

## Thyroid Hormone Actions which Increase Oxygen Consumption

- Increase mitochondrial size, number and key enzymes
- Increase plasma membrane Na-K ATPase activity
- Increase futile thermogenic energy cycles
- Decrease superoxide dismutase activity

## **Stimulation of Carbohydrate Metabolism by Thyroid hormone**

- Stimulates all of carbohydrate metabolism:
- including rapid uptake of glucose by the cells,
- increased glycolysis,
- increased gluconeogenesis,
- increased rate of absorption from the gastrointestinal tract,
- increased insulin secretion with its resultant secondary effects on carbohydrate metabolism.
- All these effects probably result from the overall increase in cellular metabolic enzymes caused by thyroid hormone.

# Stimulation of Fat Metabolism

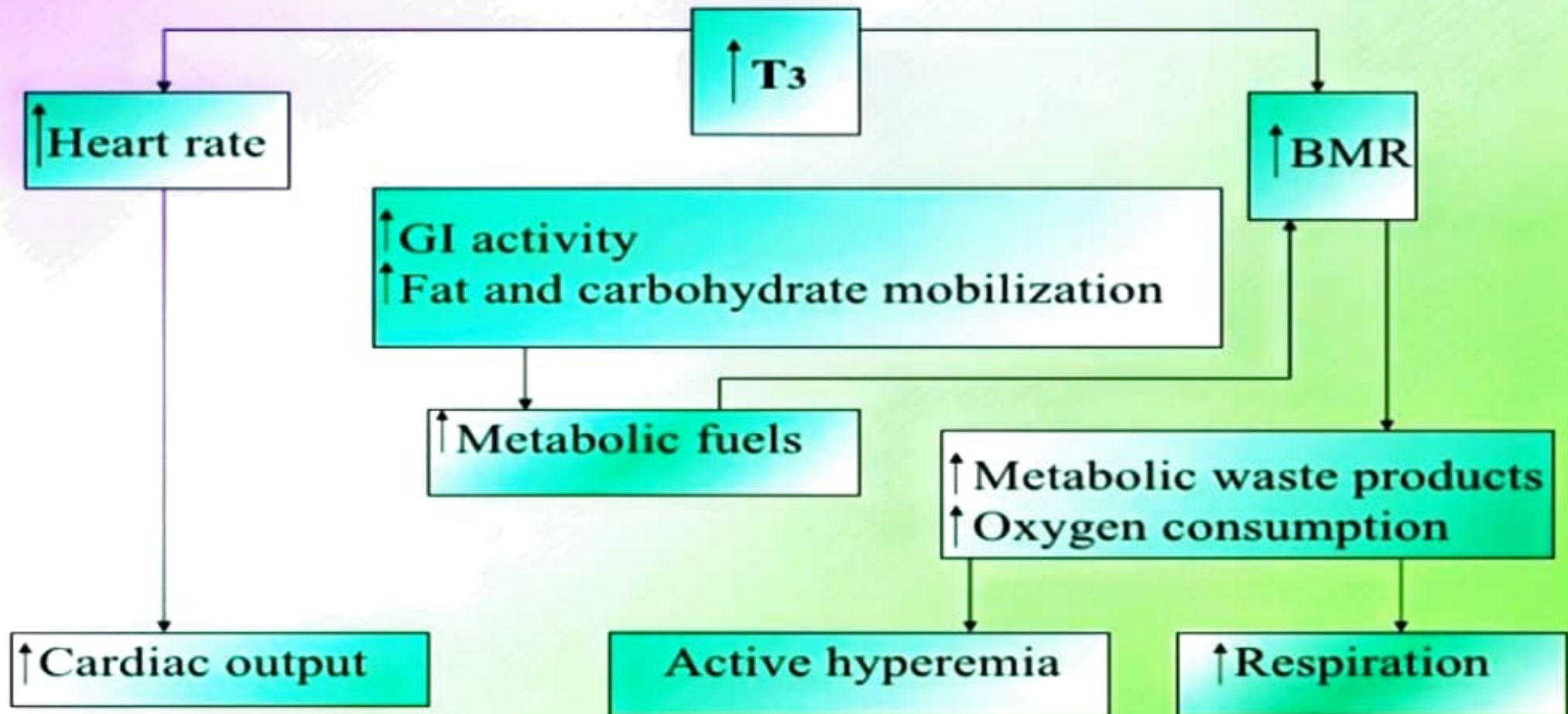
- Lipids are mobilized rapidly from the fat tissue, which decreases the fat stores and increases the free fatty acid levels in the plasma.
- *Increased thyroid hormone decreases the levels of cholesterol, phospholipids, and triglycerides in the plasma, and increases the free fatty acids.*
- *But, decreased thyroid secretion greatly increases the plasma levels of cholesterol, phospholipids, and triglycerides.*
- TH decreases the plasma cholesterol concentration through increase the rate of cholesterol secretion in the bile and consequent loss in the feces.



# Increased Basal Metabolic Rate

- Because thyroid hormone increases metabolism in almost all cells of the body,
- excessive quantities of the hormone can increase the basal metabolic rate
- Conversely, when no thyroid hormone is produced, the basal metabolic rate falls.

## Effects of Thyroid Hormone on Basal Metabolic rate



# Effects of Thyroid Hormones on the Cardiovascular System

- Increased metabolism in the tissues causes more rapid utilization of oxygen than normal and release of greater than normal quantities of metabolic end products from the tissues.
- So, the increased blood flow leads to increased cardiac output and,
- Increase heart rate
- Increase force of cardiac contractions
- Increase stroke volume
- Up-regulate catecholamine receptors

# Effects of Thyroid Hormones on the Respiratory System

- Increase resting respiratory rate
- Increase minute ventilation
- Increase ventilatory response to hypercapnia and hypoxia

# Effects of Thyroid Hormones on the Renal System

- Increase blood flow
- Increase glomerular filtration rate



- **Thyroid hormones affect renal function by both pre-renal and direct renal effects.**
  1. **Pre-renal effects are mediated by the influence of thyroid hormones on the cardiovascular system and the renal blood flow (RBF).**
  2. **The direct renal effects are mediated by the effect of thyroid hormones on glomerular filtration rate (GFR), tubular secretory and re-absorptive processes, as well as the hormonal influences on renal tubular physiology.**
- **Thyroid hormones influence Na reabsorption at the PCT primarily by increasing the activity of the Na/K ATPase and tubular potassium permeability**



# Effects of Thyroid Hormones on Oxygen-Carrying Capacity

- Increase RBC mass
- Increase oxygen dissociation from hemoglobin

# Effects of Thyroid Hormones on Intermediary Metabolism

- Increase glucose absorption from the GI tract
- Increase carbohydrate, lipid and protein turnover
- Down-regulate insulin receptors
- Increase substrate availability

# Effects Thyroid Hormones in Growth and Tissue Development

- Increase growth and maturation of bone
- Increase tooth development and eruption
- Increase growth and maturation of epidermis, hair follicles and nails
- Increase rate and force of skeletal muscle contraction
- Inhibits synthesis and increases degradation of mucopolysaccharides in subcutaneous tissue



# Effects of Thyroid Hormones on the Nervous System

- Enhances wakefulness and alertness
- Enhances memory and learning capacity
- Required for normal emotional tone
- Increase speed and amplitude of peripheral nerve reflexes

# TH in Intrauterin and infantil periods:

- Critical for normal CNS neuronal development:
- Development of cerebral and cerebellar cortex
- Proliferation of axons
- Branching of dendrite
- Synaptogenesis
- Myelinization
- Migration of cells

# Effects of Thyroid Hormones on the Reproductive System

- Required for normal follicular development and ovulation in the female
- Required for the normal maintenance of pregnancy
- Required for normal spermatogenesis in the male



# Factors that Affect Thyroid Function



T4

## Factors that contribute to proper production of thyroid hormones

- Nutrients: iron, iodine, tyrosine, zinc, selenium
- vitamin E, B2, B3, B6, C, D

## Factors that inhibit proper production of thyroid hormones

- Stress
- Infection, trauma, radiation, medications
- Fluoride (antagonist to iodine)
- Toxins: pesticides, mercury, cadmium, lead
- Autoimmune disease: Celiac

## Factors that increase conversion of T4 to RT3

- Stress
- Trauma
- Low-calorie diet
- Inflammation (cytokines, etc.)
- Toxins
- Infections
- Liver/kidney dysfunction
- Certain medications

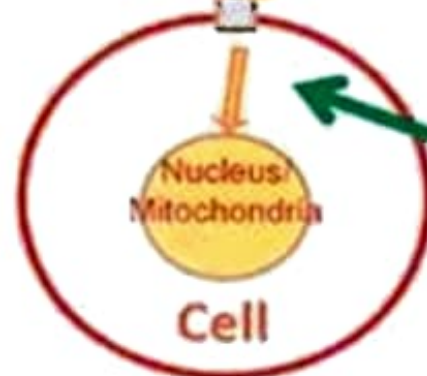
## Factors that increase conversion of T4 to T3

- Selenium
- Zinc

RT3

T3

T3 and RT3 compete for binding sites



## Factors that improve cellular sensitivity to thyroid hormones

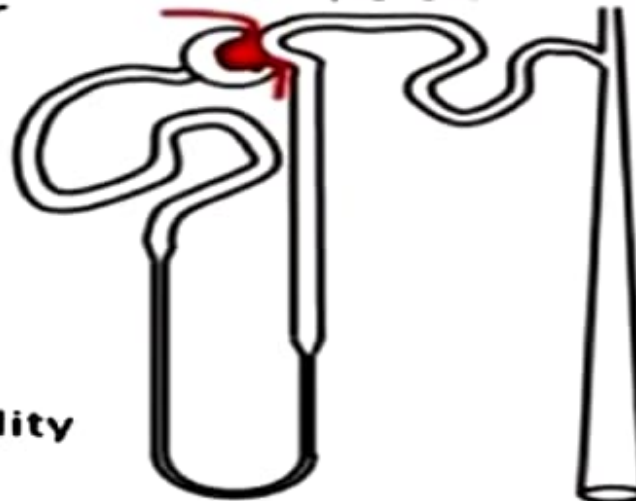
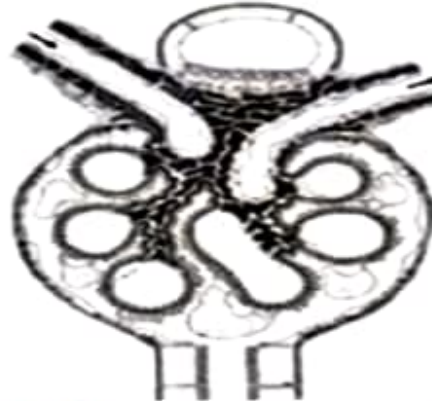
- Vitamin A
- Exercise
- Zinc

## Other Factors Regulating Thyroid Hormone Levels

- Diet: a high carbohydrate diet increases T3 levels, resulting in increased metabolic rate (diet-induced thermogenesis).
- Low carbohydrate diets decrease T3 levels, resulting in decreased metabolic rate.
- **Cold Stress**: increases T3 levels in other animals, but not in humans.

## Hyperthyroidism

- ↑ Heart rate
- ↑ Cardiac contractility
- ↑ Cardiac output
- ↓ Peripheral vascular resistance
- ↑ Renal Blood flow
- ↑  $\beta$ -adrenergic receptors in kidney
- ↑ RAAS activity
- ↑ Filtration pressure
- ↑ Glomerular filtration rate
- ↑ Tubuloglomerular feedback
- ↑ Tubular mass
- ↑ Na/K ATPase
- ↑ NHE activity
- ↓ Urinary concentrating ability



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