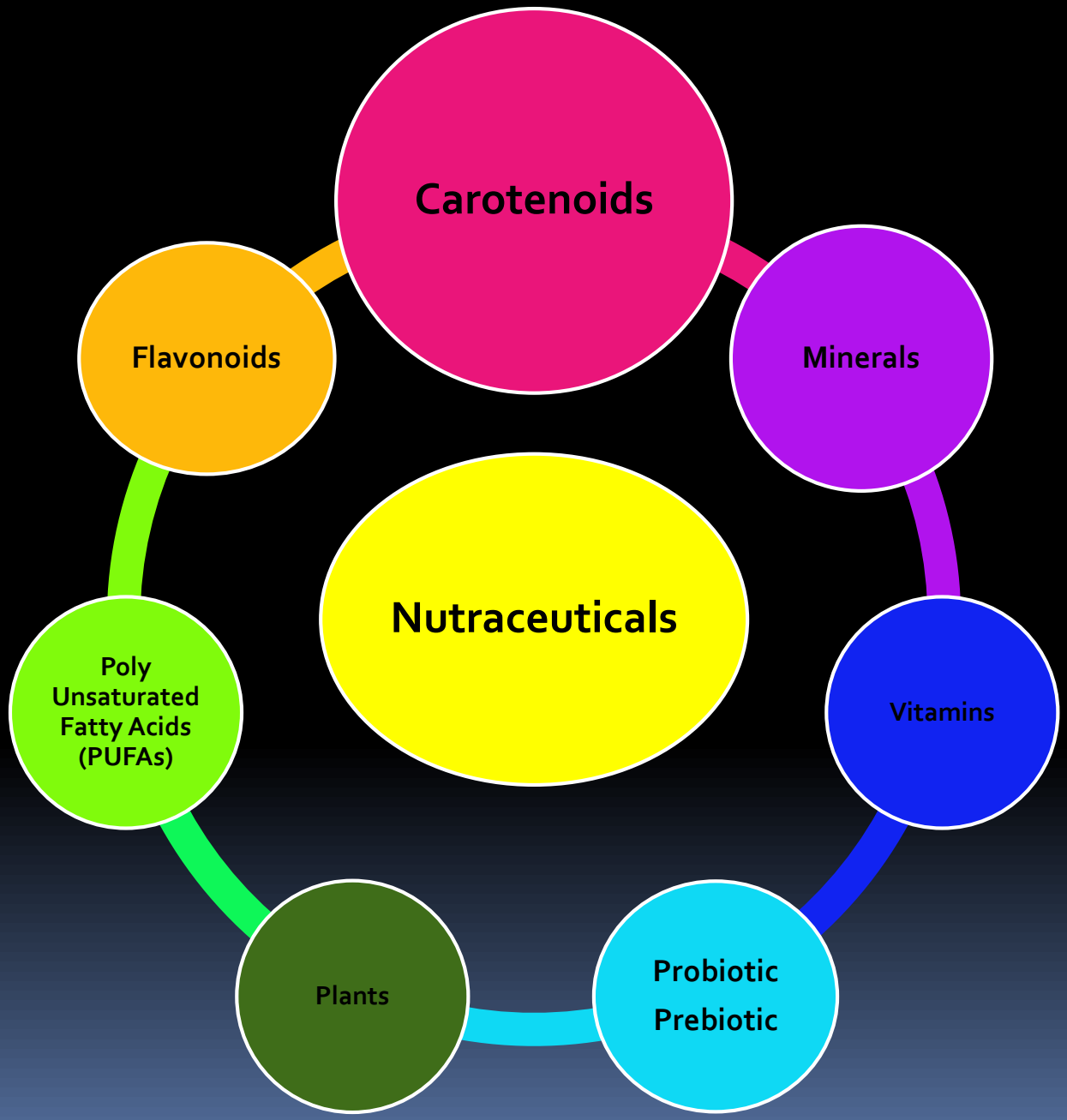

Carotenoids
Flavonoids
Minerals
Nutraceuticals
Poly Unsaturated Fatty Acids (PUFAs)
Vitamins
Plants
Probiotic
Prebiotic

Carotenoids

- Carotenoids are oil-soluble tetraterpenoid derived organic pigments which are produced by plants, algae, fungi, as well as some yeast and molds that are non-photosynthetic.
- These compounds give the color of many fruits and flowers ranging from yellow to red.

- Carotenoids are composed of 8 isoprene units.
- Carotenoids contain long polyene chain with 3-15 conjugated double bonds on their structure.
- The long chain generally ends whether with a ring structure or with a –OH containing group.
- They naturally occur as *trans*- form but they transform to *cis*- isomers after some processes.

Classification

- Carotenoids are classified to two general groups according to their chemical structure:

1. Carotenes → Carotenoids, consist of only carbon and hydrogen atoms, no oxygen atom. For example; *α*-carotene, *β*-carotene, licopene, etc.
2. Xantophylls → Carotenoids which consist of at least one or more oxygen atom together with carbon and hydrogen atoms. For example; lutein, zeaxanthin, canthaxanthin, astaxanthin etc.

- Carotenoids are characterized by 35-40 C units consist of polyene chain, generally ending with ring structures. Their main biochemical properties rely on the conjugated double bonds they contain which is also responsible from the color of them. More double bonds carotenoid hold, more electrons find place to change their positions in the conjugated systems.

- This condition causes the absorbed light to be in low energy levels. This explains why carotenoids are mostly in red colour.

- The name of the carotenoids are usually associated with the source they are isolated.
- Ex.: *β*-carotene - *Daucus carota*

Usage and Biological Activities:

- Commercially used as food dye
- High antioxidant activity
- Provitamin A activity and protective effect on the health of the eye
- Anticarcinogenic
- Skin protective
- Effective on cardiovascular system

Plants Containing Carotenoid

- *Allium cepa,*
- *Beta vulgaris,*
- *Chenopodium album,*
- *Daucus carota,*
- *Mentha spicata,*
- *Solanum nigrum,*
- *Piper betle,*
- *Brassica oleracea*

- *Lycopersicon esculentum,*
- *Rumex acetosella,*
- *Lactuca sativa,*
- *Hibiscus cannabinus,*
- *Tribulus terrestris,*
- *Citrullus lanatus,*
- *Nasturtium officinale,*
- *Eruca sativa,*
- *Capsicum annuum,*
- *Cichorium intybus*
- *Prunus armeniaca*

- Homogenization, heat (Moderate), addition of oil increase bioavailability of carotenoids.
- Processes such as boiling cause isomerization or oxidation.
- Cooking, cutting and mashing vegetables increases the bioavailability of carotenoids as these procedures break down tissues in the vegetables.

β-Carotene

- Vitamin A precursor
- Also known as Provitamin A
- Found in plants, not in animal sources
- Does not cause serious toxic effects and accumulation at high doses.

- Carrot is the richest source
- Vegetables such as parsley, sweet potato, chicory, red pepper, pumpkin, curly cabbage, spinach, lettuce and chard
- Fruits such as mango and apricot

- Cancer
- Heart diseases
- Macular degeneration
- Anti-aging
- Mechanism of action: Antioxidant effect

Toxicity

- When over-consumed, it can cause toxicity known as carotenemia, which is characterized by yellow-orange discoloration of the skin. It is rarely seen and high-dose consumption of carotenoids is required for the symptom.
- No acute toxicity
- Chronic toxicity has not been reported

Lycopene

- It is an open straight chain hydrocarbon compound with noncyclic structure and contains 13 double bonds. It has 11 conjugated double bonds and 2 unconjugated double bonds.

- Lycopene is the most common carotenoid in tomatoe and constitutes 80-90% of the pigments found in tomatoe.

- *Lycopersicum esculentum*

- Lycopene content is variable due to the specific variety and ripening stage of the tomatoes.

- For example; the amount of lycopene in raw green and pinky tomatoes is 10 and 370 µg/100g respectively, while hard red one varieties contain (reddish up to 90%) 4600 µg/100g and it contains 7050 µg/100g in its over-ripe stage.

- The other sources of lycopene → watermelon, rosehip, pink guava, papaya, pink grapefruit, carrot, pumpkin.

- Lycopene in processed tomato products has been shown to have higher bioavailability than in raw tomatoes. This is due to the fact that lycopene in *trans* form in raw tomatoes is converted to *cis* form during cooking or similar processes.

- Amount of lycopene in fruit, vegetable and tomato products:

Product	Lycopene (mg/100 g)	Lycopene (mg/serving)	Serving size
Spaghetti sauce	18,6	23,3	1/2 cup (125 g)
Tomato Juice	9,0	22,0	1 cup (243 g)
Tomato Soup (Condensed)	10,9	13,7	1 cup (245 g prepared)
Watermelon	4,5	13,0	1 wedge (ap prox 1/16 of melon)
Tomato Paste	28,8	9,2	2 tablespoons (32 g)
Guava	5,2	8,6	1 cup (165 g)
Canned Tomatoes	2,7	6,5	1 cup (240 g)
Tomato powder	46,3	4,6	10 g
Raw tomatoes (red)	2,6	3,2	1 medium (123 g)
Tomato Ketchup	16,7	2,5	1 tablespoon (15g)
Pink Grapefruit	1,4	1,7	1/2 fruit (123 g)

Source: USDA National Nutrient Database for Standard Reference, Release 18 (2005)

Lycopene Content of Selected Foods

Food	Serving	Lycopene (micrograms)
Tomato Paste, Canned	1 cup	75,362
Tomato Puree, Canned	1 cup	54,385
Marinara Sauce	1 cup	39,975
Tomato Soup, Canned	1 cup	25,615
Vegetable Soup, Canned	1 cup	23,337
Tomato Juice, Canned	1 cup	21,960
Watermelon, Raw	1 wedge	12,962
Tomatoes, Raw	1 cup	4,631
Ketchup	1 tablespoon	2,551
Pink Grapefruit, Raw	1/2 grapefruit	1,745
Baked beans, Canned	1 cup	1,298
Sweet red pepper, Raw	1 cup	459

- Reduces the risk of cancer (Digestive system, pancreas, bladder, lung and especially prostate cancer)
- It minimizes the tumors in prostate cancer cases.
- It is due to its antioxidant effect.
- Also useful in other diseases related with oxidative stress.
- It has the highest antioxidant effect among all carotenoids.

- Anti-atherogenic activity.
- Protects LDL against oxidation.
- Lycopene inhibits HMG-CoA (Hydroxymethyl glutaryl coenzyme A) reductase activiy involved in cholesterol biosynthesis and regulates LDL receptor activity, thereby reducing LDL.

- Lycopene accumulates in fatty tissues.
- When the amount of lycopene increases in the skin, it protects the skin against sunlight (a protective effect against ultraviolet lights).

- Lycopene reduces the amount of free oxygen radicals, thereby reducing lipid peroxidation and preserving the integrity of the spermatozoal cell membrane. Due to its lipophilic structure, it is frequently found in cell membrane structure and can protect the cells from oxidative stress damage when it is in sufficient amounts.
- Lycopene reduces membrane lipid peroxidation due to its antioxidant effect, thus preserving membrane fluency, which prevents decrease in motility.

- It also activates the antioxidant system by increasing the amount of other antioxidant enzymes in the body indirectly and reduces the transcription of proinflammatory factors.

- Effective on infertility.

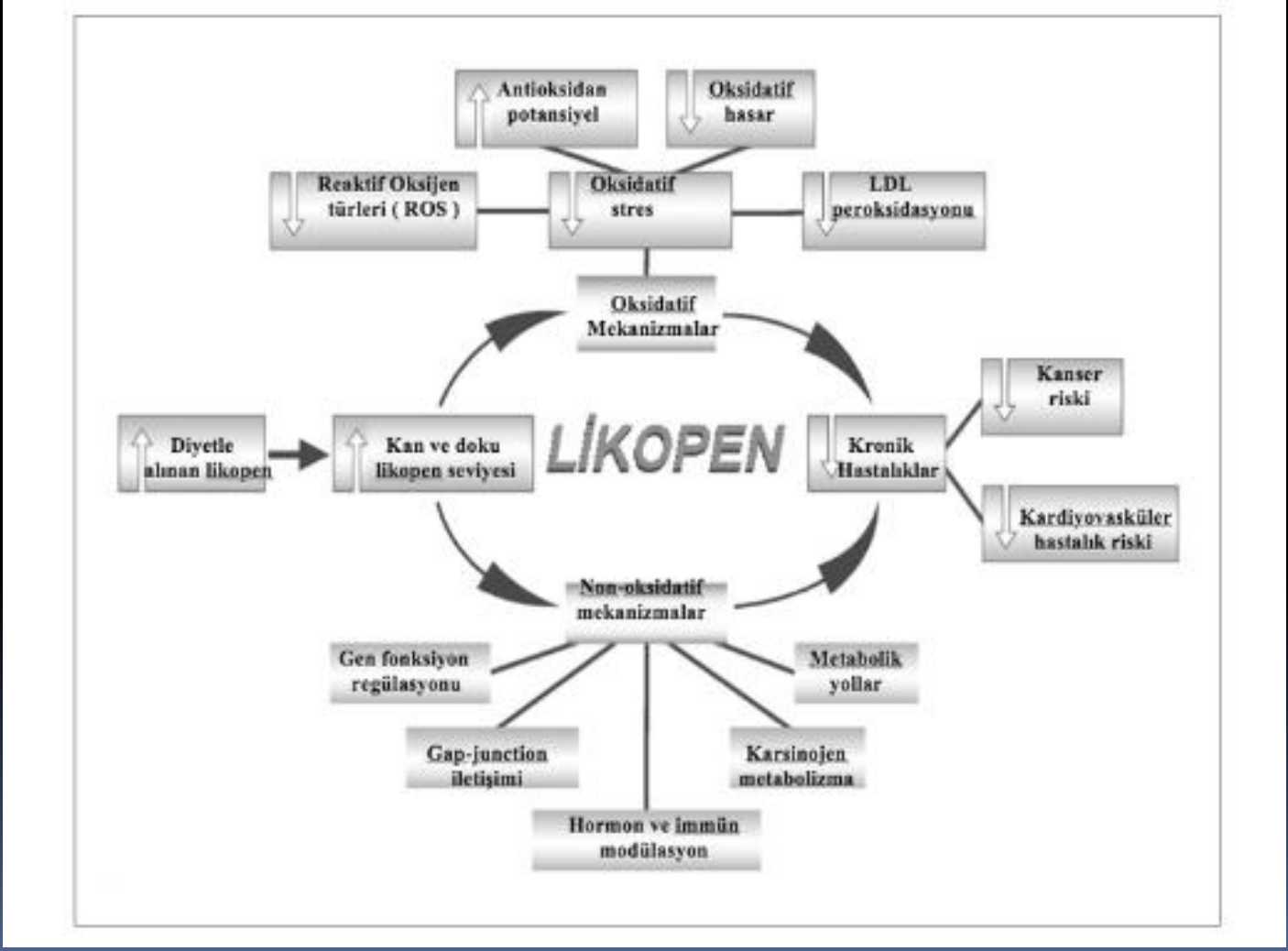
- By inhibiting DNA damage and fragmentation, apoptosis is prevented, resulting in a significant increase in male fertility rates by improving sperm parameters.

- 5-15 day/mg
- In prostate cancer → 75 mg
- LDL level reducing effect → 40 mg
- Contraindicated in patients with lycopene allergy, it may cause allergic reaction
- Should be taken with foods instead of food supplements during pregnancy and lactation.

Interaction:

- May reduce absorbtion of cholestyramine, colestipol, mineral oils, orlistat
- β-carotene; increases lycopene absorbtion.
- Pectin; may reduce lycopene absorbtion
- Oils: may increase lycopene absorbtion

Mechanism of Action for Lycopene



Lutein ve zeaxanthin

- Lutein and its stereoisomer zeaxanthin are members of xanthopyll family.
- Lutein is one of the most common carotenoids found in serum and accumulates in ocular tissue, mostly in the macula lutea and lenses.

- Lutein and zeaxanthin are responsible for the production of yellow pigment in retina (macula lutea). Yellow pigments play an active role in protecting the eye from light and can prevent retinal damage.

- It plays a protective role against macular degeneration and cataract development with aging.
- Provides filtering of phototoxic blue light and near-ultraviolet radiation
- More resistant to decomposition by prooxidants in comparison to other antioxidants

- Lutein is present in single or combined preparations in free form or in ester form of zeaxanthin.
- Daily dose → 6.9-11.7 mg reduces the risk of macular degeneration with age.
- There are commercial preparations at doses of 6-20 mg.

Foods containing lutein

Corn, egg yolk, green vegetables and fruits

Peas, zucchini, cabbage, spinach,
lettuce, kiwi, nettle, seaweeds

Petals of yellow flowers

Lutein dipalmitate/Zeaxanthin

- **Found in *Helenium autumnale* and called as helenien.**
- **Used in the treatment of vision disorders in France.**

- Obtained from Lycium chinense.
- Found in fatty acid form.
- Used in the treatment of vision disorders in China.

Effect: Ophthalmo-protective

- It is used to reduce the risk of macular degeneration and cataract.
- Each egg yolk contains 290 µg lutein and 210 µg zeaxanthin.
- Can be used safely (including pregnant women who don't have cholesterol problems)

Astaxanthin

- A very important carotenoids
- The muscles of salmon in the animal kingdom is the natural source of astaxantin.
- It is found in high amounts in the muscles of salmon fish swimming against the stream.
- Exercise causes oxidation in muscles, so people who exercise excessively need antioxidant agents.

Astaxanthin

- The –OH groups found in astaxanthin make this molecule superior to the other carotenoids (lutein, xeaksanthin, lycopene).
- That's why astaxanthin:
- Crossing the blood-brain barrier; It protects brain and central nervous system with antioxidant and anti-inflammatory mechanism of action.
- It crosses the blood-retinal barrier and makes the same effects in the eye and protects eye health.

Astaxanthin

- It acts with this mechanism in all organs and skin.
- Reduces the permeability of the cell membrane.
- Repairs muscle tissue.
- Scavenges free radicals due to its strong antioxidant effect.

Astaxanthin

- Arthritis
- Tendonitis
- Athlete's foot
- Joint pain
- Strains
- Post-operative knee joints
- Parkinson's disease

- Carotenoids are produced naturally by planktons, algae, plants and some microorganisms.
- Carotenoids in plants and algae are part of photosynthesis (chlorophyll).
- When carotenoids are eaten by animals, they are metabolized in the organism and transformed into different carotenoids.

- Flamingos
- When they eat zeaxanthin (yellow carotenoids) and beta-carotene (orange carotenoids) containing algae, these molecules turn into pink-red coloured astaxanthin and canthaxanthin in the flamingos' body.