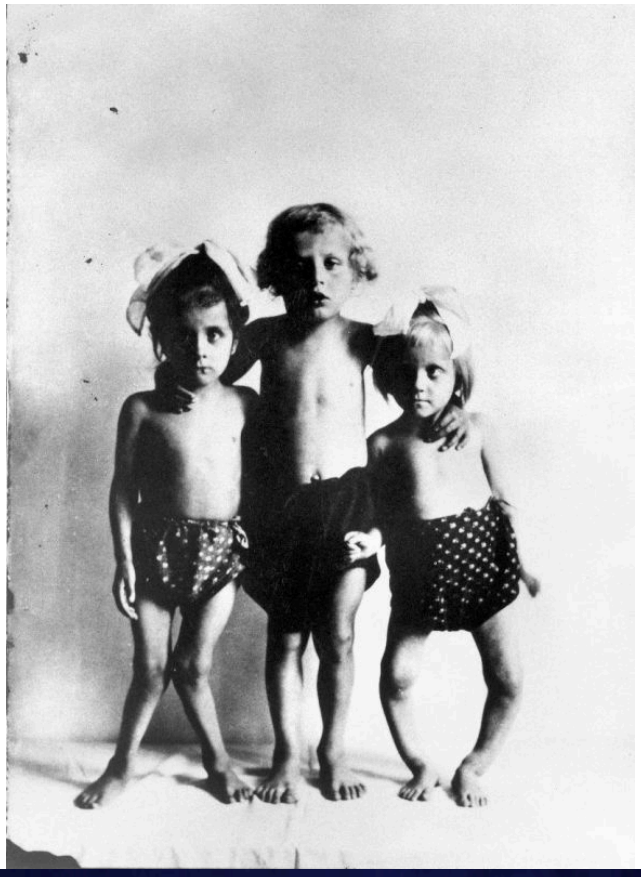
6.2.3

Factors that Influence Bone Growth

Since we are not all the same height there are obviously factors that regulate and influence bone growth. The principal players here are genetics, nutrition and hormones.

Genetics. It is obvious that genetics plays a big role in how tall we are. Look at different families and you will see that if the parents are both tall their kids will probably be tall as well. On the other hand, if the parents are short, their kids tend to be shorter. Obviously, genetics can be very complex and there are several genes involved in regulating height so we do see exceptions to this general rule.

Nutrition. Nutrition has a large impact on growth. Even if someone has the genetics to be a certain height, if they do not get proper nutrition they will not achieve their genetically programmed height. Additionally, the bones may be weak or malformed if the proper nutrients are not provided. Two key vitamins related to bone growth are vitamin D and vitamin C. Vitamin D plays a crucial role in calcium metabolism. The bones of children who do not get enough vitamin D are unable to efficiently incorporate calcium into the bones resulting in a condition known as Ricketts. Recall that the mineral component (hydroxyapatite) of the bone gives it weight bearing strength. One outcome of this condition is extremely bowed legs.



Bone Deformation in Ricketts from Vitamin D deficiency. Bottom photo shows two adult femora, one exhibiting childhood rickets.

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If the vitamin D deficiency occurs in an adult it results in a condition known as osteomalacia. This condition is characterized by an increased risk of bone fracture, pain, and collapse of the vertebral column.

Vitamin C is required for collagen synthesis. Again, recall that collagen gives the bone tensile strength allowing it to bend somewhat without breaking. The bones of individuals that are vitamin C deficient are very brittle and break easily. One condition associated with vitamin C deficiency is scurvy (as in the Pirates of the Caribbean, "you scurvy dog"). Collagen is a structural protein with many important functions, including its role in bone.

X-ray showing scurvy line. *By Hussein A. Algahtani,a Abduljaleel P. Abdu,a Imad M. Khojah,b and Ali M. Al-Khathaamic [CC BY 2.5 (http://creativecommons.org/licenses/by/2.5)], via Wikimedia Commons Link: https://upload.wikimedia.org/wikipedia/commons/8/80/ASM-30-325-g003.jpg*

The old-time sailors suffering from scurvy would lose teeth (periodontal ligaments) and have open sores (poor wound healing) among other things. The British sailors found that if they took a barrel of limes and gave one or two to the sailors periodically they could prevent scurvy (hence the nickname "limey" for the British sailors).

Hormones. Several hormones are important for normal bone growth. Growth hormone from the anterior pituitary, as the name implies, regulates general body growth, including the growth of bones. Lack of growth hormone during the growing years results in a type of dwarfism (hypopituitary dwarfism). Individuals suffering from this disorder will be very small but have normal body proportions. This type of dwarfism can be treated by administering growth hormone during the growing years. Excess growth hormone, on the other hand can result in gigantism (gigantism), think of Andre the Giant (*The Princess Bride*). This condition is usually the result of a growth hormone secreting tumor. If the condition persists after puberty (long bones have stopped growing), some bones will continue to grow, specifically the bones of the hands and feet, the jaw bone, the skull bones, particularly the supraorbital ridges. This condition of excess growth hormone after puberty is called acromegaly. The excess growth hormone also stimulates growth of some of the soft tissues such as the tongue and the abdominal organs, again picture Andre the Giant.

Another important hormone for normal growth is Thyroid hormone, produced by the thyroid gland. Although excess thyroid hormone does not cause excessive growth, lack of it can result in stunted growth. Thyroid hormone is required

for the normal action of growth hormone. It is also necessary for normal development of the nervous system. If a child lacks thyroid hormone they will not grow normally and their mental development will be impaired.

Steroid hormones from the gonads, testosterone in men and estrogen in women, also have an impact on bone growth. As mentioned above, with the onset of puberty comes a surge in growth. This surge is the result of increased levels of steroid hormones. Both testosterone and estrogen increase the rate of bone growth (both runners see the finish line and begin to run faster). The effect, however, is greater on the osteoblasts and bone formation than it is on cartilage growth, hence the second runner begins to catch the leader. Therefore, the growth surge is followed by a cessation of growth. Since estrogen is more efficient in causing the growth plates to close, it speeds up the second runner more than testosterone does, girls tend to stop growing earlier, usually around age 18. Boys, on the other hand, may continue to grow until around age 21. These differences explain why on average boys are taller than girls, they essentially have a longer time to grow.