

L3

Neuropsychiatry
Block



Vitamin A & Visual Cycle



Editing File

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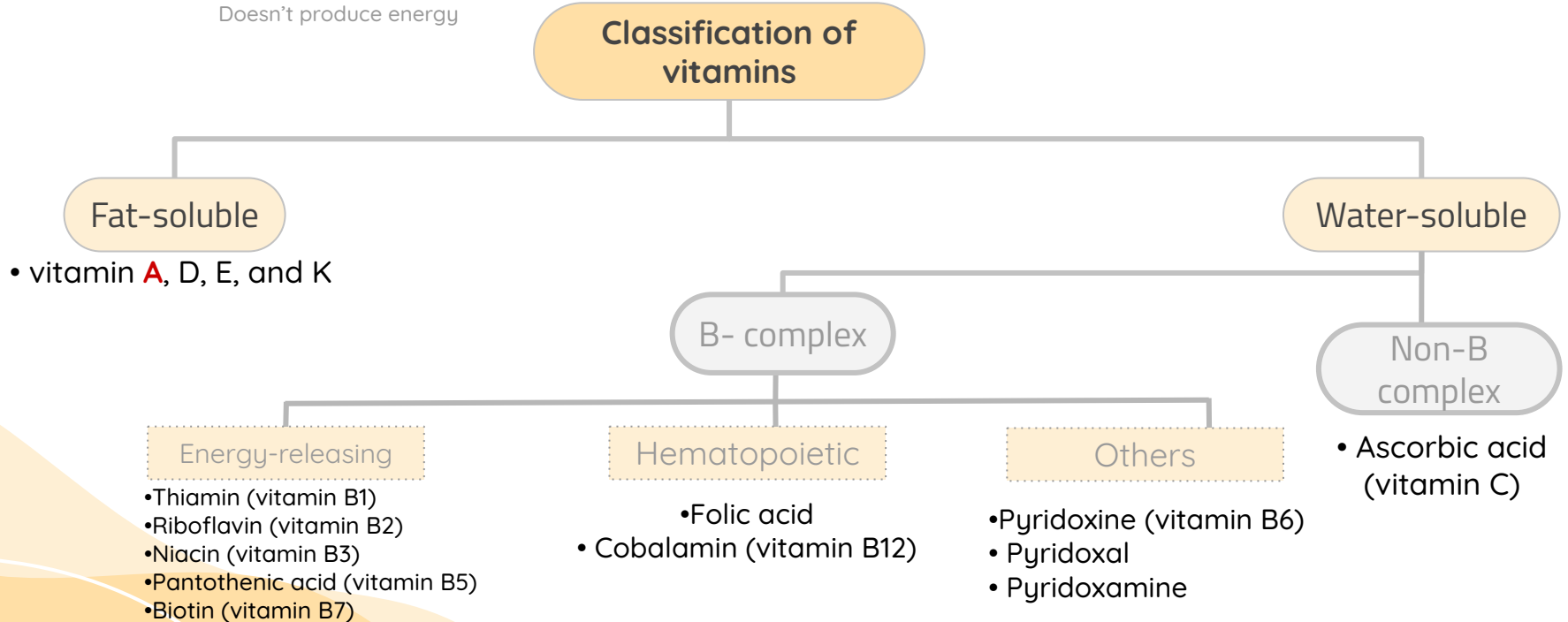
Objectives

- 1 Identify the types of vitamin A and their functions
- 2 Discuss the transport and metabolism of vitamin A
- 3 Comprehend the role of vitamin A in visual cycle
- 4 Correlate the deficiency of vitamin A with vision impairment and blindness

Vitamins

- Organic compounds present in small quantities in different types of food.
- Help in various biochemical processes in cell.
- Most act as coenzymes.
- Important for growth and maintaining good health
- Essential, Non-caloric and Required in very small amounts.

Doesn't produce energy



Important!

It might come as SAQ or MCQ. Focus on the first two points.

Fat soluble vitamins (AKED)

Fat soluble vitamins:

Stored in the **liver and adipose tissue**.

Excess may accumulate and cause **toxicity**.

Cases of toxicity with vitamin A and D have been reported.

Do not need to be consumed each day due to storage in the body.

Absorbed slowly with fats.

Diseases due to deficiency are rare as large amounts are stored in the body.

Toxicity happens when there is malabsorption of these vitamins. E.g. problem in pancreatic enzymes or bile in gallbladder.

Vitamin A

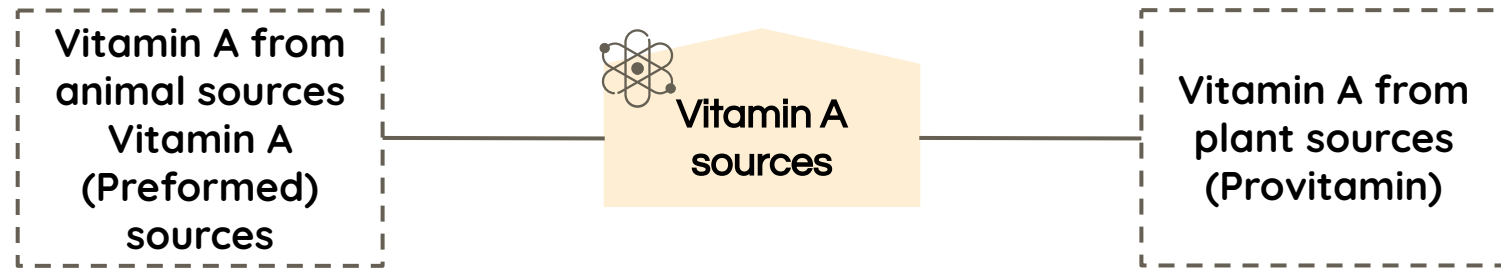
1 Essential role in vision and normal cell differentiation.

2 Large doses over a prolonged period of time can produce intoxication and eventually lead to **liver disease**.

3 Deficiency is the most significant cause of **night blindness** in the developing world.

4 Excessive carotenoids intake can result in yellowing of the skin, but appears to be harmless.

Large and prolonged doses of vitamin A can lead to?



You should know both names for each.
-Animal (Preformed)
-Plant (Provitamin)

Important!
It might come as MCQ

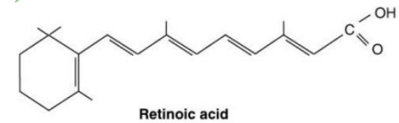
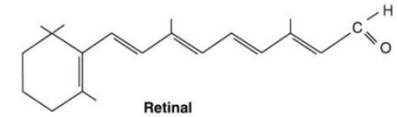
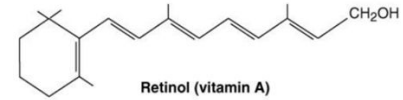
Vitamin A

Vitamin A from animal sources (Preformed):

Three preformed compounds called **retinoids** that are metabolically active.

and found in animal products: E.g live, kidney & eggs.

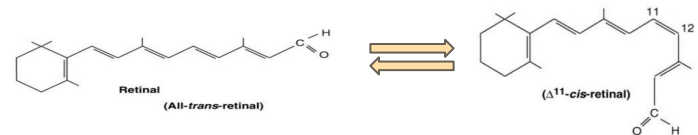
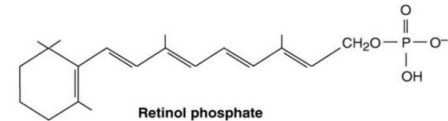
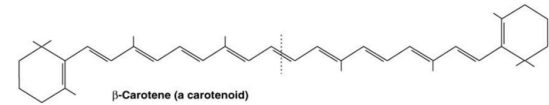
- **Retinol**: alcohol form (can be converted to other forms)
 - **Retinal** (Retinaldehyde): aldehyde form (essential in vision)
 - **Retinoic acid**: acid form (for skin and bone growth)
- Which one of the retinoids is essential for vision?
- Final form, cannot be converted



Vitamin A from plant sources (Provitamin):

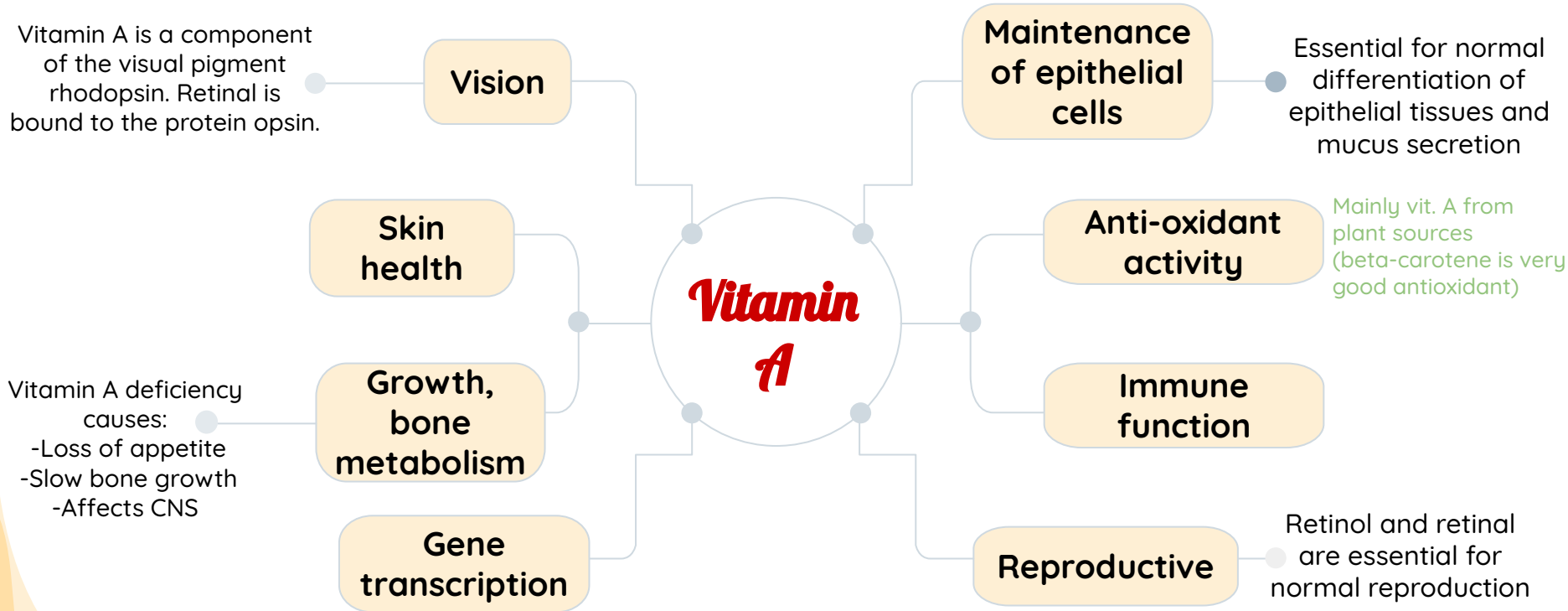
Carotenoids (β -carotene) & cryptoxanthin:

- Can yield retinoids when metabolized in the body
- These are from plant sources
- One molecule of β -carotene can be cleaved into two molecules of **retinal in the intestine.**



Important!
It might come as SAQ.

Functions of Vitamin A



Vitamin A Metabolic Pathway

Important!

- Vit A from Intestine to liver in blood (Retinyl ester form in chylomicrons)
- Vit A from liver to tissue (Retinol-RBP)
- Storage form in liver (Retinyl palmitate)

Dr.khalid:you should know all the pathway in this slide because it's important.

1 Dietary sources of vitamin A:

Retinyl esters and retinol are found in certain animal tissues.
3-Carotenes (and other carotenoids) are found in certain plants.

2 Transport of vitamin A:

Dietary retinol is transported as retinyl esters in chylomicrons. Retinol is secreted by liver in association with plasma retinol-binding proteins.

3 Storage of vitamin A:

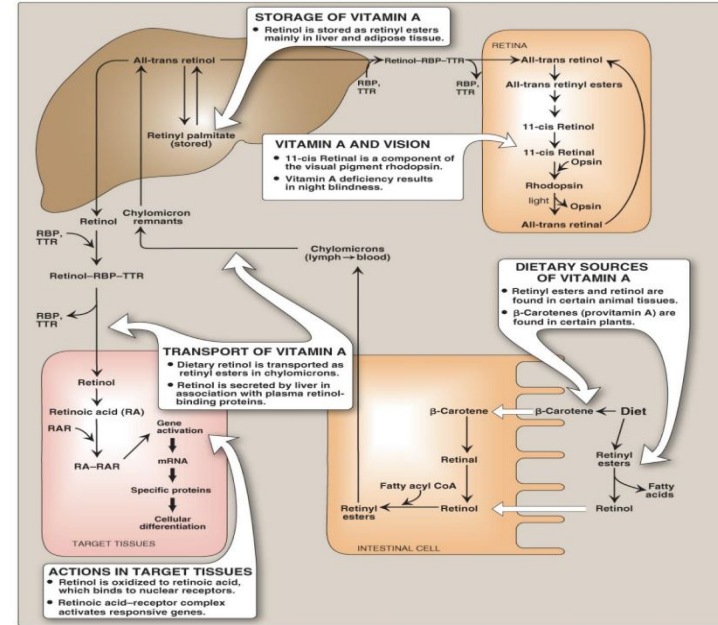
Retinol is stored as retinyl esters mainly in liver and adipose tissue.

4 Vitamin A and vision:

11-cis Retinal is a component of the visual pigment, rhodopsin.
Vitamin A deficiency results in night blindness.

5 Actions in target tissues:

Retinol is oxidized to retinoic acid, which binds to nuclear receptors.
Retinoic acid-receptor complex activates responsive genes.



steps:

1-Vitamin A is absorbed from the diet

(B-carotene from plants or retinyl esters from animals)

2-removal of fatty acids from retinyl esters will convert it to retinol

3-this retinol molecule with the B-carotene from the plant source are

Absorbed through intestinal cells

4-B-carotene is broken down to retinal and then retinal is converted to retinol

5-retinol is esterified again to retinyl esters which will be carried out by chylomicrons (imp note)

6-to liver where we remove the fatty acid and add palmitate to retinol which will form retinyl palmitate

7-retinyl palmitate is the stored form of vitamin A in the liver (imp note)

8-if retinol is needed anywhere in the body, first we remove palmitate

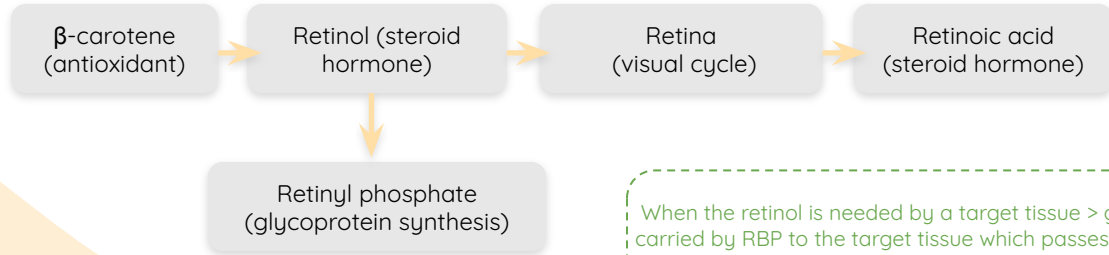
from retinyl palmitate to form retinol then retinol is carried with retinol

binding protein (imp note)

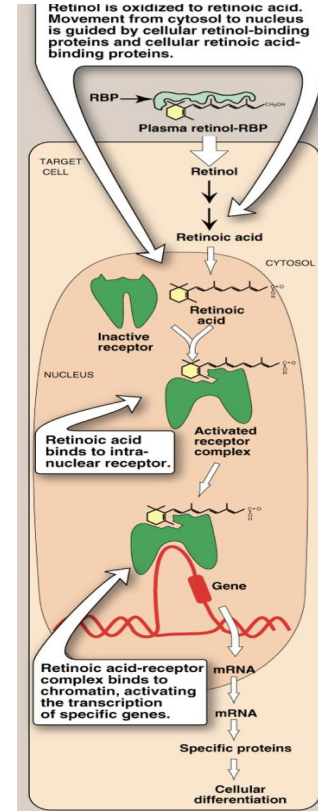
Vitamin A Metabolic Pathway

- 1 Retinol is oxidized to retinoic acid. Movement from cytosol to nucleus is guided by cellular retinol-binding proteins and cellular retinoic acid-binding proteins.
- 2 Retinoic acid binds to intranuclear receptor.
- 3 **Retinoic acid-receptor complex binds to chromatin, activating the transcription of specific genes.**

Important!



When the retinol is needed by a target tissue > get carried by RBP to the target tissue which passes through the membrane into the cytoplasm of the cell then to nucleus > binds to activated receptor complex to activate gene transcription > play a role with RNA for cellular differentiation



Role of Vitamin A in Vision

Visual cycle:

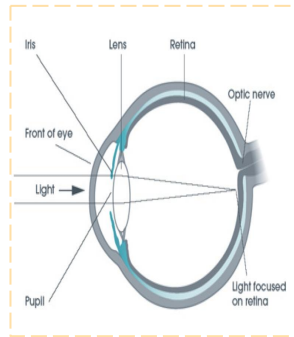
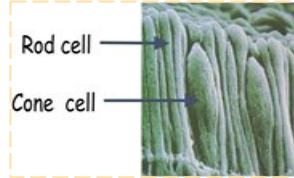
A process by which light impacting on the retina of the eye is converted to an electrical signal.

The optic nerve carries the electrical signal to the brain (nerve impulse).

The brain processes the signal into an image.

Retina is a light-sensitive layer of cells at the back of the eye where an image is formed.

Retina consists of: **Rod (black & white image)** and **cone (color image)** cells (photosensitive cells).



Normal vision depends on:

- **Retina**
- **Adequate vitamin A**

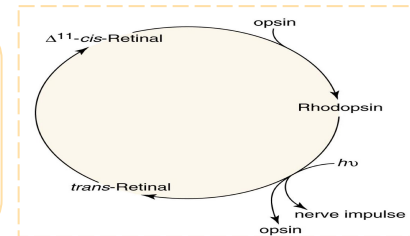
First discovered by George Wald in 1967 (a Nobel Laureate)

In the retina, vitamin A in the form of retinal binds to a protein called **opsin** to make **rhodopsin** (in rod cells) and **iodopsin** (in cone cells)

Rhodopsin and iodopsin are **light-sensitive pigments**

Important!

- When stimulated by light vitamin A isomerizes from its bent **cis** form to a straighter **trans** form and detaches from opsin
- The opsin molecule changes shape, which sends a signal to the brain via optic nerve and an image is formed
- Most retinal released in this process is quickly converted to **trans-retinol** and then to **cis-retinal**, to begin another cycle



Dark Adaptation Time

Important!
It might come as SAQ
or MCQ



Bright light depletes rhodopsin (**photobleaching**)



Sudden shift from bright light to darkness causes difficulty in seeing



Rhodopsin is synthesized (**resynthesized**) in a few minutes and vision is improved in the dark

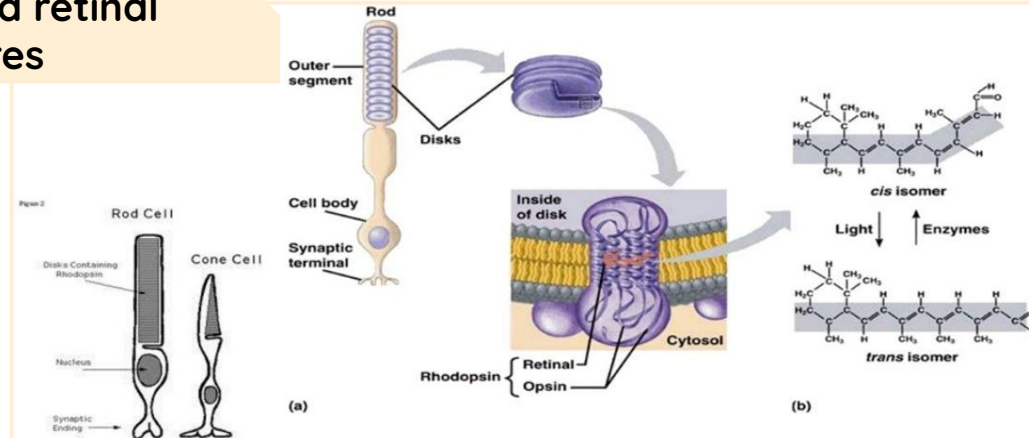


The time required to synthesize (**resynthesize**) rhodopsin in the dark is called **dark adaptation time**



Dark adaptation time is **increased** in vitamin A deficiency (**important**)

Rhodopsin and retinal structures



Cis isomer of rhodopsin "once it receives light, it will be converted into trans isomer"

Vitamin A Deficiency and Disease

Important!
It might come as SAQ
or MCQ

Nyctalopia (Night blindness)

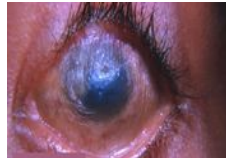
patient cannot see in low light or near darkness conditions



In nyctalopia the effect is more prominent shortly before sunrise and shortly after sunset.

Xerophthalmia

dryness of the conjunctiva and cornea



Deficiency of vitamin A alters the cell differentiation. keratinocytes would also be affected and formed in an abnormal forms "become larger in size" and they deposit in Tears "lacrima" gland causing blockage in secretion of tears → "xerophthalmia", or they may deposit in conjunctiva causing → Bitot's spots.

Bitot's spots*

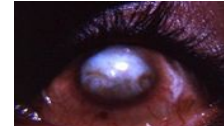
localized increased thickness of the conjunctiva



*Vitamin A deficiency leads to excess production of carotene and it will start depositing in different tissues

Keratomalacia

prolonged xerophthalmia leads to drying and clouding of cornea



Complete blindness (in severe deficiency)



Complete blindness caused by deficiency in vitamin A can be reversed by high doses of vitamin A, assuming there is no damage in the eye itself.

Recommended Dietary Allowance (RDA) Vitamin A for Adults

- Women: **700** µg or **2,330** IU
- Men: **900** µg or **3,000** IU
- UL Men or Women: **3,000** µg or **10,000** IU
(don't memorize the numbers)

Take Home Messages



Vitamin A plays a major role in visual cycle and color vision.



Its deficiency can lead to vision impairment and blindness.



Summary!



Q1: Which of the following is a fat-soluble vitamin?

A	Vitamin B2	B	Vitamin C	C	Vitamin D	D	Biotin
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Q2: Which of following is NOT function of Vitamin A?

A	Gene transcription	B	Antioxidant	C	Synthesis of the blood clotting protein	D	Maintenance of epithelial cells
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Q3: Large and prolonged doses of vitamin A can lead to?

A	Heart disease	B	Liver disease	C	Kidney disease	D	Pancreas failure
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Q4: dryness of the conjunctiva and cornea lead to?

A	Keratomalacia	B	Xerophthalmia	C	Bitot's spots	D	Nyctalopia
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Q5: What's the name of the process when bright light depletes Rhodopsin ?

A	Dark adaptation	B	Photobleaching	C	Isomerization	D	Nyctalopia
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Q6: Mention 3 functions of vitamin A?

Answer:
Slide
7

- Vision
- Skin health
- Growth
ect.....

Q7: What diseases are caused by Vitamin A deficiency?

Answer:
Slide
12

- Night blindness
- Xerophthalmia
- Bitot's spots
ect...

Q8: What is the role of Vit A in visual cycle?

Answer:
Slide
10

- Process by which light impacting on the retina of the eye is converted to an electrical signal
- The optic nerve carries the electrical signal to the brain (nerve impulse)
- The brain processes the signal into an image

