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# IODINE

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# Element 53

- Greek---'iodes'---meaning violet
  - Group 17/VII of the periodic table---halogen
  - Atomic weight is 126.9045 grams
  - Melting point is 113.7 °C
  - Boiling point is 184.4 °C
  - Bernard Courtois discovered iodine in 1811
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# Where does it exist in nature?

- Iodide ions in brines
- An impurity in Chile saltpeter
- Main natural source of iodine is kelp

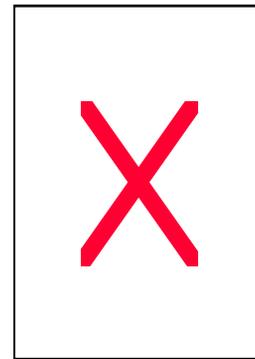
2000 kg seaweed = 1 kg iodine

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# Other Facts

- Elemental iodine is produced by oxidation with chlorine
- It produces a variety of colors in organic solvents
- Starch is a common indicator
- Be careful with handling!



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# Uses of Iodine

- Silver iodide is used in photography
  - Disinfectant for external wounds
  - Essential trace element
  - Iodine is used by the thyroid gland
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# The Thyroid

- Largest endocrine gland in the body
  - Synthesizes and stores thyroid hormones: thyroxine ( $T_4$ ) and 3,5,3'-triiodothyronine ( $T_3$ )
  - Located in the neck
  - 2 lobes connected by a narrow isthmus
  - Composed of functional units called follicles
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# The Thyroid 2

[http://www.betterhealth.vic.gov.au/bhcv2/bhc/articles.nsf/Pictures/Thyroid\\_gland\\_explained?OpenDocument](http://www.betterhealth.vic.gov.au/bhcv2/bhc/articles.nsf/Pictures/Thyroid_gland_explained?OpenDocument)

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# Iodine and the Thyroid Gland

- Normal adult thyroid weighs 20-25g and contains 8-10 mg of iodine
  - Iodine contributes to 65% of T<sub>4</sub> molecular size and 59% of T<sub>3</sub> molecular size
  - Iodine provides the raw material for hormone synthesis
  - Most ingested iodine is reduced in the gastrointestinal tract and absorbed almost completely
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# Iodine and the Thyroid Gland 2

- Iodate → iodide → completely absorbed
  - Thyroid selectively concentrates iodide in amts. required for adequate hormone synthesis
  - Most of the remaining iodine excreted in urine
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# Iodine and the Thyroid Gland 3

Iodine in the thyroid gland

+

complex series of  
reactions

= thyroid hormones

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# Iodine and the Thyroid Gland 4

- Deiodinase helps to recycle iodine within the thyroid gland
  - Thyroid-stimulating hormone (TSH) is the major regulator of thyroid function
  - Pituitary secretes TSH in response to concentrations of thyroid hormone
  - Elevated serum TSH concentration indicates primary hypothyroidism
  - Decrease in TSH concentration reflects hyperthyroidism
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What happens when you don't consume enough iodine?

# Iodine Deficiency Disorders

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# Iodine deficiency disorders: Malformations

- Fetus: abortion, perinatal death, infant death, neurological cretinism, severe mental deficiency, deaf-mutism, spastic deplegia, squint, myxedeatous cretinism, growth-stunting, severe mental deficiency, psychomotor deficiency
- Neonate: goiter, hypothyroidism
- Child and adolescent: hypothyroidism, mental deficiency, low physical development
- Adult: goiter, mechanical compression of adjacent organs in the neck, endocrine disorders (hyperthyroidism/hypothyroidism), neoplasia (benign tumors/cancer), mental deficiency

Source: *Essentials of Medical Geology*, pg. 190, Table X

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# Iodine Deficiency Disorders (I.D.D.): Statistics

- In 1990, the U.N. and W.H.O. estimated that about 1 billion people are at risk for I.D.D.
  - 211 million with goiter
  - 5.1 with cretinism
  - Mean IQ loss of 13.5 points in the population living in severely iodine deficient areas
  - Iodine deficiency is the greatest cause of preventable brain damage in childhood
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# Historical Advances

- Chinese were treating goiter with powdered seaweed and sea urchins several thousand years ago
  - BCE: Greeks used burst sponge to treat goiter
  - 1811: discovery of iodine by adding concentrated  $\text{H}_2\text{SO}_4$  to a seaweed of the type that was used to treat goiter
  - 1819: Fyfe identified iodine in sponge
  - 1820: Coindet treated goiter with iodine
  - 1854: Chatin suggested low iodine in soil, water, and food caused goiter
  - 1896: Baumann showed that the thyroid is rich in iodine; Halsted showed that maternal thyroid removal caused fetal thyroid hyperplasia in dogs
  - 1908: McCarrison characterizes endemic cretinism
  - 1909: Marine shows that maternal iodine deficiency caused goiter in the fetus (dog)
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# Historical Advances, con't

- 1915: Kendall discovers thyroxin
- 1917: Smith shows that maternal iodine deficiency caused “cretinism” (swine)
- 1921: Marine shows that goiter can be prevented by iodide
- 1927: Harrington synthesizes thyroxin
- 1941: Mackenzie shows that sulfanilguanidine inhibits iodide concentration by thyroid (rat)
- 1943: Mackenzie shows that aminobenzene and thiourea inhibit iodine concentration by thyroid (rat); Mackenzie reveals hyperplasia of pituitary gland in hypothyroid state (rat)

Source: *Essentials of Medical Geology*, pg 190, Table IX

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# What causes I.D.D.?

- Not enough iodine intake
  - Cause: low iodine concentration in soil
  - Goiter: thyroid gland becomes enlarged in an attempt to be more efficient
  - Brain damage: iodine deficiency impairs certain aspects of lipid metabolism in the developing mammalian brain
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# Case Study: Iodine Deficiency and England in the 20<sup>th</sup> Century

- 1920s British research: iodine supplementation reveals improved livestock reproductive performance
  - Rise of the iodine content in milk
  - Government policies of increased consumption of milk
  - Endogenous infant mortality rates decrease as iodine intake increases
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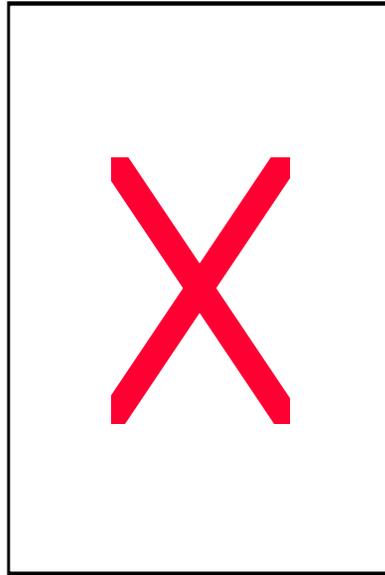
# Case Study: Maring of New Guinea

- Georgeda Buchbinder, Department of Anthropology, Queens College
  - Endemic goiter and endemic cretinism a by-product of culture contact
  - Substitution of non-iodized trade salt for locally manufactured salt that was high in iodine
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# Evidence from Research in Geochemistry

- Geographically defined---high mountain ranges, rain shadow areas, and central continental regions
  - Little iodine in the secondary environment is derived from weathering of the lithosphere
  - Iodine concentration decreases as you move inland
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How do you know if you have I.D.D.?

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# More Research Methods: Clinical Assessment of Iodine Status

- Goiter and cretinism
  - Chemical methods
  - Potentiometry
  - Neutron Activation Analysis
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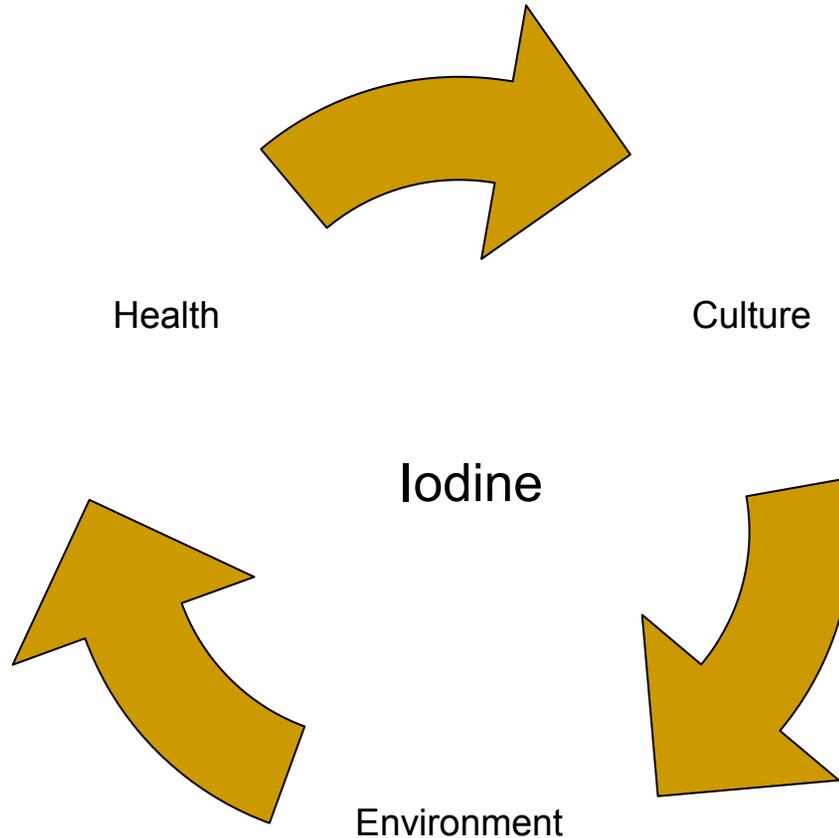
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# Normal Clinical Values of Iodine for Healthy Adults

- Urinary > 1000 µg/L
  - Serum T<sub>4</sub> 60-100 µg/L
  - Serum TSH 1-50 µg/L
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# What does this all mean?



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# Preventative Measures

- Iodine supplements
  - Iodized oil
  - Food fortified with iodine
  - Iodized salt
  - World Health Organization, UNICEF
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# Summary and Conclusion

- Iodine and its chemical properties
  - Iodine and the Thyroid Gland
  - Iodine Deficiency Disorders
  - Prevention
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# References

- Atkins and Jones. *Chemical Principles: The Quest for Insight*. New York: W.H. Freeman and Company, 2005.
  - Cunnane, Stephen. *Survival of the Fattest: The Key to Human Brain Evolution*. Singapore: World Scientific, 2005.
  - Duncan and Scott. *Demography and Nutrition: Evidence from Historical and Contemporary Populations*. Oxford: Blackwell Science, 2002.
  - Fitzgerald, Thomas. *Nutrition and Anthropology in Action*. Amsterdam: van Gorcum, 1977.
  - Selinus, Alloway, Centeno, Finkelman, Fuge, Lindh, and Smedley (Editors). *Essentials of Medical Geology: Impacts of the Natural Environment on Public Health*. Singapore: Elsevier Academic Press, 2005.
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