A Preschool Nutrition Primer for RDs

Nutrient Deficiencies: Iron and Vitamin D

NutriSTEP®

Nutrition Screening Tool
for Every Preschooler
Évaluation de l'alimentation
des enfants d'âge préscolaire

NUTRITION
RESOURCE
CENTRE

CENTRE DE
RESSOURCES
EN NUTRITION

Learning Objectives

- Know about iron and vitamin D metabolism and their related deficiencies.
- Learn the risk factors and consequences of iron and vitamin D deficiency in children.
- Be aware of the treatments used in both types of deficiencies.
- Understand how to prevent iron and vitamin D deficiency in young children.

Outline

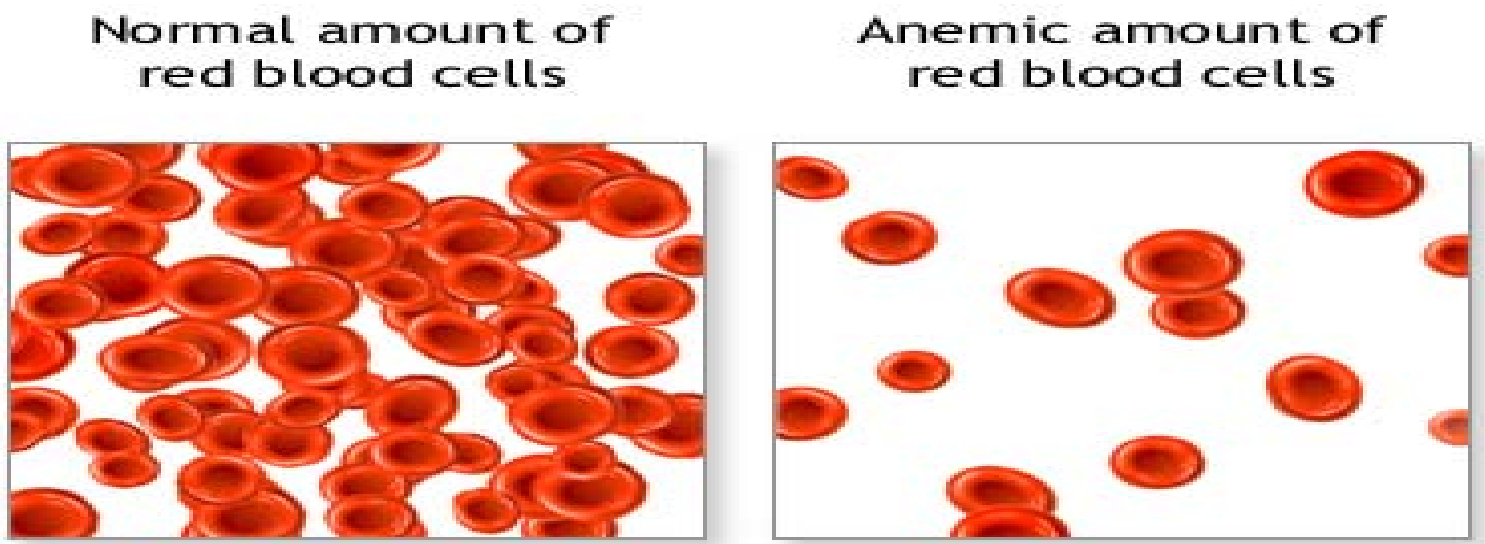
- Iron Deficiency Anemia
  - Role of Iron
  - Iron Balance and Requirements
  - Long Term Consequences
  - Clinical Presentation
  - Stages
  - Incidence and Risk Factors
  - Prevention
  - Treatment

Outline

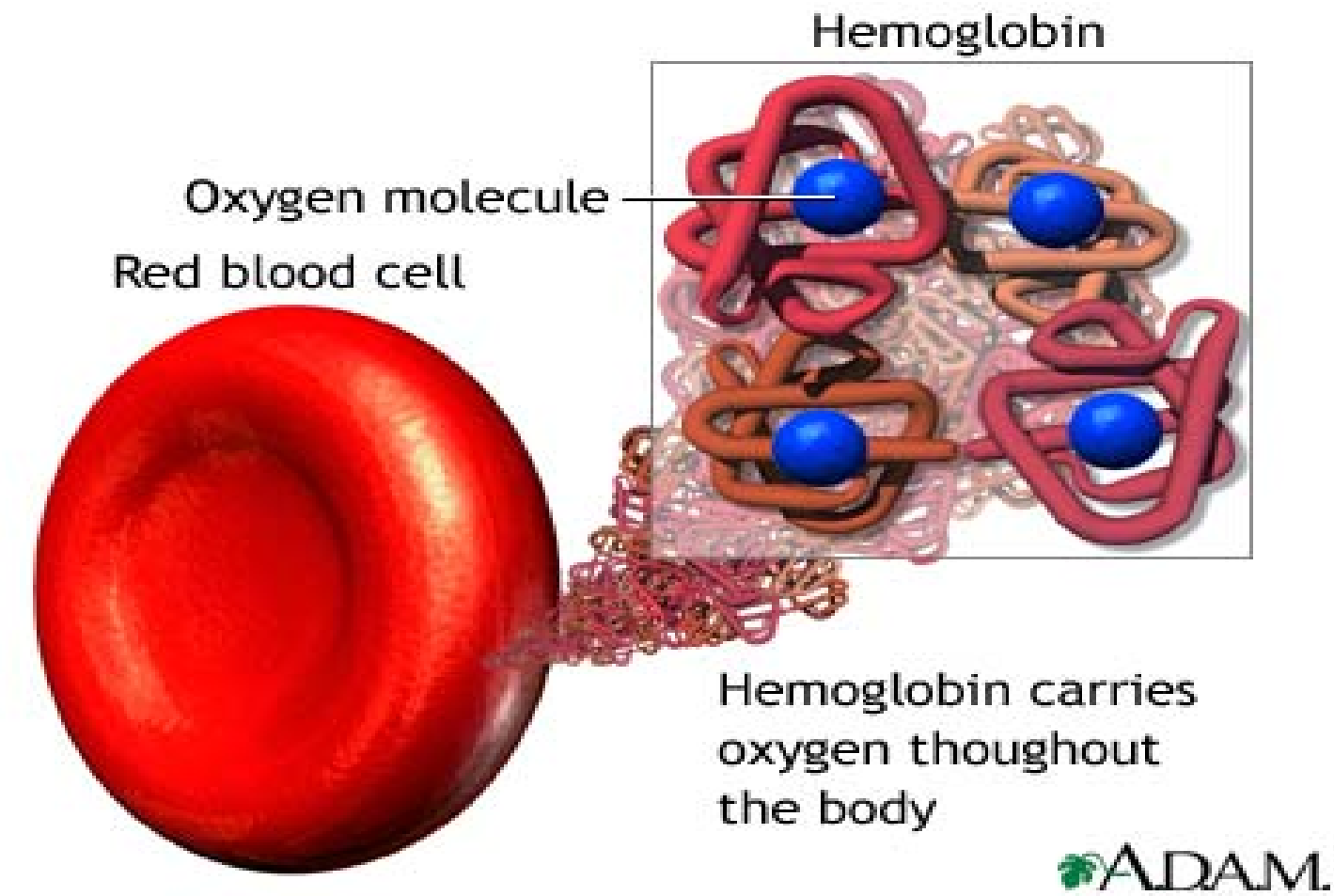
- Vitamin D
  - Functions
  - Sources
  - Physiology
  - Vitamin D deficiency
    - Prevalence
    - Risk factors
  - Osteomalacia/Rickets
- References

Iron Deficiency Anemia (IDA)

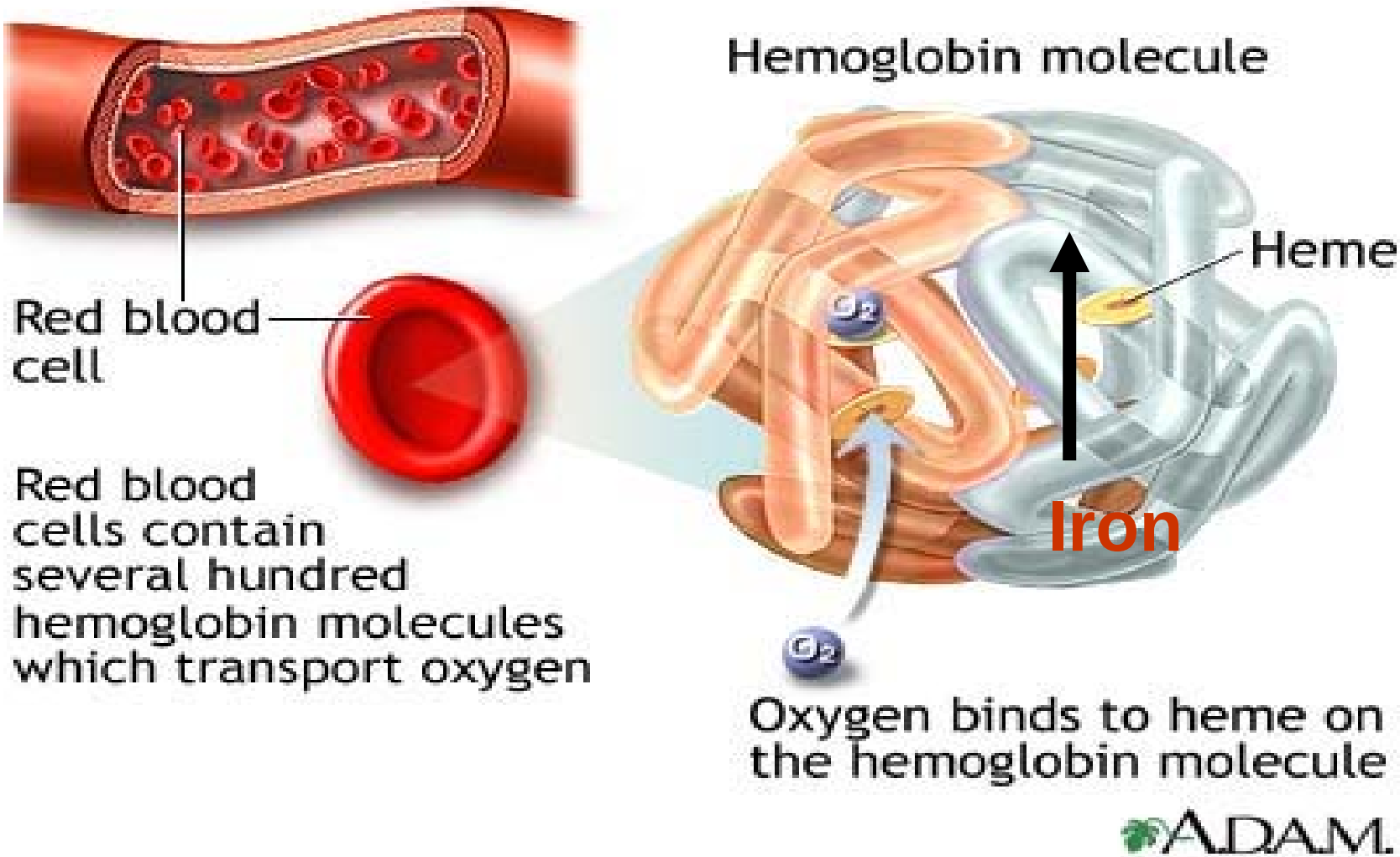
- ↓ erythrocytes (RBC's)
- ↓ hemoglobin (Hb)
- due to iron deficiency



RBC and Hemoglobin



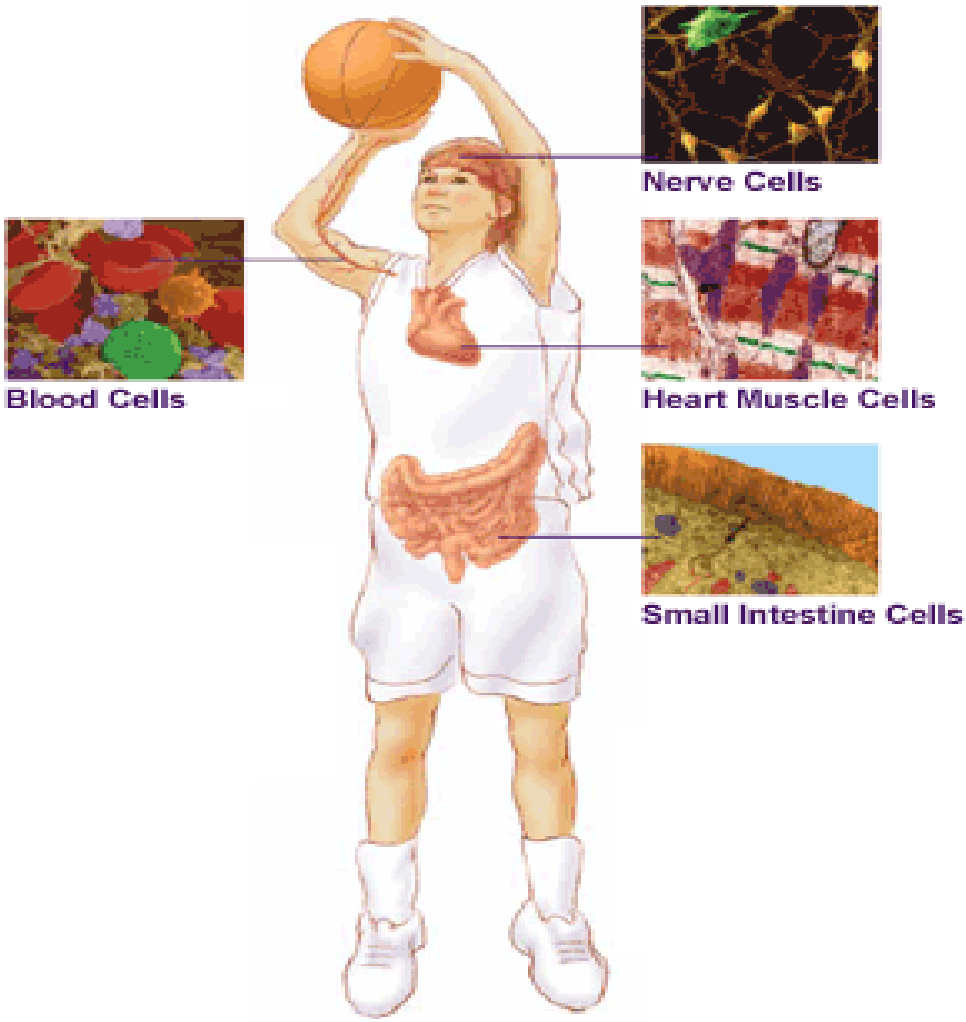
RBC, Hemoglobin & Heme



Role of Iron in IDA

- ***Heme*** is the ***iron*** compound in Hb.
- Iron is essential in the formation of Hb.
- Iron deficiency can lead to ↓ Hb.
- Heme in Hb transports oxygen from the lungs to body tissues via the blood.

Transports Oxygen to Tissues



Iron Balance

- Absorption
  - body iron stores.
  - form and amount of iron in foods.
  - combination of foods in the diet.
- Excretion
  - by loss through intestinal mucosa.
  - iron deficiency decreases excretion.
  - iron overload increases excretion.

Iron Absorption

- Two dietary sources: Heme and Non-heme
- Heme iron
  - mainly from meat, well absorbed.
  - 10% of iron in the average diet (less for infants).
  - diet has little influence on its absorption.
- Non-heme iron
  - iron salts.
  - majority of infant's diet.
  - absorption influenced by diet (enhancers: meat, citric acid, ascorbic acid; inhibitors: phosphates (cow's milk, egg yolk), bran, oxalates (spinach) and polyphenols (tannate in tea).

Iron Absorption

- Well absorbed in breastmilk.
- Possible Factors:
  - lower calcium and phosphate content.
  - increased concentration of lactoferrin (iron binding protein).
  - digestibility (influence of intestinal mucosa may facilitate iron absorption).
- If decrease in iron stores → increase in iron absorption.
- If good iron stores → decrease in absorption.

Iron Requirements

0-6 months	0.27mg/day
7-12 months	11.0 mg/day
1-3 years	7.0 mg/day
4-8 years	10.0mg/day

Long Term Consequences of IDA

- Iron is prioritized to the RBCs at the expense of other tissues, including the brain.
- The tissue level of iron deficiency results in neurobehavioural consequences.
- Poorer performance on developmental tests (motor & psychomotor).
- Poorer performance on tests of cognitive function.
- ? Irreversible – can not be ruled out.

Clinical Presentation of IDA

- ↓ or absent iron stores (ferritin)
- ↓ serum iron
- ↓ transferrin saturation
- ↓hemoglobin and hematocrit
- ↓ Mean Cell Volume (microcytic)

Some **Other Findings in IDA**

- ↓ energy, fatigue
- ↓ appetite (anorexia)
- Eating non-food items (pica, pagophagia)
- Poorer cognitive performance
- Delayed psychomotor development

Stages of Iron Status

Iron Depletion

Iron Deficient Erythropoesis

Iron Deficiency Anemia

Stages of Iron Status

Stage	Ferritin	Transferrin Saturation	Serum Iron	MCV	Hb	Hct
Normal	N	N	N	N	N	N
Iron Depletion	↓	N	N	N	N	N
Iron Deficient Erythropoesis	↓	↓	↓	N	N	N
Iron Deficiency Anemia	↓ ↓	↓	↓	↓	↓	↓

Incidence of IDA

- Greatest incidence in children aged 1 -3 years.
- ***9%*** incidence of ***iron deficiency*** in US children age 1 – 3 years old (NHANES III. 1989-1994).
- ***1/3 (3%)*** of those had ***IDA.***
- Ages 3 – 11 are at less risk.
- Risk increases again during rapid growth period of puberty; females at more risk.
- Incidence of IDA was >20% in early 1970's.

…despite the decreased incidence, it is still…

the most common childhood nutritional problem

Risk Factors

- Premature birth
- Low birth weight (<2500g)
- Multiple birth
- Low income
- Age 1-3 years
- Adolescence (menstruating females)
- Pregnancy

Diet-Related Risk Factors

- Use of non-iron fortified infant formulas.
- Early introduction of cow's milk (<9-12mo).
- Exclusive breast feeding > 6 months (*without* alternate iron source introduced).
- Delayed introduction to iron-containing solids
- Excessive cow's milk intake or overall fluid intake to the exclusion of solids.

Prevention of IDA

- AAP and CPS Recommendations.
- Exclusive breast feeding to 6 months with introduction of supplemental source of iron at 6 months.
- For breastfed preterm or LBW infants, give iron supplement drops until 12 months corrected age (2mg/kg/day).
- In non-breastfed infants, use of iron-fortified infant formula from birth to 12 months with introduction of iron-containing solid foods at 6 months (infant cereal, meat).

AAP and CPS Recommendations

- Delay introduction of cow's milk until 9-12 months old.
- Avoid excessive milk intake of >24oz/day in children 1 – 5 years old.
- Continue iron-fortified foods beyond the first year.
- May supplement high-risk children with an iron-containing multivitamin in the 2nd year, especially if no heme iron in the diet.

Iron-Rich Diet

- At least 2 servings of high-iron foods each day (e.g. infant cereal, meat).
- Include iron-absorption enhancing foods (e.g. vitamin C, heme with non-heme foods).
- Limit intake of milk (16-24oz/day).
- Limit juice (4oz/day).

Samples of Iron-Rich Foods

- Beef, chicken, turkey, lamb, fish, pork.
- Cooked beans and lentils
- Eggs, peanut butter, chick peas and tofu.
- Dried fruit and dark green vegetables.

Treatment of IDA

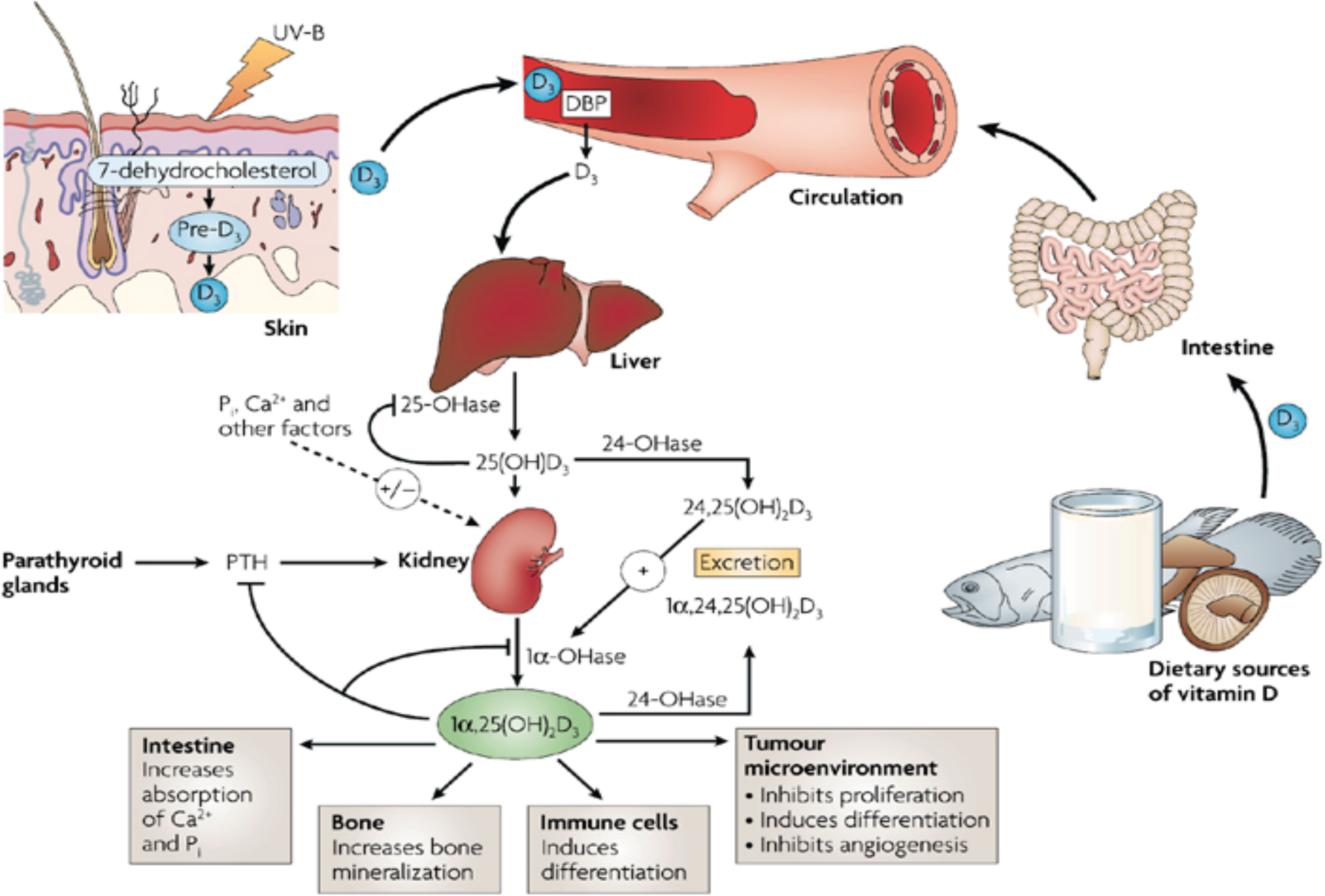
- Ferrous sulphate 3-6mg/kg x 3 months.
- Recheck Hb or Hct levels at 1 and 3 months.
- Reassess Hb or Hct 6 months after successful treatment
- Iron-rich diet may be used to help maintain normal iron status (i.e. prevention).

Functions of Vitamin D

- A hormone.
- A vitamin.
- A gene-regulator (genomic).
- Structurally vitamin D is derived from a steroid and is a seco-steroid since one of its rings is broken, or open.
- Vitamin D and its metabolites exhibit unusual flexibility that allows interactions with binding proteins.

Sources of Vitamin D

- Photosynthesis by skin
  - Vitamin D3→Hydroxylated by liver to 25-hydroxyvitamin D→hydroxylated by kidney to 1,25 dihydroxyvitamin D.
- Oily fish
- Shitake mushrooms
- Fortified foods:
  - Milk, margarine, cereals.


UV-B
7-dehydrocholesterol
Pre-D3
D3
Skin
D3
DBP
D3
Circulation
Liver
Intestine
D3
Pi, Ca2+ and other factors
25-OHase
25(OH)D3
24-OHase
+/−
24,25(OH)2D3
Parathyroid glands
PTH
Kidney
+
Excretion
1α,24,25(OH)2D3
1α-OHase
24-OHase
1α,25(OH)2D3
Dietary sources of vitamin D
Intestine
Increases absorption of Ca2+ and Pi
Bone
Increases bone mineralization
Immune cells
Induces differentiation
Tumour microenvironment
• Inhibits proliferation
• Induces differentiation
• Inhibits angiogenesis

Forms of Vitamin D

- The primary circulating form of Vitamin D is 25(OH)D.
- The physiologically active form of Vitamin D is $1,25(OH)_2D$.

Physiology of 1,25(OH)2D

- Most tissues and cells in the body have vitamin D receptors.
- Jejunum and ileum
  - Increases absorption of calcium and magnesium.
- Bone
  - Required for proper mineralization.
- Cardiovascular system
  - Inhibition of vascular smooth muscle proliferation.
  - Suppression of vascular calcification.
  - Down regulation of pro-inflammatory cytokines.
  - Down regulation of renin-angiotensin system.
- Islet cells
  - Improved insulin sensitivity.

Physiology of 1,25(OH)2D

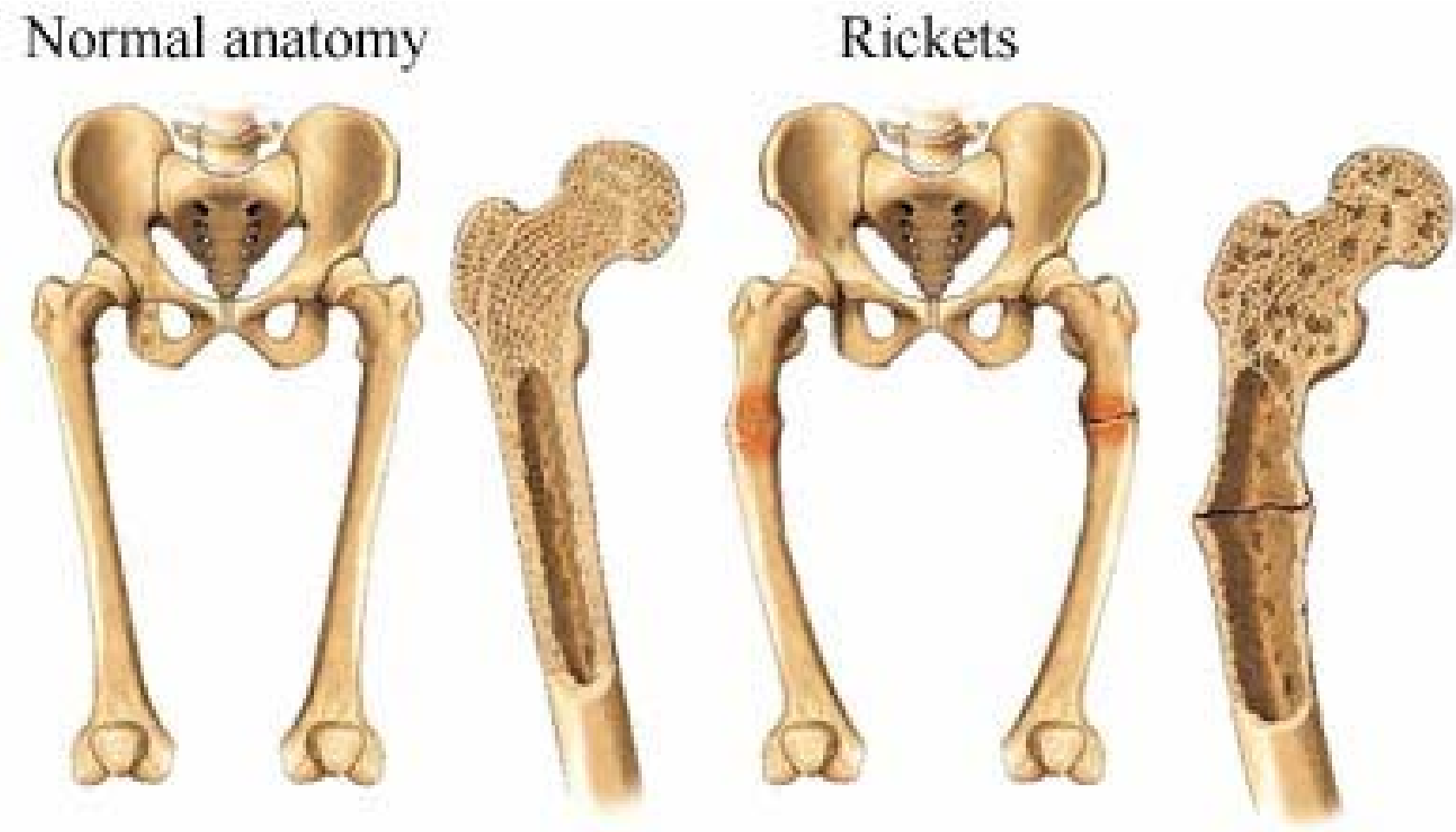
- Muscle
  - Increases protein synthesis and increased number and size of type 2 muscle fibers.
- Skin
  - Antiproliferative, immunosuppressive and prodifferentiating effects.
- Immune System
  - Expression of potent antimicrobial peptides.
  - Increased oxidative burst potential of macrophages.
- Selected Cancer Cells
  - Antiproliferative, prodifferentiating, increases apoptosis, decreases angiogenesis.

Vitamin D Deficiency in Canada

- Suboptimal Vitamin D levels are wide spread – an estimated 1 billion worldwide.
- Canadian population is particularly vulnerable since sun must be greater than 45 degrees above horizon to synthesize Vitamin D.
- For most of Canada, skin photosynthesis can not occur between October-March.

1.Holick 2007;267.

Osteomalacia / Rickets



Causes / Risk Factors

- The most common cause is a deficiency of vitamin D
  - Vitamin D facilitates calcium absorption and other minerals in the gastrointestinal tract necessary for bone building.
  - Lack of vitamin D, calcium and other minerals aren't absorbed efficiently, so they are not available for mineralization in the bone building process. This then result in soft bones.

- Risk Factors:
  - Insufficient sunlight exposure
  - Insufficient vitamin D intake
  - Certain Surgeries
  - Chronic pancreatitis
  - Chronic sprue

Symptoms/Diagnosis

- In the early stages may not feel the symptoms, but may be seen in x-rays or diagnostic tests.
- As condition worsens symptoms may include:
  - bone pain (lower spine, pelvis, legs and feet) and muscle weakness.
  - may cause weakness and stiffness in the arms and legs.
  - decreased muscle tone and discomfort during movement.
- When diagnosing, health professionals will inquire about the patient's time spent in the sun and about their diet. In order to rule out other bone diseases the following tests may be conducted:
  - Blood and urine tests
  - X-ray
  - Bone biopsy

Treatment

- If caused from a dietary or sunlight deficiency, replenishing the low serum vitamin D usually cures the condition.
- Doctors also recommend vitamin D supplements depending on the dose needed and other health problems.
- Oral Vitamin D supplements for several weeks or months. Rarely but vitamin D can also be given as an injection or through a vein in the arm.
- If serum calcium and phosphorous are low, may also take these mineral supplements.
- Undergo periodic blood tests to assess vitamin D and other mineral levels are within normal limits. X-rays taken to determine bone improvement.
- Symptoms may lessen within a few weeks of treatment but doctors suggest vitamin D indefinitely for prevention.

Prevention

- **Spend a few minutes in the sun**
  - Direct sun exposure to arms and legs for 5-10 minutes daily is sufficient for adequate vitamin D production.
  - If living in cold climates and don’t get enough sun exposure during the winter, can build enough vitamin D stores in the skin during warmer months.
  - Regular use of sunscreen helps prevent skin cancer and premature skin aging but is concern that the frequent use of strong sunscreen can increase the risk of developing ostemalacia.
- **Eat foods high in vitamin D**
  - Oily fishes (salmon, mackerel, and sardines) and egg yolks.
  - Fortified foods such as cereal, bread, milk, and yogurt.

Prevention

- **Take supplements**
  - If not enough vitamins and minerals in diet or a medical condition affecting the ability of absorb nutrients, recommend ask doctor about taking vitamin D and calcium supplements.
- **Exercise**
  - Such as walking helps strengthen bones, but if patient has slight fractures due to osteomalacia, they should avoid strenuous activity until their bones heal.

DRIs Updates for Vitamin D and Calcium

- Health Canada and the Food and Nutrition Board of the Institute of Medicine assessing current data and updating the DRI values for calcium and vitamin D.
  - Chronic and non-chronic indicators will be considered.
  - Evidence-based literature to be reviewed.
  - Intake adequacy and excess will be based on strength of evidence and significance.
  - Uncertainty in the evidence also be considered.
- Updates to be completed in March 2011.
- At present time, DRIs for calcium and Vitamin D remain the same.

Professional and Parent Resources

- Canadian Paediatric Society. Position Statement. Vitamin D supplementation: Recommendations for Canadian mothers and infants, September 2007.
- Caring for Kids (Vitamin D & Iron Needs): http://www.caringforkids.cps.ca
- Dietitians of Canada. Current Issues: Vitamin D-Current Dilemmas, May 2008.
- Dietitians of Canada. Members in Action newsletter, February 2009. (DC Members only).

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- Feightner, J.W. Prevention of iron deficiency anemia in Infants. In: Canadian Task Force on the Periodic Health Examination. Canadian Guide to Clinical Preventive Health Care. Ottawa: Health Canada, 1994; 244-255. Summary available at: http://www.ctfphc.org/

Professional and Parent Resources

- Meeting the iron needs of infants and young children: An update. Nutrition Committee, Canadian Paediatric Society (CPS). *Canadian Medical Association Journal* 1991;144(11): 1451-1454. Publication are available at: http://www.cps.ca
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- The Canadian Task Force on the Periodic Health Examination. *Canadian Medical Association Journal 1991;144(11):1451-145.*

Professional and Parent Resources

- Vitamin D supplementation in northern Native communities. Paediatrics & Child Health 2002; 7(7): 459-63. Publication available at: http://www.cps.ca.
- Wagner, C.L., Greer, F.R., and the Section of Breastfeeding Committee on Nutrition. Prevention of rickets and Vitamin D deficiency in infants, children, and adolescents. Pediatrics 2008;122;1142-1152.
- Ward, LM., Gabourg, I., Ladhani, M., & Zlotkin, S. Vitamin D-deficiency rickets among children in Canada. CMAJ 2007; 177(2): 161-6.
- Health Canada: Dietary Reference Intakes – NEW!

http://www.hc-sc.gc.ca/fn-an/nutrition/reference/index-eng.php

Acknowledgements

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