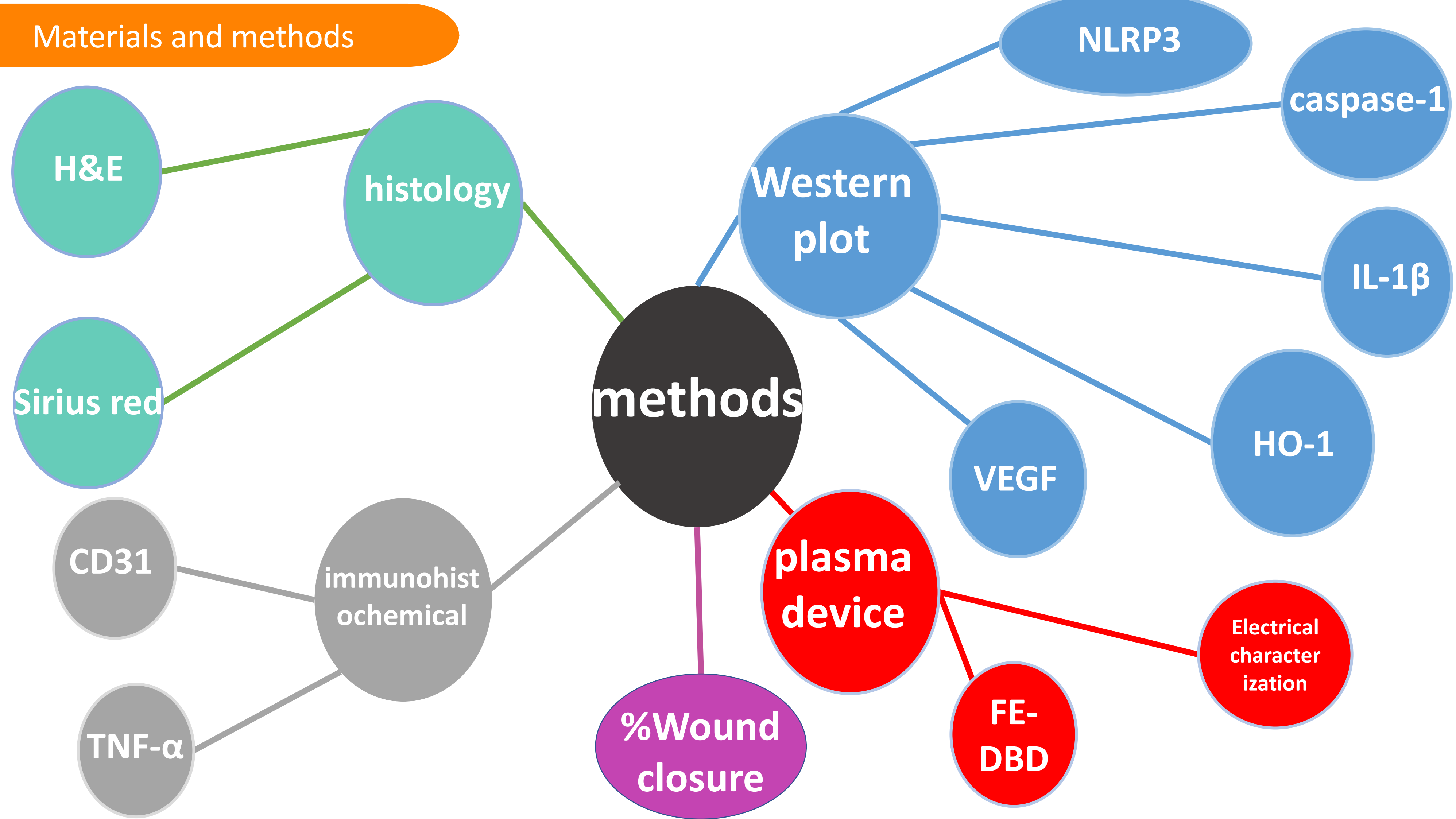
Aim of work

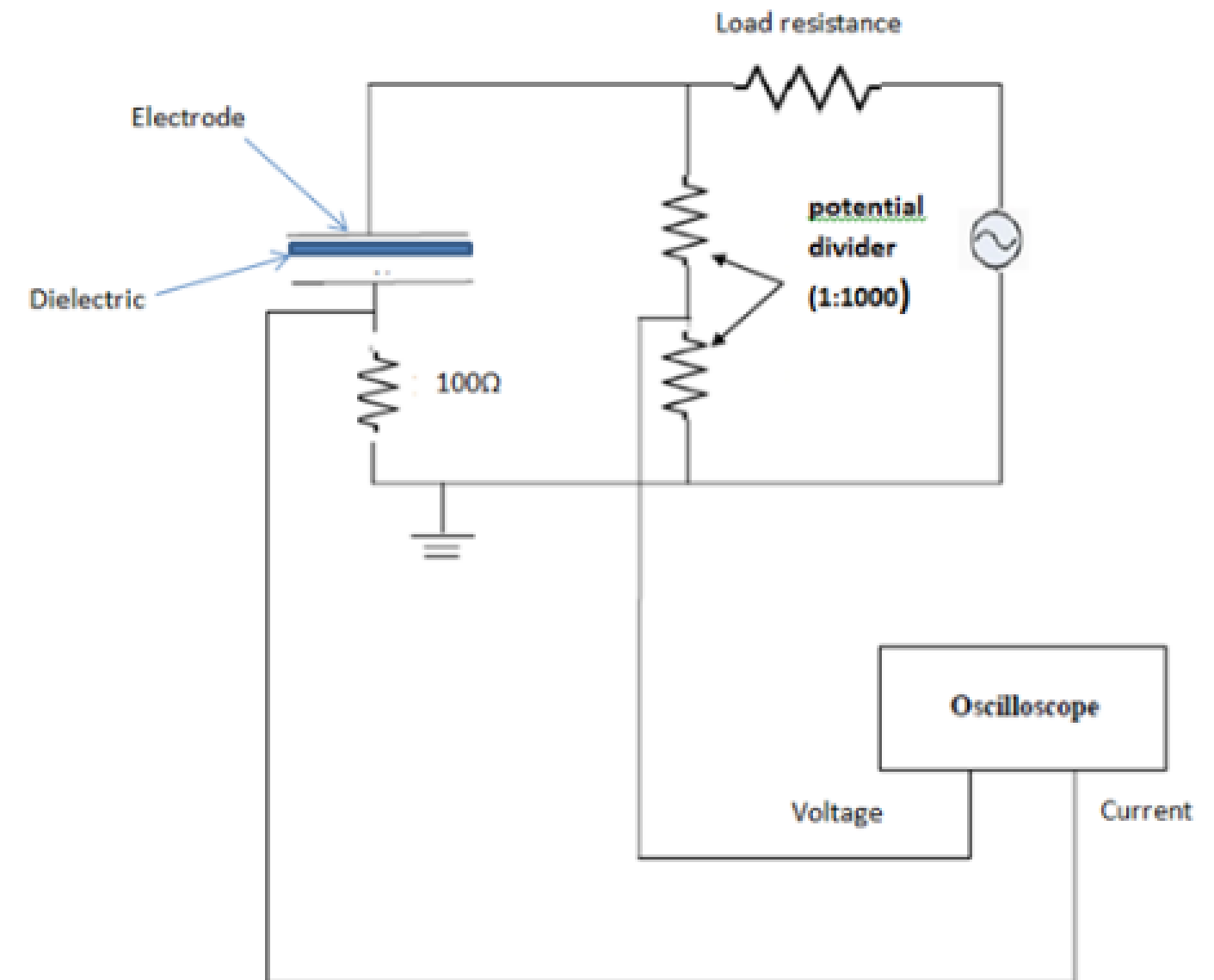
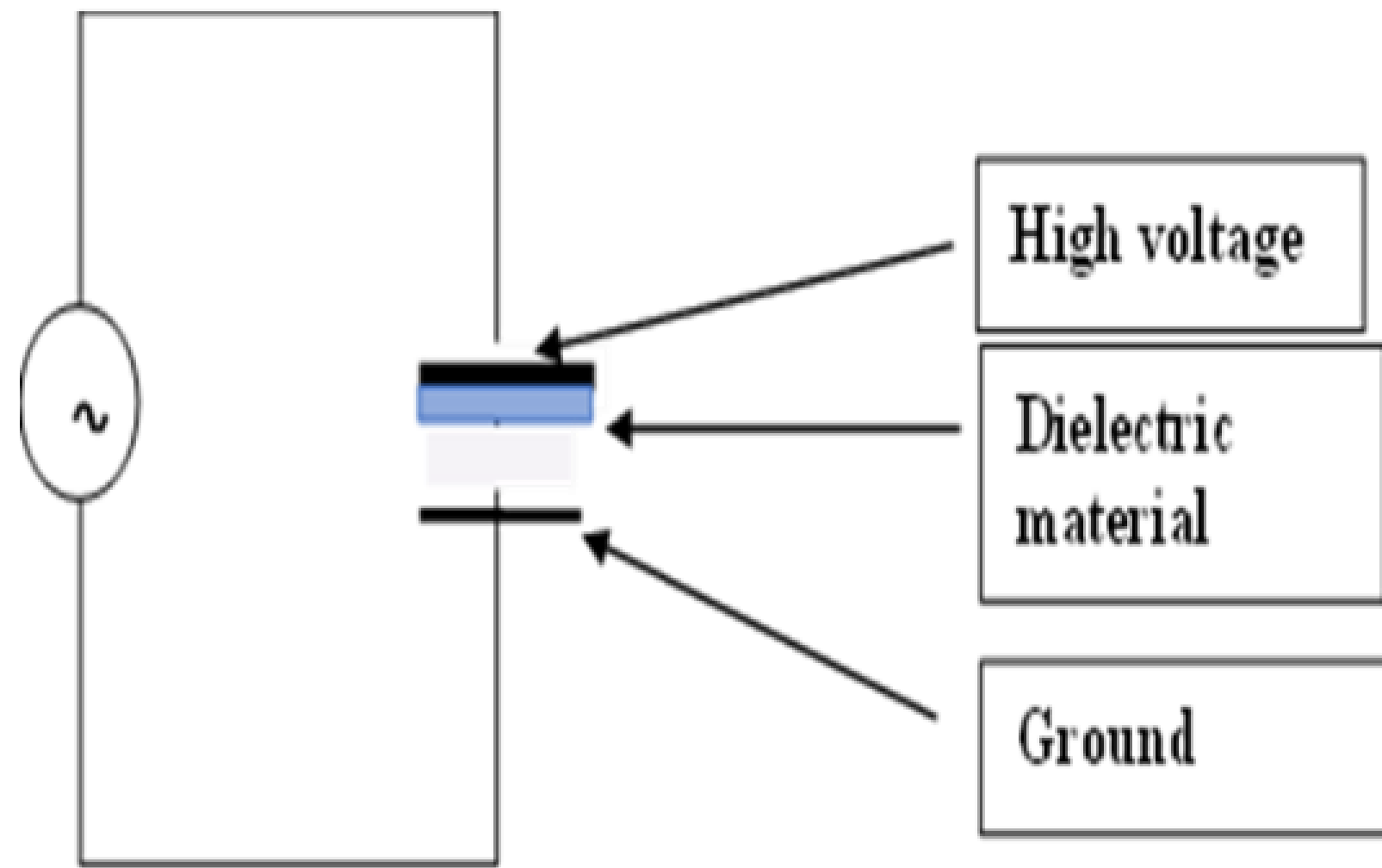


Materials and methods



Materials and methods



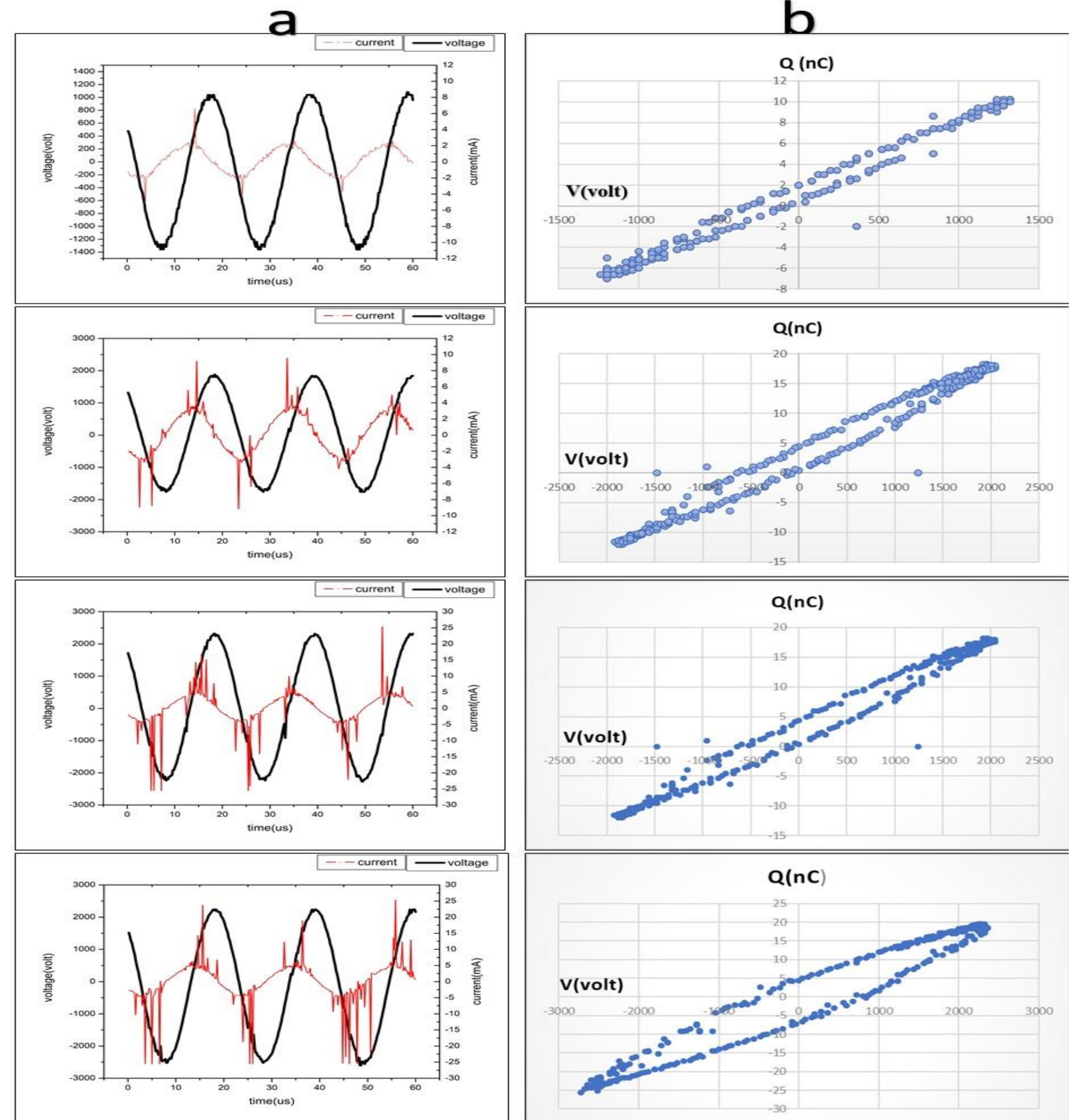


$$P = 4fC_d \left(\frac{1}{1 + \frac{C_d}{C_g}} \right) V_{min}(V_{max} - V_{min})$$



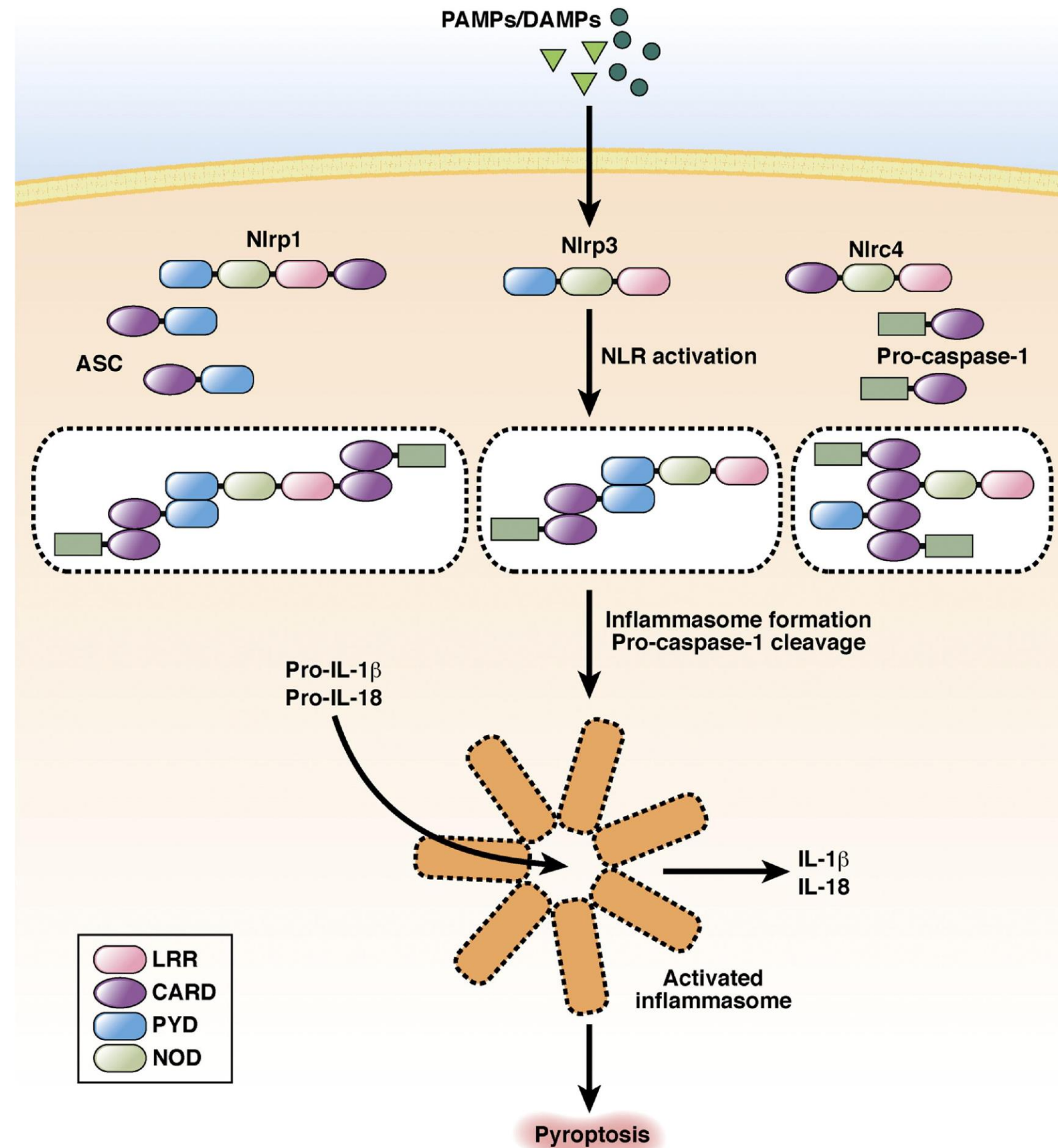
Electrical characteristics of FE-DBD

- Fig. 2.a Measurements of voltage and current versus time (μs) with a plasma discharge for
- different values of the input voltage
- Fig. 2.b Q – V relationship for atmospheric pressure plasma and room temperature in different value of input voltage



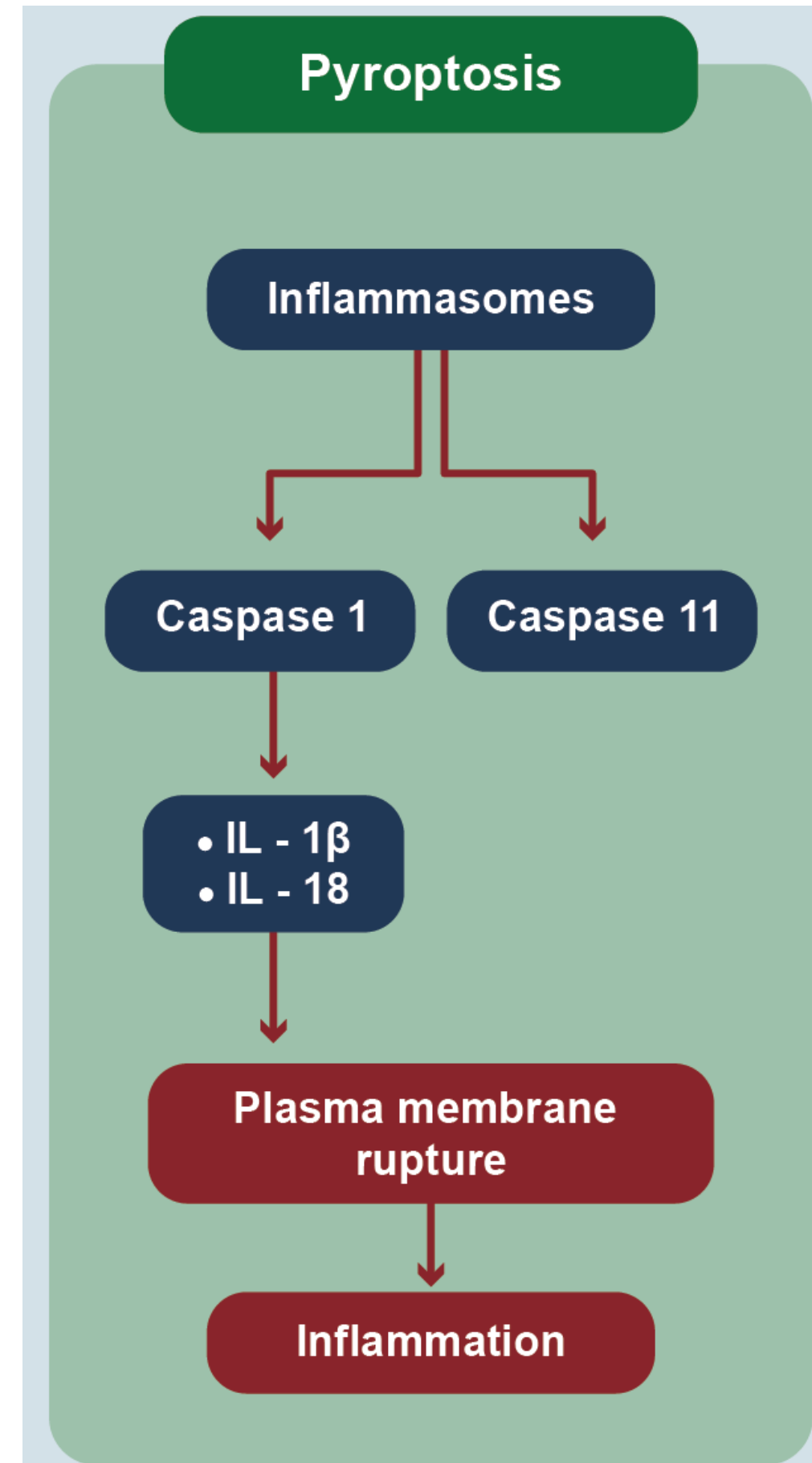
pyroptosis

- Pyroptosis is a type of programmed necrotic cell death that is activated upon intracellular infections from bacteria, viruses, fungi, and protozoa in the presence of pathogen-associated molecular patterns (PAMPs) or cell-derived damage-associated molecular patterns (DAMPs).

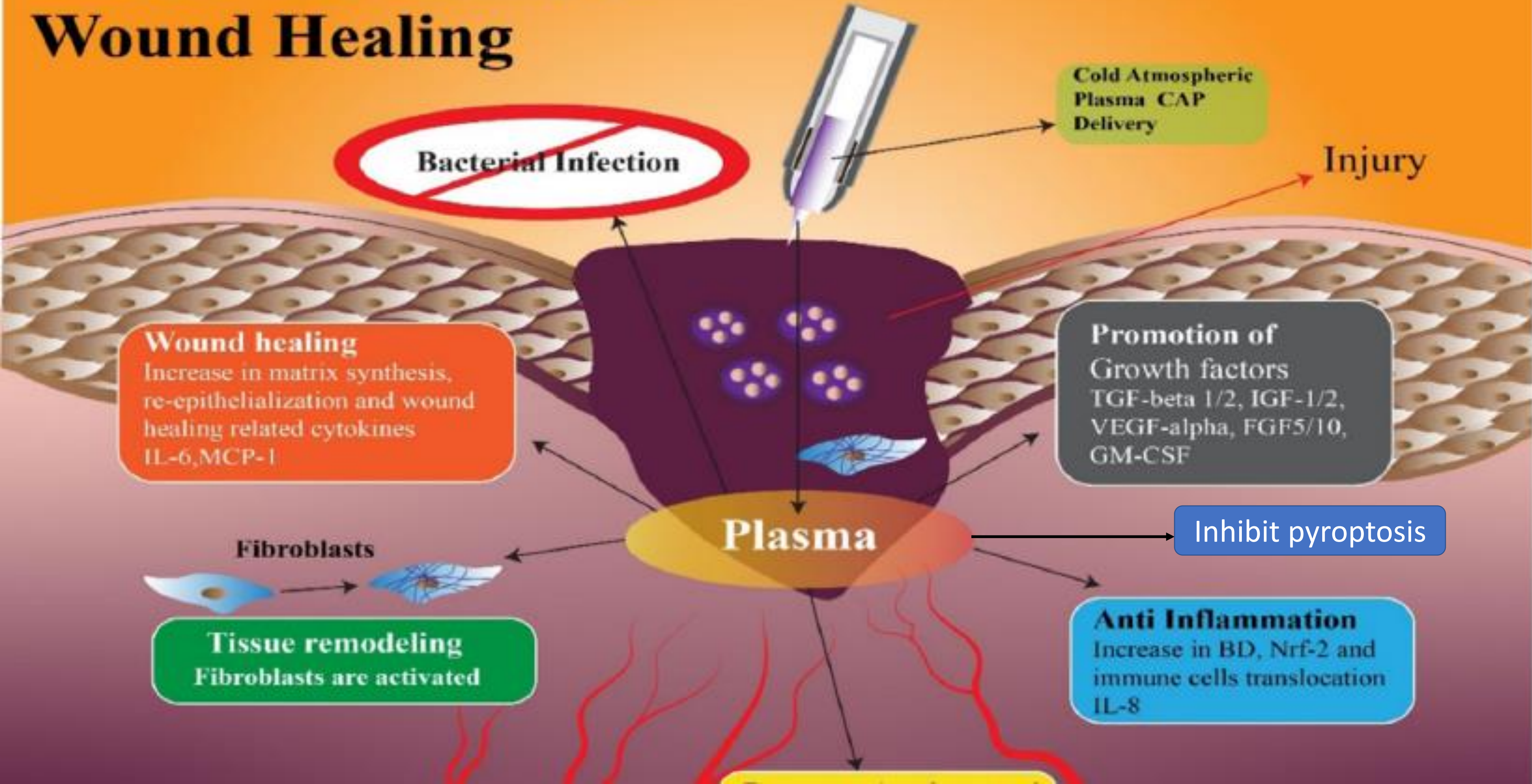


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Effects of Plasma on Wound Healing



SUMMARY

CAP is new tool in medical field that used in wound healing and approved its ability to improve wound process by

- 1. Prevent prolong inflammatory phase**
- 2. Inhibit pyroptosis**
- 3. Promote angiogenesis**
- 4. Promote remodelling**



MEET THE TEAM



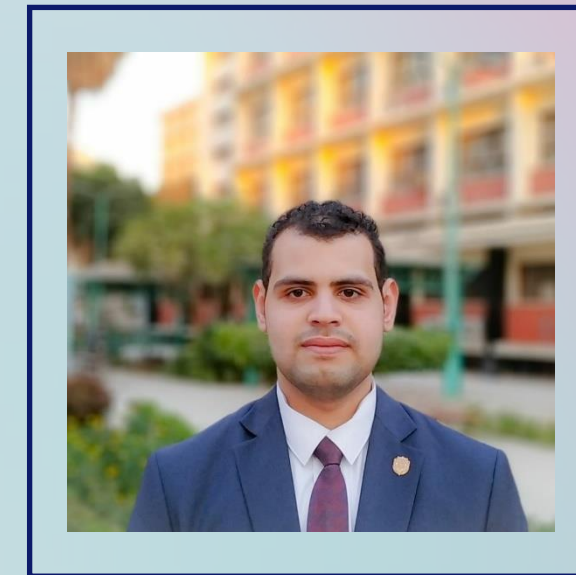
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Plasm lab director



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THANK YOU

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