A Content Secondary Science Newsletter from the
Southern Nevada Regional Professional Development Program

# Science Dissected

Southern Nevada RPDP

## *Homeostasis of the Body Systems*
## *Model-Evidence Link Diagram (MEL)*

The human body is an exquisite machine, partly because it maintains functionality in a variety of environments. Humans can thrive in conditions ranging from the arctic to the equator, and with a variety of diets and lifestyles. Part of the reason for this adaptability is the body's ability to maintain homeostasis.

Homeostasis is a fancy word meaning "equilibrium," and it entails many interwoven variables that are amazing to consider. Temperature is among the most straightforward of these. The body sweats to keep cool and shivers to stay warm. But the human body is masterful at balancing many other factors. Most are subtler, involving the regulation of hormones and other bodily chemicals. All of the body's systems self-regulate using an intricate coordination of three principle roles: signal reception, centralized control and action.

***Model A:*** The human body synthesizes elements (i.e. I, Na, Ca, K, Cl) as needed to maintain homeostasis.

***Model B:*** The human body must ingest, elements (i.e. I, Na, Ca, K, Cl) through diet to maintain homeostasis.

***Evidence #1:*** Iodine deficiency is the world's leading cause of preventable intellectual disability or mental retardation in children.

***Evidence #2:*** Elements forged in the stars.

***Evidence #3:*** Iron deficiency is a condition resulting from too little iron in the body. Iron deficiency is the most common nutritional deficiency and the leading cause of anemia in the United States.

***Evidence #4:*** Down syndrome is a developmental disorder caused by an extra copy of chromosome 21.

***Evidence #5:*** Adequate calcium consumption and weight bearing physical activity build strong bones, optimizes bone mass, and may reduce the risk of osteoporosis later in life.

**The following is a suggestion for using this MEL with students:**

1. Hand out the Homeostasis of the Body Systems Model Evidence Link Diagram (page 1). Instruct students to read the directions, descriptions of Model A and Model B, and the four evidence texts presented.
2. Handout the five evidence text pages (pages 3-18).
3. Instruct students to carefully review the Evidence #1 text page (page 3), then construct two lines from Evidence #1; one to Model A and one to Model B. Remind students that the shape of the arrow they draw indicates their plausibility judgment (potential truthfulness) connection to the model.
4. Repeat for Evidence #2-5 (pages 4-18).
5. Handout page 2 for the students to critically evaluate their links and construct

Once students have completed page 2, they can then engage in collaborative argumentation as they compare their links and explanations with that of their peers. Students should be given the opportunity to revise the link weighting during the collaborative argumentation exercise. If time permits, have students reflect on their understanding of homeostasis of the Body Systems and create questions that they might explore in the future.

***Archived Issues of Science Dissected, [http://www.rpdp.net/link.news.php?type=sciencedis](http://www.rpdp.net/link.news.php?type=sciencedis). Instructional Resource resulting from Plausibility, It's All About Connecting the Models Workshop co-sponsored by CPDD and SNRPDP Science March 6, 2012***

*Written by: Kim Peterson*

**Name:**________________________________________ ____________________ **Period:**________________

**Directions:** draw two arrows from each evidence box. One to each model. You will draw a total of 10 arrows.

**Key**:

- The evidence **supports** the model
- The evidence **STRONGLY supports** the model
- The evidence **contradicts** the model (shows its wrong)
- The evidence has **nothing to do with** the model

Standard: 9 Human Biology

9.2 (9) [L12B3] TSW DISCUSS HOW DISRUPTION OF HOMEOSTASIS OF THE BODY SYSTEMS CAN CAUSE DISEASE.

9.3 (4, 9) [L12B3, L12C1] TSW INVESTIGATE VARIOUS CAUSES OF DISEASES.

**Evidence #1**

Iodine deficiency is the world's leading cause of preventable intellectual disability or mental retardation in children.

**Evidence #2**

Elements forged in the stars.

**Model A**

The human body synthesizes elements (i.e. I, Na, Ca, K, Cl) as needed to maintain homeostasis.

**Model B**

The human body must ingest, elements (i.e. I, Na, Ca, K, Cl) through diet to maintain homeostasis.

**Evidence #3**

Iron deficiency is a condition resulting from too little iron in the body. Iron deficiency is the most common nutritional deficiency and the leading cause of anemia in the United States.

**Evidence #4**

Down syndrome is a developmental disorder caused by an extra copy of chromosome 21.

**Evidence #5**

Adequate calcium consumption and weight bearing physical activity build strong bones, optimizes bone mass, and may reduce the risk of osteoporosis later in life.

Provide a reason for three of the arrows you have drawn. **Write your reasons for the three most interesting or important arrows.**

A. Write the number of the evidence you are writing about.
B. Circle the appropriate descriptor (**strongly supports | supports | contradicts | has nothing to do with**).
C. Write the letter of the model you are writing about.
D. Then write your reason.

**1. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:**

**2. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:**

**3. Evidence # ____ strongly supports | supports | contradicts | has nothing to do with Model _____ because:**

**4. Circle the plausibility of each model. [Make two circles. One for each model.]**

| | Greatly implausible (or even impossible) | | | | | | | | | Highly Plausible |
|---|---|---|---|---|---|---|---|---|---|---|
| **Model A** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Model B** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**5. Circle the model which you think is correct. [Only circle one choice below.]**

| | | | | |
|---|---|---|---|---|
| Very certain that Model A is correct | Somewhat certain that Model A is correct | Uncertain if Model A or B is correct | Somewhat certain that Model B is correct | Very certain that Model B is correct |


2

**Evidence #1: Iodine deficiency is the world's leading cause of preventable intellectual disability or mental retardation in children.**

# Iodine explained

## Summary

Iodine is important for hormone development. It is found in dairy products, seafood, kelp, eggs, bread, some vegetables and iodized salt. A lack of dietary iodine can cause an enlarged thyroid gland (goiter) or other iodine deficiency disorders including mental retardation in children. Pregnant women need higher levels of iodine.

Iodine is found in a range of foods including dairy products, seafood, kelp, eggs, bread, some vegetables and iodized salt. Our bodies need iodine for the development of essential thyroid hormones. The thyroid is a gland in the throat that regulates many metabolic processes, such as growth and energy use. If you don't have enough iodine in your diet, it can lead to an enlarged thyroid gland (goiter) or other iodine deficiency disorders.

Iodine deficiency is the world's leading cause of preventable intellectual disability or mental retardation in children. All women who are pregnant, breastfeeding or considering becoming pregnant should ask their health professional for advice about their individual dietary needs.

## Thyroid hormones regulate metabolism

The thyroid hormones regulate the body's metabolic rate and promote growth and development throughout the body, including the brain. If there isn't enough thyroid hormone circulating in the blood, the brain (via the pituitary gland) sends a chemical message (thyroid stimulating hormone) to the thyroid gland, which then releases a measured dose of these hormones.

The two main thyroid hormones, thyroxine and triiodothyronine, are synthesized from the amino acid tyrosine in combination with iodide. Thyroxine (T4) contains four iodine atoms and triiodothyronine (T3) contains three. If a person's diet is too low in iodine, the thyroid gland gets larger and larger in an attempt to make more thyroid hormone. This overgrowth of the thyroid gland is called goiter.

## Long-term deficiency can be serious

An enlarged thyroid gland, or goiter, isn't the only side effect of not having enough iodine in the diet. If the deficiency is long term, hypothyroidism develops. Symptoms include dry skin, hair loss, fatigue and slowed reflexes.

Goiters can also increase the risk of thyroid cancer. Goiter can be associated with hyperthyroidism, a condition in which too much thyroid hormone is produced.

## Iodine deficiency in babies and children

In the developing fetus, baby or young child, the effects of iodine deficiency are serious. They include stunted growth, diminished intelligence and retardation. Lack of iodine is a major problem in developing countries. It is the world's number one cause of preventable intellectual disability in children. There is evidence that some levels of iodine deficiency may be too mild to cause goiter but may still retard brain development.

In Australia, studies conducted over the last decade in Victoria and New South Wales (where approximately 60 per cent of the Australian population lives) indicate the presence of mild-to-moderate iodine deficiency in all groups tested. Western Australia and Queensland appear to have adequate intakes, while South Australia is borderline.

## How much iodine do we need?

The recommended daily intake (RDI) for iodine depends on your age and life stage. The amount we need is very small (around one teaspoonful over a lifetime for most adults) when compared to other nutrients and is measured in micrograms (mcg, or µg):

- Younger children (1 to 8 years) – 90µg
- Older children (9 to 13 years, boys and girls) – 120µg
- Adolescents (14 to 18 years) – 150µg
- Men – 150µg
- Women – 150µg
- Pregnancy and breastfeeding – 220µg and 270µg respectively.

If you don't get enough iodine in your diet, you may need to consider taking a supplement. For most people, an additional 50µg per day would be ample.

# How to get enough iodine in your diet

The best way to get the nutrients your body needs is as part of a healthy, well-balanced diet. Some suggestions to make sure you get the required daily amount of iodine include:

- **Seafood** – dietitians recommend two to three meals of seafood per week to get the beneficial fish oils. Eating fish twice a week will also provide most adults with enough iodine to fulfill their average iodine requirement.
- **Bread –** is now made using iodized salt in Australia. Organic breads and 'no added salt' breads are the only exceptions to this rule.
- **Seaweed (kelp), dairy products and eggs** – provide additional dietary sources of iodine.
- **Some vegetables** – may contain iodine, but only if they are grown in iodine-rich soils.
- **Supplements** – may be necessary if your dietary intake is inadequate. Many multivitamin capsules and tablets supply 100–150µg of iodine.

Although it comes from the ocean, sea salt is not a good source of iodine. Take care when choosing seafood as some fish may contain high levels of mercury or chemicals (such as PCBs) from inland waterways.

# Pregnancy and iodine

Pregnant women need higher levels of iodine, as lack of this nutrient can retard normal development in a baby. Eating two serves of seafood each week will not be enough to meet a woman's iodine requirements during pregnancy – you would need to eat almost nine cans of tuna a day to reach the recommended level (220mcg, or micrograms). In Australia, the National Health and Medical Research Council (NHMRC) recommends that all women who are pregnant, breastfeeding or considering pregnancy take an iodine supplement of 150mcg each day to make sure their needs are met.

If you are pregnant, breastfeeding or considering becoming pregnant, ask your registered medical doctor (GP) for advice about your individual daily needs. In particular, women with pre-existing thyroid conditions should not take iodine supplements until they have checked with their doctor.

Seafood is a valuable source of iodine, but pregnant women or women intending to become pregnant within the next six months should take care to avoid seafood that may contain large amounts of mercury. Mercury can be passed through the placenta and may affect the brain development of your baby. Some fish that contain high levels of mercury include shark, orange roughly, swordfish and ling.

# Vegetarian diet

Vegetarians can get iodine from bread, seaweed and some soymilks that include extracts of seaweed.

# Things to remember

- Dietary iodine is needed to make essential thyroid hormones.
- Not enough iodine in the diet can cause mental retardation and stunted growth in children and an enlarged thyroid gland (goiter) in adults.
- Good sources of iodine include bread fortified with iodized salt and any type of seafood, including seaweed.
- Young children should avoid eating salt added at the table or in cooking.

**If you would like to link to this fact sheet on your website, simply copy the code below and add it to your page:**

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<a href="http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Iodine_explained?open">Iodine explained - Better Health Channel</a><br/>
Iodine is important for hormone development. It is found in dairy products, seafood, kelp, eggs, bread, some vegetables and iodized salt. A lack of dietary iodine can cause an enlarged thyroid gland (goiter) or other iodine deficiency disorders including mental retardation in children. Pregnant women need higher levels of iodine.
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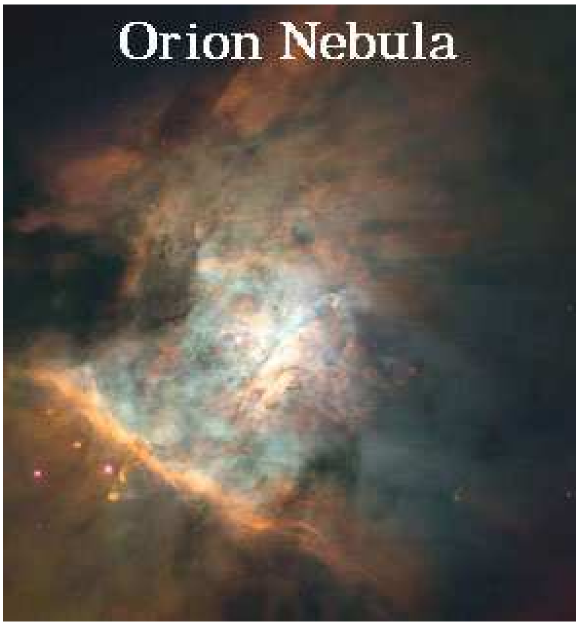
# Evidence # 2: Elements forged in the stars.

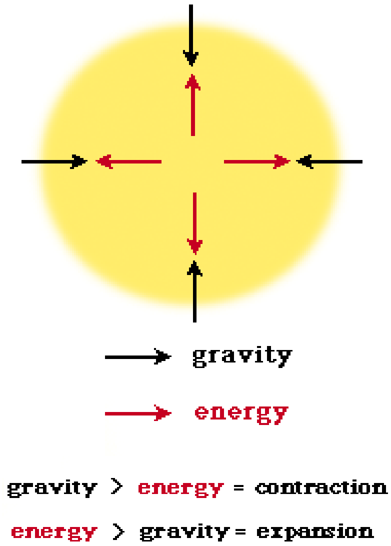
## Formation of the High Mass Elements

**(What Happens Inside a Star)**



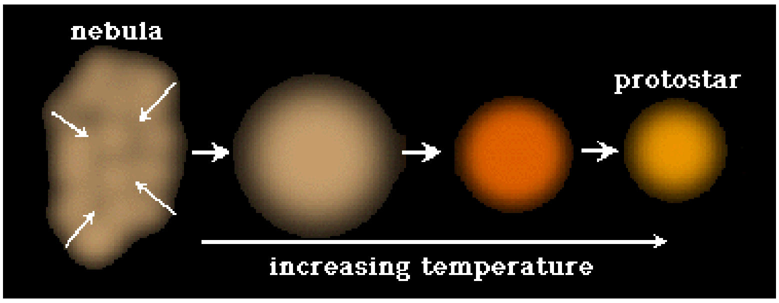

ABSTRACT
Once the universe was created by the Big Bang, the only abundant elements present were hydrogen (H) and helium (He). These elements were not evenly distributed throughout space, and under the influence of gravity they began to "clump" to form more concentrated volumes. Evidence of this uneven distribution can be found in the anisotropies detected in the Cosmic Background Radiation (CMB) by the COBE satellite in the early 90's. These clumps would eventually form galaxies and stars, and through the internal processes by which a star "shines" higher mass elements were formed inside the stars. Upon the death of a star (in a nova or a supernova) these high mass elements, along with even more massive nuclei created during the nova or supernova, were thrown out into space to eventually become incorporated into another star or celestial body.

The conditions inside a star that allow the formation of the higher mass elements can be related to a pushing match between gravity and the energy released by the star. Gravity creates a force that would cause a star to shrink and collapse, but the energy released by nuclear reactions within the star flows outward, and produces thermal pressure that opposes gravity. When these two forces are balanced, the star maintains a particular size. But when there is some type of imbalance, the star (or some part of it) will expand or contract in response to the stronger of the two forces.



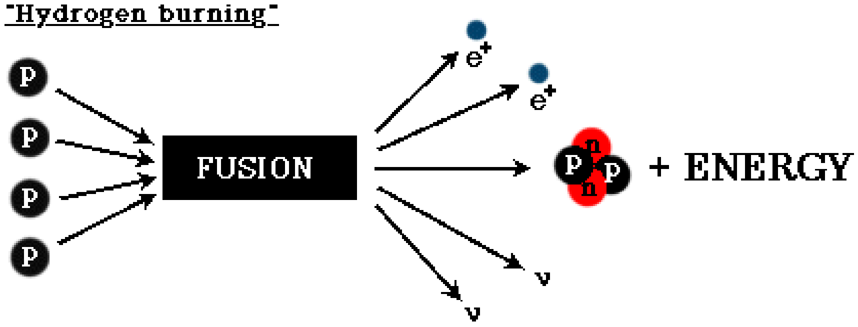

When the universe was first created, essentially all matter was in the form of two elements- hydrogen and helium. Their relative abundance (by weight) was 75% hydrogen and 25% helium. (This means that for every He nucleus there were 12 H nuclei/protons) They were not evenly distributed throughout space. This is critical, because this uneven distribution allowed gravity to act in the areas of higher concentration to initiate the "clumping" of matter. If everything were evenly spread out, nothing would have happened, for each atom would have been attracted evenly from all directions, and would have remained where it was relative to neighboring atoms. As a result of slight discrepancies in the distribution of matter, gravity was able to initiate the collapse of huge volumes of H and He into more concentrated areas of gas. These areas eventually would evolve to form galaxies. Within these areas, there was a second level of more concentrated clumping of H and He that would form stars, where the higher mass elements would be created.

In these more concentrated areas, as the clouds of H and He (called nebulas) collapsed, the atoms were speeding up as they were pulled toward the center by gravity. This caused two things to happen. First, the increase in the velocity of the atoms resulted in an increase in the temperature of the material. At some point, the temperature became high enough so that the material began to glow. Second, the atoms were becoming packed more tightly, increasing the density, and the frequency of collisions between atoms. As this happened, the mass of H and He became more spherical. At this stage the mass of H and He is called a protostar.




The temperature inside a star is not uniform. The central region (called the core) is the hottest, with the temperature decreasing as you move out toward the surface of the star. At some point, the temperature became high enough in the core of the protostar to form a phase of matter called a PLASMA. In a plasma, the electrons become separated from the nuclei, so instead of individual atoms, you have a "sea" of nuclei and electrons. This allows the nuclei of the atoms to interact with each other, which would not happen if each atom possessed its own electron cloud.

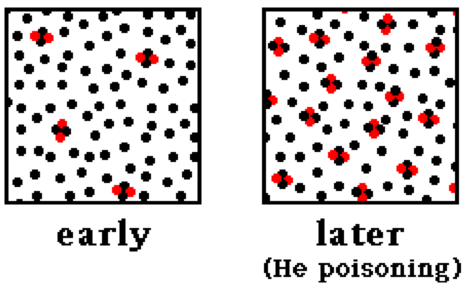
The temperature and density continued to increase until they reached what is called the "flash point." Up until this moment, all the collisions between nuclei were like marbles bouncing off each other. Each nucleus, having a positive charge, would only get so close to another nucleus before being pushed away by the electrostatic repulsion between both nuclei. Once the conditions reached the flash point, some of these collisions occurred in a manner (with the sufficient velocity and geometry) to allow the nuclei to get close enough to interact with each other. This allowed the STRONG NUCLEAR FORCE (strong force) to bind these smaller nuclei together, forming a more massive nucleus. This process is called FUSION. In the process of fusing nuclei together, tremendous amounts of energy are released, and this energy is what causes the star to "shine." The flash point conditions vary depending on what types of nuclei are fusing. The lighter the nuclei (and therefore the smaller the electric charge), the lower the flash point temperature and density are because there is less energy needed to bring the nuclei close enough for the strong force to bind them (this will become more important later). So, with the original mixture of H and He, the flash point that was reached first is that for H. When H undergoes fusion, the overall process involves four H nuclei (protons) coming together to form a He nucleus, two positrons, and two neutrinos, with the release of energy. This energy takes the form of gamma rays, and the kinetic energy of the products. (The positrons produced quickly annihilate with surrounding electrons to release more gamma rays.) In either form, the energy goes into heating up the core. (This can be referred to as "hydrogen burning", but it is nothing like the "burning" we talk about here on earth.)

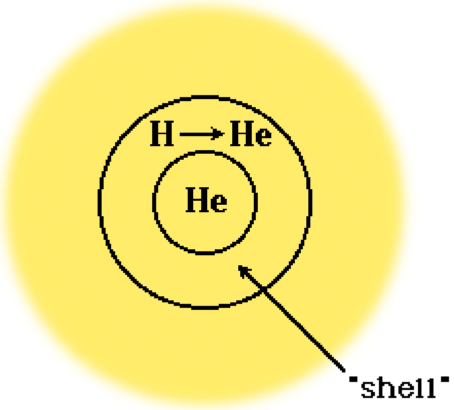



There are a number of possible pathways for H fusion, but the primary reaction mechanisms are believed to be the PROTON-PROTON CHAIN (p-p chain), or the CARBON-NITROGEN-OXYGEN CYCLE (CNO cycle). Which mechanism is utilized depends on the conditions in the core of a particular star. The proton-proton chain occurs under milder conditions (lower temperature and pressure) than the carbon-nitrogen-oxygen cycle.

Regardless of which process occurs, once fusion of H has begun in the core of the star, what is happening is that H is being converted to He, and this is accompanied by a release of energy. During most of a star's lifetime this is the primary fusion reaction that powers the star. The outward flow of energy (thermal pressure) released balances the collapsing force of gravity, and this stabilizes the star's size.

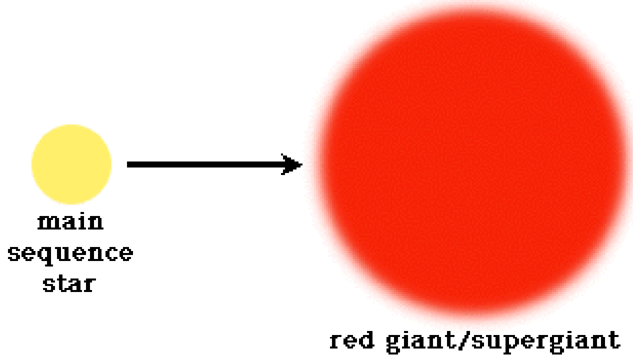
As time passes the fusion process causes He to accumulate in the core. The increase in the number of He nuclei begins to interfere with the H nuclei collisions and causes a reduction in the rate of H fusion (sometimes called "helium poisoning"). This reduces the thermal pressure, and the star will begin to contract.



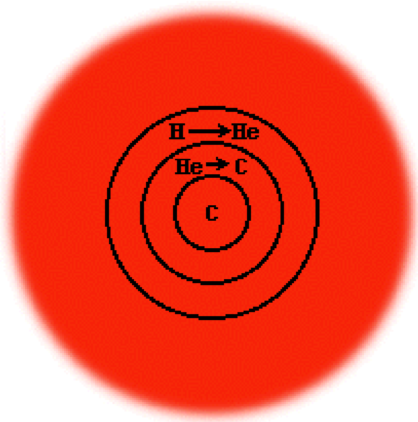




The more massive He nuclei are drawn to the center of the core by gravity. As the He nuclei move toward the center of the core, the temperature and density in that region increases. With the formation of this central He core, the H fusion continues. This occurs in a layer surrounding the He core, where the He concentration is lower. This layer is referred to as a "shell." The rate of hydrogen burning is boosted due to the increase in temperature of the He core.

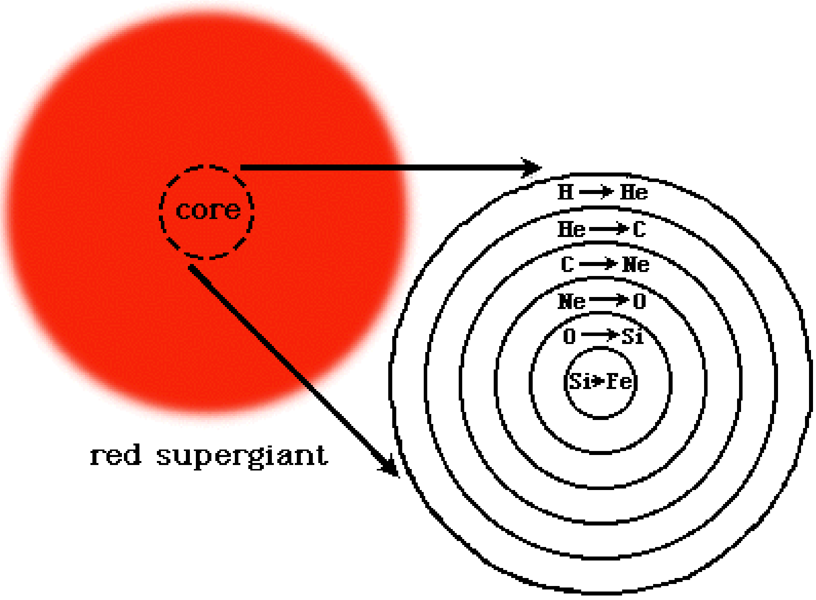
The He core continues to contract under the influence of gravity and draw in the He forming in the hydrogen shell. If the temperature reaches 100,000,000 K (which depends on the initial mass of the protostar), He burning can begin. This is where the He nuclei are able to undergo fusion. This results in the formation of carbon nuclei through a series of reactions called the TRIPLE ALPHA PROCESS. The release of energy through the triple alpha process combines with the increased energy produced in the H shell to boost the thermal pressure of the core to the point where it overcomes gravity, and the size of the overall star increases. The increase in the surface area grows at a faster rate than the increase in released energy, so the surface actually cools even though the star is giving off more energy. This causes the star to glow red, and the star is referred to as a red giant. (Just to give you an idea of size, when our sun reaches the red giant stage, it will extend almost to where the earth is, having already vaporized Mercury and Venus.)



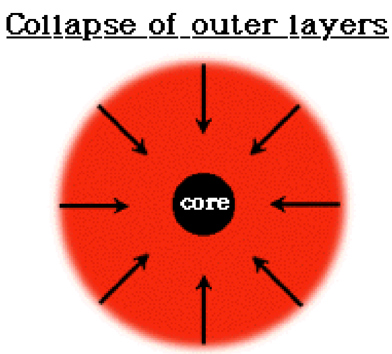

At this point the star has a central core of He being fused into C, surrounded by a shell that has H being turned into He. As the C nuclei are produced, they are pulled toward the center, just as the He nuclei were earlier, and a C core is created. For an average-sized star, this is as far as it goes because of the mass of the star. There is not enough gravitational force (due to the lack of mass) in the star to allow the temperature and density to reach levels where C nuclei can fuse into heavier nuclei.

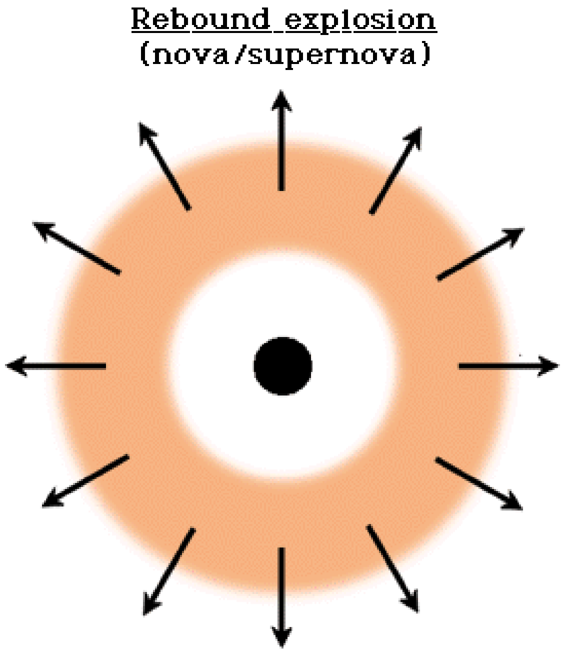


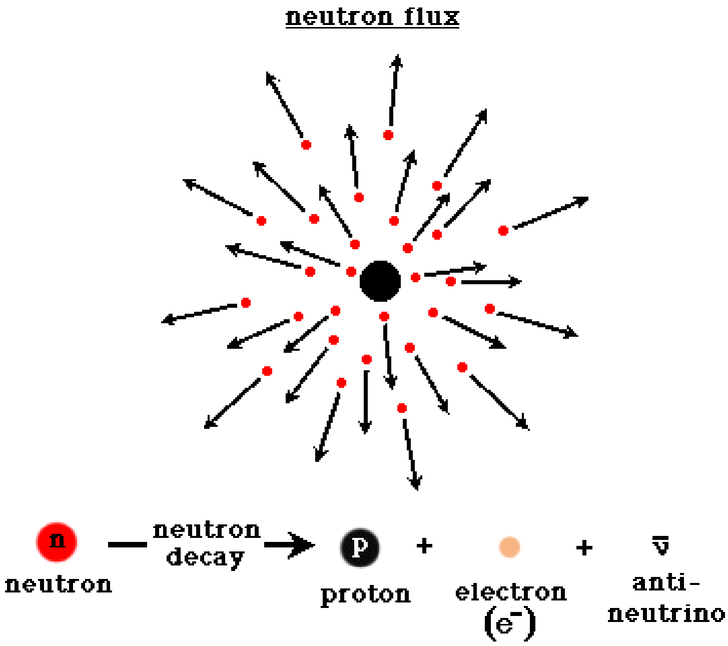

If a star had sufficient mass, though, eventually enough C would accumulate so that the temperature and density reach a point where C nuclei could be fused into Neon nuclei. This carbon burning core would be surrounded by two outer shells, the innermost burning He, and the outermost burning H. This pattern of the central core collapsing and increasing temperature continues until a further round of fusion occurs and more shells form. How many shells are eventually formed is dependent on the initial mass of the collapsing nebula. This is because the main force that produces conditions suitable for fusion to happen is gravity, and the mass of the star determines the force of gravity. If enough mass accumulates in a forming core, gravity will be able to create enough force to raise the temperature and density to levels where the next series of fusion reactions can take place. Therefore, the larger the mass of the protostar, the greater its ability to form more shells during the lifetime of the star. This will also reduce the lifetime of the star since the increases in temperature also increase the fusion rates in the core and the surrounding shells, thus using up fuel even faster. Further cores/shells involve neon being converted to oxygen, oxygen fusing to silicon, and finally, silicon going to Ni (this product is radioactive and decays to form iron). Stars that reach this stage are called red supergiants. This is the limit to what a star can do (the reason why is mentioned later). In a fully developed star the shells would look like this:



As the fusion process continues, the concentration of Fe increases in the core of the star, the core contracts, and the temperature increases again. When the temperature reaches a point where Fe can undergo nuclear reactions, the resulting reactions are different than the ones that have previously taken place. Fe nuclei are the most stable of all atomic nuclei. Because of this, when they undergo nuclear reactions, they don't release energy, but absorb it. Therefore, there is no release of energy to balance the force of gravity. In fact, there is actually a decrease in the internal pressure that works with gravity to make the collapse of the core more intense. In this collapse, the Fe nuclei in the central portion of the core are broken down into alpha particles, protons, and neutrons and are compressed even further. However, they cannot be infinitely compressed. Eventually, the outer layers of material rebound off the compressed core and are thrown outward. This situation can be likened to a rubber ball on the ground that is struck with a hammer. Initially the hammer can compress the rubber ball because of its force, but eventually it is stopped by the density and pressure of the rubber ball reaching its limit, and is thrown back violently by the recoiling rubber ball, which itself will bounce off the surface because of this recoil. In the star, the outer layers of the core are like the hammer, and the core is the rubber ball. Following the collapse of the inner core, the outer layers of the star are pulled toward the center. This sets the stage for a tremendous collision between the recoiling core layers and the collapsing outermost layers. Under the extreme conditions of this collision, two things happen that lead to the formation of the heaviest elements. First, the temperature reaches levels that cannot be attained by even the most massive stars. This gives the nuclei present large kinetic energies, making them very reactive. Second, because of the breaking apart of the iron nuclei in the central core, there is a high concentration of neutrons (called the neutron flux) that are ejected from the core during the supernova. These neutrons are captured by surrounding nuclei, and then decay to a proton by emitting an electron and an antineutrino. Each captured neutron will cause the atomic number of that nucleus to go up by one upon its decay.




With the large neutron flux created during a supernova, this neutron capture/decay sequence can be repeated many times, adding protons to form increasingly more massive nuclei. These conditions exist for only a short time, but long enough to form the highest mass nuclei.

Because of this "rebound explosion," all the outer layers of the star, enriched with the higher mass nuclei, are blown off into space, and this material will later make its way into other nebulas to become incorporated into other stars (where the same cycle of events will be repeated). Each cycle uses up more of the H and He from the early universe and creates greater amounts of the higher mass elements.

**EVIDENCE #3: Iron deficiency is a condition resulting from too little iron in the body. Iron deficiency is the most common nutritional deficiency and the leading cause of anemia in the United States.**

# Iron and Iron Deficiency

The following information is adapted from:
Recommendations to Prevent and Control Iron Deficiency in the United States. *MMWR* 1998;47 (No. RR-3) p. 5

## What is iron and why do we need it?

Iron is a mineral needed by our bodies. Iron is a part of all cells and does many things in our bodies. For example, iron (as part of the protein hemoglobin) carries oxygen from our lungs throughout our bodies. Having too little hemoglobin is called anemia. Iron also helps our muscles store and use oxygen.

Iron is a part of many enzymes and is used in many cell functions. Enzymes help our bodies digest foods and also help with many other important reactions that occur within our bodies. When our bodies don't have enough iron, many parts of our bodies are affected.

## What is iron deficiency and why is it a concern?

Iron deficiency is a condition resulting from too little iron in the body. Iron deficiency is the most common nutritional deficiency and the leading cause of anemia in the United States.[1]

The terms anemia, iron deficiency, and iron deficiency anemia often are used interchangeably but equivalent. Iron deficiency ranges from depleted iron stores without functional or health impairment to iron deficiency with anemia, which affects the functioning of several organ systems.[2]

Iron deficiency is a concern because it can:

- Iron deficiency can delay normal infant motor function (normal activity and movement) or mental function (normal thinking and processing skills).[3-6]
- Iron deficiency anemia during pregnancy can increase risk for small or early (preterm) babies.[7-8] Small or early babies are more likely to have health problems or die in the first year of life than infants who are born full term and are not small.
- Iron deficiency can cause fatigue that impairs the ability to do physical work in adults.[9-10] Iron deficiency may also affect memory or other mental function in teens.[11]

## What causes iron deficiency?

Iron deficiency has many causes. (See table below for a summary). These causes fall into two main categories:

**1. Increased iron needs**
Many common conditions can cause people to need additional iron:

- Because of their rapid growth, infants and toddlers need more iron than older children. Sometimes it can be hard for them to get enough iron from their normal diet.
- Women who are pregnant have higher iron needs. To get enough, most women must take an iron supplement as recommended by their healthcare provider.
- When people lose blood, they also lose iron. They need extra iron to replace what they have lost. Increased blood loss can occur with heavy menstrual periods, frequent blood donation, as well as with some stomach and intestinal conditions (food sensitivity, hookworms.)

**2. Decreased iron intake or absorption** (not enough iron taken into the body)
The amount of iron absorbed from the diet depends on many factors:

- Iron from meat, poultry, and fish (i.e., heme iron) is absorbed two to three times more efficiently than iron from plants (i.e., non-heme iron).
- The amount of iron absorbed from plant foods (non-heme iron) depends on the other types of foods eaten at the same meal.
- Foods containing heme iron (meat, poultry, and fish) enhance iron absorption from foods that contain non-heme iron (e.g., fortified cereals, some beans, and spinach).
- Foods containing vitamin C (see Dietary Sources of vitamin C) also enhance non-heme iron absorption when eaten at the same meal.
- Substances (such as polyphenols, phytates, or calcium) that are part of some foods or drinks such as tea, coffee, whole grains, legumes and milk or dairy products can decrease the amount of non-heme iron absorbed at a meal. Calcium can also decrease the amount heme-iron

absorbed at a meal. However, for healthy individuals who consume a varied diet that conforms to the Dietary Guidelines for Americans, the amount of iron inhibition from these substances is usually not of concern.

- Vegetarian diets are low in heme iron, but careful meal planning can help increase the amount of iron absorbed.
- Some other factors (such as taking antacids beyond the recommended dose or medicine used to treat peptic ulcer disease and acid reflux) can reduce the amount of acid in the stomach and the iron absorbed and cause iron deficiency.

| **Increased Iron Needs** | **Decreased Iron Intake and Absorption** |
|---|---|
| • Rapid growth<br>• Pregnancy<br>• Blood loss<br>  o Heavy menstrual periods<br>  o Frequent blood donation<br>  o Some stomach and intestinal conditions (food sensitivity, hookworms) | • Lack of heme iron sources in the diet (e.g., vegetarian diets)<br>• Low absorption<br>  o Taking antacids beyond the recommended dose or medicine used to treat peptic ulcer disease and acid reflux can reduce the amount of iron absorbed in the stomach. |

# Who is most at risk?

- Young children and pregnant women are at higher risk of iron deficiency because of rapid growth and higher iron needs.
- Adolescent girls and women of childbearing age are at risk due to menstruation.
- Among children, iron deficiency is seen most often between six months and three years of age due to rapid growth and inadequate intake of dietary iron. Infants and children at highest risk are the following groups:
  - Babies who were born early or small.
  - Babies given cow's milk before age 12 months.
  - Breastfed babies who after age 6 months are not being given plain, iron-fortified cereals or another good source of iron from other foods.
  - Formula-fed babies who do not get iron-fortified formulas.
  - Children aged 1–5 years who get more than 24 ounces of cow, goat, or soymilk per day. Excess milk intake can decrease your child's desire for food items with greater iron content, such as meat or iron fortified cereal.
  - Children who have special health needs, for example, children with chronic infections or restricted diets.

# Signs and Symptoms of Iron Deficiency

Too little iron can impair body functions, but most physical signs and symptoms do not show up unless iron deficiency anemia occurs. Someone with early stages of iron deficiency may have no signs or symptoms. This is why it is important to screen for too little iron among high risk groups.

Signs of iron deficiency anemia include[12]

- Feeling tired and weak
- Decreased work and school performance
- Slow cognitive and social development during childhood
- Difficulty maintaining body temperature
- Decreased immune function, which increases susceptibility to infection
- Glossitis (an inflamed tongue)

# How is iron deficiency detected?

Your doctor or healthcare provider will do blood tests to screen for iron deficiency. No single test is used to diagnose iron deficiency. The most common tests for screening are

- Hemoglobin test (a test that measures hemoglobin which is a protein in the blood that carries oxygen)
- Hematocrit test (the percentage of red blood cells in your blood by volume)
  These tests show how much iron is in your body. Hemoglobin and hematocrit levels usually aren't decreased until the later stages of iron deficiency, i.e., anemia.

Sometimes other blood tests are used to confirm that anemia is due to iron deficiency. These might include

- Complete blood count (to look at the number and volume of the red blood cells)
- Serum ferritin (a measure of a stored form of iron)
- Serum iron (a measure of the iron in your blood)
- Transferrin saturation (a measure of the transported form of iron)
- Transferrin receptor (a measure of increased red blood cell production)

# How is iron deficiency treated?

- If you are found to have an iron deficiency, it is important to see your healthcare provider for treatment. Your treatment will depend on factors such as your age, health, and cause of iron deficiency.
- If your doctor or health care provider thinks that you have iron deficiency she or he may prescribe iron supplements for you to take and then ask that you return after a period to have your hemoglobin or hematocrit tested.
- If your healthcare provider determines that the iron deficiency is due to a diet low in iron, you might be told to eat more iron-rich foods. Your health care provider may also prescribe an iron supplement for you.

Again, it is important to be diagnosed by your healthcare provider because iron deficiency can have causes that aren't related to your diet. Your healthcare provider's recommendations will be specific to your needs.

# What can I do to prevent iron deficiency?

In general, you can eat a healthful diet that includes good sources of iron. A healthful diet includes fruits, vegetables, whole grains, fat free or nonfat milk and milk products, lean meats, fish, dry beans, eggs, nuts, and is low in saturated fat, trans fats, cholesterol, salt, and added sugars.

In addition to a healthful diet that includes good sources of iron, you can also eat foods that help your body absorb iron better. For example, you can eat a fruit or vegetable that is a good source of vitamin C (see table on Dietary Sources of vitamin C) with a food or meal that contains non-heme iron (see table below for Dietary Sources of Iron). Vitamin C helps your body absorb the non-heme iron foods you eat, especially when the food containing non-heme iron and the vitamin-C rich food are eaten at the same meal.

The following recommendations are for specific groups who are at greater risk for iron deficiency.

**Babies**

- If possible, breastfeed your baby for at least 12 months and starting at 4 to 6 months of age, give your baby plain, iron-fortified infant cereal and/or pureed meat. Just two or more servings a day can meet a baby's iron needs at this age. Meats should be home prepared or commercially prepared plain pureed (chopped until smooth in a blender) meats.
- When your baby is about 6 months of age, include a feeding per day of foods rich in vitamin C with foods that are rich in non-heme iron to improve iron absorption.
- If you can't breastfeed, use iron-fortified formula.
- Don't give low-iron milks (e.g. cow's milk, goat's milk, and soy milk) until your baby is at least 12 months old.
- If your baby was born early or small, talk to your doctor about giving iron drops to your baby.
- If your baby can't get two or more servings per day of iron rich foods (such as iron-fortified cereal or pureed meats), talk to your doctor about giving iron drops to your baby.

**Young children (aged 1–5 years)**

- After your child is one year old, give no more than three 8 ounce servings of whole cow, goat, or soy milk per day. After your child is 2 years old, low fat or nonfat milks should be used in place of whole milks. Vitamin D-fortified milk is a good source of calcium and vitamin D, but not iron.
- Give your child a diet with iron-rich foods such as iron-fortified breads and iron-fortified cereals and lean meats. See Dietary Sources of Iron
- Include fruits, vegetables or juices that are rich in vitamin C. Vitamin C helps your child absorb non-heme iron especially when the food that is a source of non-heme iron and the vitamin C-rich food are eaten at the same meal. See Dietary Sources of Vitamin C.

**Adolescent girls and women of childbearing age**

- Eat iron-rich foods. See Dietary Sources of Iron.
- Eat foods that are vitamin C sources. Vitamin C helps your body absorb non-heme iron especially when the food that is a source of non-heme iron and the vitamin C-rich food are eaten at the same meal. See Dietary Sources of Vitamin C.
- Eat lean red meats, poultry, and fish. The iron in these foods is easier for your body to absorb than the iron in plant foods.

**Pregnant women**

- Eat iron-rich foods. See Dietary Sources of Iron.
- Eat foods that are vitamin C sources. Vitamin C helps your body absorb non-heme iron especially when the food that is a source of non-heme iron and the vitamin-C rich food are eaten at the same meal. See Dietary Sources of Vitamin C below.
- Eat lean red meats, poultry, and fish. The iron in these foods is easier for your body to absorb than the iron in plant foods.
- Talk to your doctor about taking an iron supplement.

# How much iron do I need?

If you have already been diagnosed with iron deficiency, talk to your doctor or healthcare provider about treatment. For healthy individuals, the Recommended Dietary Allowance (RDA) for iron is listed in the following table.

| **Recommended Dietary Allowance (RDA) for iron by age and sex.** | | |
|---|---|---|
| **Age/Group** | **Life Stage** | **Iron (mg/day)** |
| **Infants** | 0–6 months | 0.27* |
| | 7–12 months | 11 |
| **Children** | 1–3 years | 7 |
| | 4–8 years | 10 |
| **Males** | 9–13 years | 8 |
| | 14–18 years | 11 |
| | 19–30 years | 8 |
| | 31–50 years | 8 |
| | 51–70 years | 8 |
| | >70 years | 8 |
| **Females** | 9–13 years | 8 |
| | 14–18 years | 15 |
| | 19–30 years | 18 |
| | 31–50 years | 18 |
| | 51–70 years | 8 |
| | >70 years | 8 |
| **Pregnant Women** | 14–18 years | 27 |
| | 19–30 years | 27 |
| | 31–50 years | 27 |
| **Lactating Women** | 14–18 years | 10 |
| | 19–30 years | 9 |
| | 31–50 years | 9 |

*This value is an Adequate Intake (AI) value. AI is used when there is not enough information known to set a Recommended Dietary Allowance (RDA).
Source: Dietary Reference Intakes, Institute of Medicine, Food and Nutrition Board.* (PDF-86k)

# Dietary Sources of Iron

Food Sources of Iron ranked by milligrams of iron per standard amount; also calories in the standard amount. (All amounts listed provide 10% or more of the Recommended Dietary Allowance (RDA) for teenage and adult females, which is 18 mg/day.)

| **Food, Standard Amount** | **Iron (mg)** | **Calories** |
|---|---|---|
| Clams, canned, drained, 3 oz | 23.8 | 126 |
| *Fortified dry cereals (various), about 1 oz | 1.8 to 21.1 | 54 to 127 |
| Cooked oysters, cooked, 3 oz | 10.2 | 116 |
| Organ meats (liver, giblets), cooked, 3 oza | 5.2 to 9.9 | 134 to 235 |
| *Fortified instant cooked cereals (various), 1 packet | 4.9 to 8.1 | Varies |
| *Soybeans, mature, cooked, ½ cup | 4.4 | 149 |
| *Pumpkin and squash seed kernels, roasted, 1 oz | 4.2 | 148 |

| | | |
|---|---|---|
| *White beans, canned, ½ cup | 3.9 | 153 |
| *Blackstrap molasses, 1 Tbsp | 3.5 | 47 |
| *Lentils, cooked, ½ cup | 3.3 | 115 |
| *Spinach, cooked from fresh, ½ cup | 3.2 | 21 |
| Beef, chuck, blade roast, cooked, 3 oz | 3.1 | 215 |
| Beef, bottom round, cooked, 3 oz | 2.8 | 182 |
| *Kidney beans, cooked, ½ cup | 2.6 | 112 |
| Sardines, canned in oil, drained, 3 oz | 2.5 | 177 |
| Beef, rib, cooked, 3 oz | 2.4 | 195 |
| *Chickpeas, cooked, ½ cup | 2.4 | 134 |
| Duck, meat only, roasted, 3 oz | 2.3 | 171 |
| Lamb, shoulder, cooked, 3 oz | 2.3 | 237 |
| *Prune juice, ¾ cup | 2.3 | 136 |
| Shrimp, canned, 3 oz | 2.3 | 102 |
| *Cowpeas, cooked, ½ cup | 2.2 | 100 |
| Ground beef, 15% fat, cooked, 3 oz | 2.2 | 212 |
| *Tomato puree, ½ cup | 2.2 | 48 |
| *Lima beans, cooked, ½ cup | 2.2 | 108 |
| *Soybeans, green, cooked, ½ cup | 2.2 | 127 |
| *Navy beans, cooked, ½ cup | 2.1 | 127 |
| *Refried beans, ½ cup | 2.1 | 118 |
| Beef, top sirloin, cooked, 3 oz | 2.0 | 156 |
| *Tomato paste, ¼ cup | 2.0 | 54 |

Food Sources of iron are ranked by milligrams of iron per standard amount; also calories in the standard amount. (All amounts listed provide 10% or more of the Recommended Dietary Allowance (RDA) for teenage and adult females, which is 18 mg/day.) a High in cholesterol.
*These are non-heme iron sources. To improve absorption, eat these with a vitamin-C rich food.

Source: USDA/HHS Dietary Guidelines for Americans, 2005
Nutrient values from Agricultural Research Service (ARS) Nutrient Database for Standard Reference, Release 17. Foods are from ARS single nutrient reports, sorted in descending order by nutrient content in terms of common household measures. Food items and weights in the single nutrient reports are adapted from those in the 2002 revision of USDA Home and Garden Bulletin No. 72, Nutritive Value of Foods. Mixed dishes and multiple preparations of the same food item have been omitted from this table.

# Dietary Sources of Vitamin C

| Food, Standard Amount | Vitamin C (mg) | Calories |
|---|---|---|
| Guava, raw, ½ cup | 188 | 56 |
| Red bell pepper, raw, ½ cup | 142 | 20 |
| Red bell pepper, cooked, ½ cup | 116 | 19 |
| Kiwi fruit, 1 medium | 70 | 46 |
| Orange, raw, 1 medium | 70 | 62 |
| Orange juice, ¾ cup | 61 to 93 | 79 to 84 |
| Green bell pepper, raw, ½ cup | 60 | 15 |
| Green bell pepper, cooked, ½ cup | 51 | 19 |
| Grapefruit juice, ¾ cup | 50 to 70 | 71 to 86 |
| Vegetable juice cocktail, ¾ cup | 50 | 34 |
| Strawberries, raw, ½ cup | 49 | 27 |
| Brussels sprouts, cooked, ½ cup | 48 | 28 |
| Cantaloupe, ¼ medium | 47 | 51 |

| | | |
|---|---|---|
| Papaya, raw, ¼ medium | 47 | 30 |
| Kohlrabi, cooked, ½ cup | 45 | 24 |
| Broccoli, raw, ½ cup | 39 | 15 |
| Edible pod peas, cooked, ½ cup | 38 | 34 |
| Broccoli, cooked, ½ cup | 37 | 26 |
| Sweet potato, canned, ½ cup | 34 | 116 |
| Tomato juice, ¾ cup | 33 | 31 |
| Cauliflower, cooked, ½ cup | 28 | 17 |
| Pineapple, raw, ½ cup | 28 | 37 |
| Kale, cooked, ½ cup | 27 | 18 |
| Mango, ½ cup | 23 | 54 |

Food sources of vitamin C are ranked by milligrams (mg) of vitamin C per standard amount; also calories in the standard amount. (All amounts listed provide 20% or more of the Recommended Dietary Allowance (RDA) of 90 mg/day for adult men.)

Source: USDA/HHS Dietary Guidelines for Americans, 2005
Nutrient values from Agricultural Research Service (ARS) Nutrient Database for Standard Reference, Release 17. Foods are from ARS single nutrient reports, sorted in descending order by nutrient content in terms of common household measures. Food items and weights in the single nutrient reports are adapted from those in the 2002 revision of USDA Home and Garden Bulletin No. 72, Nutritive Value of Foods. Mixed dishes and multiple preparations of the same food item have been omitted from this table.

# Iron Overload and Hemochromatosis

Iron overload is the accumulation of excess iron in body tissues. Hemochromatosis is the disease resulting from significant iron overload. Hemochromatosis can have genetic and non-genetic causes. For more information, see Iron Overload and Hemochromatosis

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# Evidence #4: Down syndrome is a developmental disorder caused by an extra copy of chromosome 21.

# DOWN SYNDROME

### What is Down syndrome?

**Down syndrome is a developmental disorder caused by an extra copy of chromosome 21 (which is why the disorder is also called "trisomy 21"). Having an extra copy of this chromosome means that each gene may be producing more protein product than normal. Cells seem to tolerate this better than having not enough protein, or having altered protein due to a mutation in the DNA sequence. However, producing too much protein can also have serious consequences, as seen in Down syndrome. Genes on chromosome 21 that specifically contribute to the various symptoms of Down syndrome are now being identified.**

### How do people get Down syndrome?

Down syndrome is typically caused by what is called nondisjunction. If a pair of number 21 chromosomes fails to separate during the formation of an egg (or sperm), this is referred to as nondisjunction. When that egg unites with a normal sperm to form an embryo, that embryo ends up with three copies of chromosome 21 instead of the normal two. The extra chromosome is then copied in every cell of the baby's body.

Interestingly, nondisjunction events seem to occur more frequently in older women. This may explain why the risk of having a baby with Down syndrome is greater among mothers age 35 and older.

In rare cases Down syndrome is caused by a Robertsonian translocation, which occurs when the long arm of chromosome 21 breaks off and attaches to another chromosome at the centromere. The carrier of such a translocation will not have Down syndrome, but can produce children with Down syndrome.

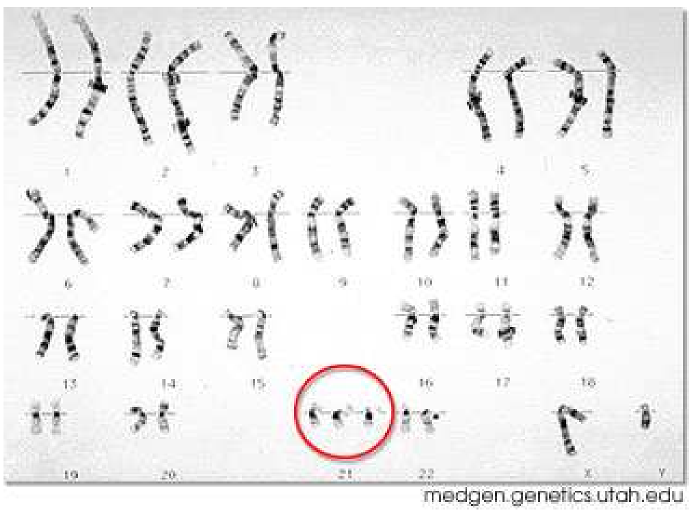
### What are the symptoms of Down syndrome?

People with Down syndrome have very distinct facial features: a flat face, a small broad nose, abnormally shaped ears, a large tongue, and upward slanting eyes with small folds of skin in the corners.

People with Down syndrome have an increased risk of developing a number of medically significant problems: respiratory infections, gastrointestinal tract obstruction (blocked digestive tract), leukemia, heart defects, hearing loss, hypothyroidism, and various eye abnormalities. They also exhibit moderate to severe mental retardation; children with Down syndrome usually develop more slowly than their peers, and have trouble learning to walk, talk, and take care of themselves.

Because of these medical problems most people with Down syndrome have a decreased life expectancy. About half live to be 50 years of age.

### How do doctors diagnose Down syndrome?



Two types of tests check for Down syndrome during a woman's pregnancy: screening and diagnostic tests.

Screening tests identify a mother who is likely carrying a baby with Down syndrome. The most common screening tests are the Triple Screen and the Alpha-Fetoprotein Plus. These tests measure levels of certain substances in the blood.

Alternatively, ultrasounds (which use sound waves to look inside the mother's uterus) allow the doctor to examine the fetus in the womb for the physical signs of Down syndrome.

To confirm a positive result identified in a screening test, one of the following diagnostic tests can be performed: chorionic villus sampling (CVS), amniocentesis, and percutaneous umbilical blood sampling (PUBS). Each takes a sample from the placenta, amniotic fluid, or umbilical cord, respectively, to examine the baby's chromosomes and determine if he or she has an extra chromosome 21.

If Down syndrome is not diagnosed in the womb, doctors can usually recognize it after the baby is born by the distinctive facial features. The diagnosis is confirmed with a karyotype - an examination of the baby's chromosomes.

### How is Down syndrome treated?

No cure exists for Down syndrome. But physical therapy and/or speech therapy can help people with the disorder develop more normally. Screening for common medical problems associated with the disorder, followed by corrective surgery, can often improve quality of life. Moreover, enriched environments significantly increase their capacity to learn and lead a meaningful life.

### Interesting facts about Down syndrome

Down syndrome is really the only trisomy compatible with life. Only two other trisomies have been observed in babies born alive (trisomies 13 and 18), but babies born with these trisomies have only a 5% chance of surviving longer than one year.

In 90% of Trisomy 21 cases, the additional chromosome comes from the mother's egg rather than the father's sperm.

Down syndrome is the most common genetic disorder caused by a chromosomal abnormality. It affects 1 out of every 800 to 1,000 babies.

Down syndrome was originally described in 1866 by John Langdon Down. It wasn't until 1959 that a French doctor, named Jerome Lejeune, discovered it was caused by the inheritance of an extra chromosome 21.

**Evidence # 5: Adequate calcium consumption and weight bearing physical activity build strong bones, optimizes bone mass, and may reduce the risk of osteoporosis later in life.**

# Calcium and Bone Health

Bones play many roles in the body. They provide structure, protect organs, anchor muscles, and store calcium. Adequate calcium consumption and weight bearing physical activity build strong bones, optimizes bone mass, and may reduce the risk of osteoporosis later in life.

For more information on bone health and osteoporosis please visit the National Osteoporosis Foundation.*

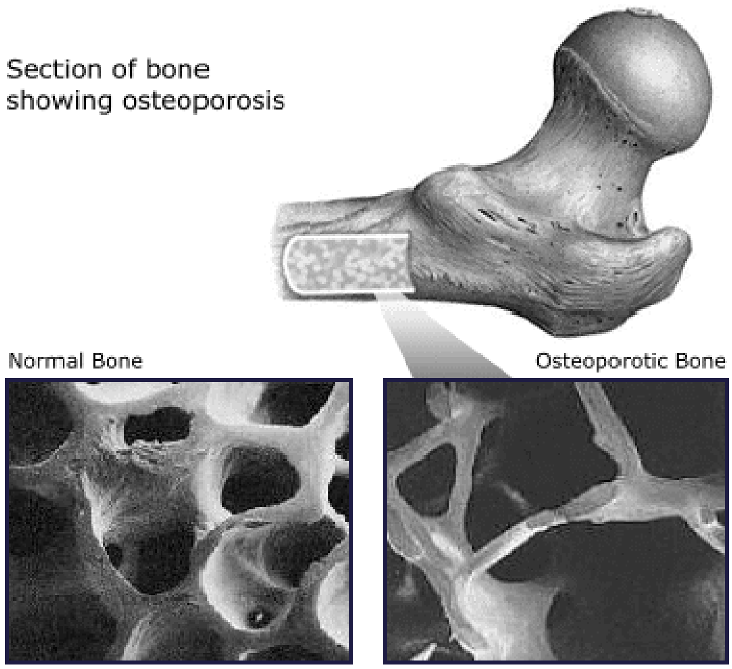
## Peak Bone Mass

Peak bone mass refers to the genetic potential for bone density. By the age of 20, the average woman has acquired most of her skeletal mass. A large decline in bone mass occurs in older adults, increasing the risk of osteoporosis. For women this occurs around the time of menopause.

It is important for young girls to reach their peak bone mass in order to maintain bone health throughout life. A person with high bone mass as a young adult will be more likely to have a higher bone mass later in life. Inadequate calcium consumption and physical activity early on could result in a failure to achieve peak bone mass in adulthood.

## Osteoporosis

Osteoporosis or "porous bone" is a disease of the skeletal system characterized by low bone mass and deterioration of bone tissue. Osteoporosis leads to an increase risk of bone fractures typically in the wrist, hip, and spine.

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While men and women of all ages and ethnicities can develop osteoporosis, some of the risk factors for osteoporosis include those who are

- Female
- White/Caucasian
- Post menopausal women
- Older adults
- Small in body size
- Eating a diet low in calcium
- Physically inactive

To find out more about the prevalence and risk factors associated with osteoporosis, please visit the National Osteoporosis Foundation.*

## Calcium

Calcium is a mineral needed by the body for healthy bones, teeth, and proper function of the heart, muscles, and nerves. The body cannot produce calcium; therefore, it must be absorbed through food. Good sources of calcium include

- Dairy products—*low fat or nonfat milk, cheese, and yogurt*
- Dark green leafy vegetables—*bok choy and broccoli*

- Calcium fortified foods—*orange juice, cereal, bread, soy beverages, and tofu products*
- Nuts—*almonds*

Recommended amount of calcium vary for individuals. Below is a table of adequate intakes as outlined by the National Academy of Science.

**Recommended Calcium Intakes**

| Ages | Amount mg/day |
|---|---|
| **Birth–6 months** | 210 |
| **6 months–1 year** | 270 |
| **1–3** | 500 |
| **4–8** | 800 |
| **9–13** | 1300 |
| **14–18** | 1300 |
| **19–30** | 1000 |
| **31–50** | 1000 |
| **51–70** | 1200 |
| **70 or older** | 1200 |
| **Pregnant & Lactating** | 1000 |
| **14–18** | 1300 |
| **19–50** | 1000 |

Source: Dietary Reference Intakes for Calcium, National Academy of Sciences, 1997

Vitamin D also plays an important role in healthy bone development. Vitamin D helps in the absorption of calcium (this is why milk is fortified with vitamin D).

For more information on calcium and children visit the National Institute of Child Health and Human Development (NICHD).

## Weight-Bearing Physical Activity

Regular physical activity has been associated with many positive health benefits including strong bones. Like proper calcium consumption, adequate weight-bearing physical activity early in life is important in reaching peak bone mass. Weight-bearing physical activities cause muscles and bones to work against gravity. Some examples of weight bearing physical activities include

- Walking, Jogging, or running
- Tennis or Racquetball
- Field Hockey
- Stair climbing
- Jumping rope
- Basketball
- Dancing
- Hiking
- Soccer
- Weight lifting

Incorporating weight-bearing physical activity into an exercise plan is a great way to keep bones healthy and meet physical activity recommendations set forth in the Dietary Guidelines for Americans.

**Adults**: Engage in at least 30 minutes of moderate physical activity [on] most, preferably all, days of the week

**Children**: Engage in at least 60 minutes of moderate physical activity [on] most, preferably all, days of the week

For more information, visit Dietary Guidelines for Americans.

## Selected Resources

**Best Bones Forever!**

A bone health campaign for girls and their BFFs to "grow strong together and stay strong forever!"

**Also available for Parents.**

**Bone Health and Osteoporosis: A Surgeon General's Report**

By 2020, one in two Americans aged 50 years or older will be at risk for fractures from osteoporosis or low bone mass.

**NIH National Resource Center**

Information about the prevention, early detection, and treatment of osteoporosis and related bone diseases.

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