Amazing Colossal Science

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Submitted for your approval

It is Amazing what Colossal science one can learn from a film like THE AMAZING COLOSSAL MAN (1957). Bill Warren, in his *Keep Watching the Skies* book says, TACM "is crass, heavy-handed and cumbersome". Videohound gives it two "bones" and refers to it as a "standard '50s Sci-fi film about atomic radiation". For me, I could develop an entire semester class just discussing all the interesting science in this film. For example, potential topics could include radiation biology, dermatology, endocrinology, cardiology, physiology, biochemical metabolism, psychiatry, stem cells, and new tissue regeneration from burns. Yes, all of this from a film like TACM. Quite remarkable which is why this film is one of my favorites from the 1950s.

I was 5 years old when my parents took me to see TACM at the theater and was quite taken by the story line. To remind you, this was during the Cold War era when the threat of atomic bombs was on everyone's mind and the basic atomic radiation plot fed into those fears. Though at the time a lot of this was over my head the film nevertheless was scary to me.

At the core of the film, written by Mark Hanna and Bert I. Gordon (aka, Mr. BIG), is radiation induced gigantism. For the film's major plot, a human, Colonel Glen Manning, is exposed to a sudden and normally lethal dose of radiation via a plutonium bomb explosion but, instead, survives the blast and grows into a proportionally correct giant.

So, as far as the science in TACM goes we first begin with radiation, then tissue rejuvenation, metabolism, growth and hormones, followed by cardiology, and psychiatric issues. All in all a tough few days for Colonel Manning.

At the film's beginning, at the Desert Rock proving grounds in Nevada, the military is in the process of detonating a plutonium bomb and all was in ready for the moment. However, the plutonium bomb did not detonate right away when triggered with a military announcer explaining the delay, "…chain reaction did not complete its cycle as calculated". As a military brass comments, this is the "first plutonium bomb" so initial miscalculations may be realistically acceptable though doubtful. Along with Colonel Manning are many other soldiers in a trench near ground zero of the blast. The soldiers are there to receive the blast "under simulated combat conditions" so there were others who were also exposed to radiation. Did any of those soldiers also receive a dose of radiation similar to that of Manning? What happened to them?

Meanwhile, while waiting for the blast, a private plane crash landed near the detonation site and in an attempt to save them (this remarkable Good Samaritan, humanitarian deed seems to have gone unnoticed) Col. Manning was caught in the blast and took a direct hit of plutonium radiation. He instinctively covered his eyes with his arms during the blast but the rest of his body was directly exposed to the heat and the radiation. His shirt was mostly blown/burnt off from the blast and his skin had immediate radiation burns, not to mention his lack of hair. All in all quite an effective scene for its time and one that made a big impression on me when I saw it at the theater when it first came out.

Radioactive Rant

The first sustaining nuclear chain reaction was performed on December 2, 1942 in an abandoned handball court at the University of Chicago's Stagg Field by Enrico Fermi. Less that three years later the first nuclear bombs were dropped on Hiroshima and Nagasaki which brought a rapid end to World War II. The first atomic bomb test, codenamed "Trinity", and detonated on July 16, 1945, near Alamogordo, New Mexico, had used plutonium as its fissionable material. Since this was the "first plutonium bomb" explosion then Colonel Manning must have been present at this detonation. The implosion design of "the Gadget", as the Trinity device was code-named, used conventional explosive lenses to compress a sphere of plutonium into a supercritical mass, which was simultaneously showered with neutrons from the "Urchin", an initiator made of polonium and beryllium. Together, these radionuclides caused a runaway chain reaction and subsequent explosion. The Gadget weapon weighed over 4 tons, although it used just 6.2 kg of plutonium in its core. Even so, about 20% of the plutonium used in the Trinity weapon underwent fission, resulting in an explosion with an energy equivalent to approximately 20,000 tons of TNT, so this explosion was only one fifth of its potential.

Fission vs fusion

There are two different types of nuclear reactions in which a large amount of energy is released. Nuclear fission is the splitting of a large atom into two or more smaller ones whereas nuclear fusion is the fusing of two or more smaller (or lighter) atoms into a larger one. In simple terms, fusion fuses atoms lighter than iron where fission divides atoms heavier than iron. The two major radioisotopes used for nuclear fission are uranium-235 (Ur-235) and plutonium-239 (Pu-239) and when they are done releasing their energy very stable lead-207 (Pb-207) is the end result. Just so you gentle readers know, the ratio of radioisotopes Ur-238 to Ur-235 is used by geologists to determine the ages of minerals since their decay levels can be precisely determined. When someone says that dinosaur bones are 100 million years old they know this by the Ur-238/Ur-235 ratio.

Fission reactions do not normally occur in nature whereas fusion reactions occur primarily in stars, such as our sun, where four hydrogen atoms fuse to produce a helium atom thereby releasing a significant amount of heat. Fission reactions produce many highly radioactive particles whereas fusion reactions produce fewer radioactive particles. A nuclear bomb based on fission is also known as an atomic or atom bomb whereas a hydrogen bomb uses a fission reaction to trigger a fusion reaction so it is much more explosive and therefore dangerous.

The atomic bomb dropped on Hiroshima on August 6, 1945 was codenamed "Little Boy" and used Ur-235 as its fissionable material and not plutonium. The second atomic bomb, codenamed "Fat Man" that was dropped on Nagasaki three days later did use Pu-239 as its fissionable material. Only after the announcement of the first atomic bombs was the existence of plutonium made public since it is a man-made radioisotope (very little exists in nature so it must be manufactured).

There are 15 different plutonium radioisotopes and collectively are a class of highly toxic and unstable chemicals whose radioactivity is measured by the number of atoms disintegrating per unit time. Plutonium radioisotopes decay to uranium by emitting many types of radiation as high-energy alpha particles (in the form of an energetic helium nucleus, He^{++}), medium-energy gamma rays, x-rays, and beta particles. The main isotope in weapon-grade plutonium is Pu-239 and it has a long half-life of 24,000 years so its potential damage is far ranging. It takes about 10 kilograms of nearly pure Pu-239 to make a plutonium bomb. Producing this requires 30 megawatt-years of reactor operation, with frequent fuel changes and reprocessing of the 'hot' fuel. Therefore, weapons-grade plutonium needs to be made in special production reactors by burning natural uranium fuel.

Radiation biology

An atom is composed of its nucleus and surrounding electrons. The bigger the atom the more components of its nucleus, mostly made up of protons and neutrons, and the more electrons. When the nucleus decays or electrons come off a lot of energy is released oftentimes in the form of radiation.

First of all, it should be noted that not all radiation is the same. Radiation is the physical process in which energetic particles or waves travel through various types of materials or space. There are two major types of radiation, ionizing and non-ionizing with ionizing being the most deadly since it has enough energy to ionize an atom; the ions produced by ionizing radiation have the potential to damage DNA and therefore can cause biological mutations many of which would be fatal. (Examples of non-ionizing radiation are radio waves, heat or visible light.) These ionized particles or waves "radiate" or travel in all directions from its source and as such are capable of being measured in three dimensions.

There are three major types of ionizing radiation, alpha, beta, and gamma and they are classified as to their degree of energy. Each type of radiation has a different biological effect because they transfer their energy to tissues in different ways. The lowest energy are alpha particles and these can be stopped by a sheet of paper. The clothes you are wearing are sufficient enough to stop alpha particle radiation. Alpha particles do not penetrate skin and therefore there is no damage to overall health. In reality, alpha particles only penetrate just a few centimeters of air. However, highly energetic alpha particles are in cosmic rays and can penetrate the body but are stopped by our atmosphere and deflected by earth's magnetic field so they are only a problem for astronauts.

Alpha radiation emitting isotopes are only a problem when ingested (breathed or swallowed) because this brings the radiation directly close enough to tissues as to be dangerous. In terms of biological effectiveness ingested alpha radiation is the most deadly because of the damage the ionizing particle leaves in its wake being so close to cells and tissues (and therefore, DNA). At close range alpha particles are at least 20 times more deadly at cell damage than gamma rays or x-rays. Examples of deadly alpha radiation emitters are radium, radon, and polonium.

Beta radiation particles have a higher level of ionizing radiation energy than alpha particles, though not as much as gamma particles, and can be stopped with thin metals such as an aluminum plate. Beta radiation consists of energetic electrons from radioactive isotopes and can be stopped by a few centimeters of plastic or a few millimeters of metal. Beta particle radiation occurs when a neutron decays into an atom's proton thereby releasing the radioactive beta particle. Radioisotopes that release beta radiation are sometimes used in the clinic to treat superficial tumors so when you hear that cancer was being irridiated means that beta radiation was used.

Another source of beta radiation is when neutrons, particles in an atom's nucleus, are released. Neutrons are the only type of ionizing radiation that can make other materials or objects radioactive by directly ionizing them. This is the primary commercial method to make radioisotopes useful in medical and industrial applications. Neutrons collide with atomic nuclei thereby creating unstable radioisotopes that release radioactivity. When a neutron knocks an atom out of a molecule the atom's electrons are left behind and the chemical bond is broken resulting in free radicals that are biologically harmful. When a neutron hits an atom's nucleus think of a billiard ball striking another ball in which all the energy of the striking ball is transferred to the hit ball causing it to move away. High energy neutrons can travel hundreds to thousands of meters through air and several meters through common solids. Nuclear reactors use several meters thick water as a shield against neutron radiation.

Gamma radiation is the most energetic, strongest, and most deadly of radiation

particles and thick walls are needed to stop these particles. Gamma radiation occurs after a decaying atom's nucleus emits either alpha or beta radiation. Gamma radiation is composed of photons and these have neither mass or electric charge so they can penetrate much deeper through matter and are difficult to stop.

Another significant form of radiation released by nuclear bombs that can affect health is x-rays. X-rays are electromagnetic waves with very small wavelengths and the smaller the wavelength the higher the energy content. A packet of electromagnetic x-rays are called a photon and when an x-ray photon collides with an atom two events occur. If the photon is weak the atom could absorb the energy of the photon and boost an electron to a higher orbital level or if the photon is very energetic it could knock an electron away from its atom causing the atom to ionize. Ionized atoms are harmful to animal and human health. Generally, larger atoms are more likely to absorb x-ray photons than smaller ones. (Soft tissue in our bodies are composed of atoms smaller than the calcium atoms in our bones which is why x-rays are so effective and allow physicians to distinguish between tissue and bones when examining x-ray photos. These medical x-rays are of the low energy kind and not a real worry.)

One aspect unclear, and central to the level of radiation sustained by Manning, is how close was he to ground zero when the plutonium blast went off. If he was too close then he could have been easily disintegrated in the blast. Since he did survive then he must have been some distance away, just far enough to sustain some radiation damage but not enough to be fatal. However, it must also be pointed out that later in the film it was noted that the crashed plane and pilot that Manning was attempting to rescue could not be found, suggesting they were atomized. Manning could not have been that far away from the plane since he clearly saw it and was within running distance so there was a critical distance window that manning was just in when the blast went off. He was not too close to get atomized, nor close enough for extensive and deep skin burns. He was at the "just right Goldilocks baby bear" distance of getting enough radiation to mutate just the right amount of DNA that altered just the right number of genes to give just the right proportionally correct growth. Perhaps a meter closer or a meter farther away from the blast could have made all the difference. And so goes the wonderful world of SF cinema where everything is in the just right mode for all the screen fun to happen. Manning was just where he needed to be to get just the right amount of radiation to grow in just the right proportional way.

Health Issues

There are three principal routes by which plutonium (or any other radioisotope for that matter) can get into human beings who might be exposed to it: ingestion, inhalation, and contamination of open wounds. In total, Manning was not only

exposed to the initial bomb blast that caused severe burns to appear on his body thereby causing contamination of open wounds, but also Manning probably inhaled a significant amount of the radiation getting major doses into his body. And if the radioactive particles were in his mouth, very likely, they probably mixed with saliva and subsequently swallowed so he ingested radiation too.

The stomach does not absorb plutonium very well so ingestion, either via food or water, is not a significant hazard because plutonium passing through the gastro-intestinal tract is poorly taken up and is expelled from the body through natural processes before it can do harm. The main threat to humans comes from inhalation. When inhaled, plutonium can remain in the lungs depending upon its particle size and how well the particular chemical form dissolves. The chemical forms that dissolve less easily may lodge in the lungs or move out with phlegm, and either be swallowed or spit out. But, the lungs may absorb chemical forms that dissolve more easily and pass them into the bloodstream. While it is very difficult to create airborne dispersion of a heavy metal like plutonium, certain forms, including the insoluble plutonium oxide, at a particle size less than 10 microns (0.01 mm), are a hazard. If inhaled, which Manning did, then much of the material is immediately exhaled or is expelled by mucous flow from the lung airway bronchial system into the gastro-intestinal tract, as with any particulate matter. Some however will be trapped and readily transferred, first to the blood or lymph system and later to other parts of the body, notably the liver and bones. This had to have happened in Manning's case. It is here that the deposited plutonium's alpha radiation may eventually cause cancer via the mutation of DNA.

The most likely routes for internal contamination from plutonium radioisotopes are by ingestion or inhalation. People can inhale plutonium as a contaminant in dust and it can also be ingested with food or water. This is especially important for people who live near government weapons production or testing facilities who may have increased exposure. External exposure of plutonium to the body poses very little health risk since plutonium isotopes emit alpha radiation, and almost no beta or gamma radiation. In contrast, internal exposure to plutonium is an extremely serious health hazard. Internal exposure continues until the radioactive material is either flushed from the body by natural processes or decays. Inhaled or ingested plutonium is distributed to different organs and will remain there for days, months, or years until it decays or is excreted. Once internalized and in the blood stream, plutonium radioisotopes can most significantly affect lung, bone, liver, and other body organs. Plutonium that reaches body organs can stay in the body for decades and continue to decay and expose the surrounding tissues with harmful radiation thereby increasing the risk of cancer. Plutonium is also a toxic metal, and may cause damage to the kidneys.

However, the hazard from weapons grade Pu-239 is similar to that from any other alpha-emitting radionuclides that might be inhaled. It is less hazardous

than those that are short-lived and hence more radioactive, such as radon daughters, the decay products of radon gas, which (although in low concentrations) are naturally common and widespread in the environment.

Contamination of wounds has rarely occurred although thousands of people have worked with plutonium. Their health has been protected by the use of remote handling, protective clothing and extensive health monitoring procedures.

The ionizing radiation caused by plutonium disrupts molecules in cells and deposits energy in tissues, causing damage. Both immediate and delayed health risks occur. Observable effects occurring soon after receiving very large doses include hair loss, skin burns, nausea, and gastrointestinal distress or death (this is called Acute Radiation Syndrome). Long-term risks, including increased cancer risk, are a function of the specific radioisotopes involved and depend on the route, magnitude and duration of exposure. If Manning had out-lived the sequel, WAR OF THE COLOSSAL BEAST, then with all the radiation he received he most likely would have developed some sort of cancer and probably would have died from that.

For those exposed to large doses of radioactivity the emergency medical care to save their lives is the first priority. Effective patient decontamination is important to limit the spread of radioactive materials in the hospital, and to prevent exposure to other patients and staff. Typically, these patients are placed in isolation wards to help minimize contamination. Treatment to reduce the internal radioactive dose consists of using chelators, chemicals that tightly bind to the radioactive metal atoms, and flush them out of the body thereby reducing the radioisotope body burden. Some forms of radiation can stay in the body for years.

To minimize their exposure to radiation, called secondary contamination, the time people spend with the patient should be limited, they should avoid direct contact, maintain some sort of distance from the source, and use shielding or respiratory protection to prevent ingesting or inhaling any radioactive contamination. Patients exposed to excessive radiation have many tests taken to monitor their health and situation. The most common test is a blood test where the number and function of the patient's blood cells are analyzed. Since blood cells rapidly divide, compared to other cells in the body, defects brought about by the effects of radioactivity can be easily detected. These blood tests would be done frequently.

Despite being toxic both chemically and because of its ionizing radiation, plutonium is far from being "the most toxic substance on Earth" or so hazardous that "a speck can kill". Just so you gentle readers know there are substances in daily use that, per unit of mass, have equal or greater chemical toxicity (arsenic, cyanide, caffeine) and radiotoxicity (such as smoke detectors) than plutonium.

Dermatology or the skinny on skin

The study of skin is called dermatology. The primary purpose of skin is to serve as a barrier between the harsh and contaminated outside world and our sensitive and sterile internal body. The skin contains many specialized cells and structures that not only help maintain a proper body temperature but also plays an active role in our immune system in protecting us from disease. When skin becomes severely compromised then many health issues can result.

By definition, skin is the tissue above the superficial fascia where the first layers of muscle and nerves are located. Those tissues below the fascia are not considered skin. Skin is composed primarily of three layers. The upper or outer layer of skin is called the epidermis and is mostly composed of dead and dying cells and itself is composed of 5 different layers; as the cells move up these layers they push already formed cells further upwards to the surface where they flatten and die and subsequently are sloughed off. This is a natural cyclical process and it takes about 2 weeks to shed off dead surface cells. The thinnest epidermis is on the eyelids (0.05mm) and the thickest is on the palms of your hands and the soles of your feet (1.5mm). Though Manning did cover his eyes with his forearms he did so with his palms directly facing the blast so those skin cells were hardest hit.

The middle layer of skin is called the dermis that has the blood vessels and nerve endings. The dermis is primarily composed of 3 tissue layers and also varies in thickness and is 0.03mm on the eyelid and 3.0mm on the back. Within the dermal layer are many specialized cells such as the hair follicles, oil (sebaceous), scent (apocrine), and sweat (apocrine) glands, blood vessels and nerves. It is these nerves that transmit the sensations of pain, itch, touch, pressure, and temperature. When dermal cells die off they replace the sloughed off epidermal cells in a constant cycle.

The third lowest layer of the skin, the hypodermis or the subcutaneous tissue layer, is primarily a layer of fat and connective tissue. The larger blood vessels and nerves are located here. The size and thickness of this layer varies considerably throughout the body and from person to person. For Manning, it is unknown how much of this third layer was destroyed by the plutonium blast. And, of course, if any of these three major layers of skin were destroyed then complicated health issues can result and recouperation may take some time, perhaps several months for healing.

For burn victims, including radiation burn victims, there are two main considerations depending upon how much skin can be salvaged from what was left behind. Either a skin graft can be placed over already existing skin, irreguardless of which layers are still present, or over the fascia directly since no other skin would be available. Based on the image of Manning just after he took the brunt of the plutonium blast quite a lot of his skin was still present since we

could see very little, if any, of the underlying fascia muscle layer. As such, this could serve as a good foundation upon to which to place the necessary skin grafts. Even so, it is unclear which layers of Manning's skin were damaged and which layers of skin needed replacing. As a doctor says, "third degree burns on almost 100% of his body surface and the man still lives". The back of Manning should not have received any radiation induced burns since he was facing the blast so "100% of his body" is open for interpretation. Also, saying he had burns on "100% of his body" does not necessarily mean all *layers* of skin were destroyed. If you had a severe sunburn over 100% of your body you would be very sore but all layers of skin would still be there. After being exposed to the blast Manning was taken to a burn unit at a hospital and treated. Furthermore, the stem cells also present in the left over skin on Manning could then serve as a source of fresh replacement skin cells.

Since Manning took a direct radiation blast to the front of his body then this area should suffer the most radiation-induced burns. The skin on the back of his body would not of had such severe burns and could have potentially served as skin grafts for the rest of his body. Even so, all in all the entire surgical procedure to take care of Manning's destroyed skin would have taken many long hours with weeks of recuperation.

Since his skin tissues healed in such a rapid manner would suggest that only the top most superficial layer of skin, the epidermis, was burnt off by the heat of radiation and not the underlying dermal layers. This also suggests that Manning was indeed at the "just right Goldilocks" limit where just some of his skin was destroyed leaving enough behind that it served as the basis for self-repair. The underlaying dermal layers could have replenished the outer layer with new skin cells. If the underlaying dermal layers were also burnt off (most likely with such radiation) then the newly developed skin would have to come from other sources such as a back skin graft or by available stem cells. So you know it takes around 27 days for your skin epidermis to replenish and replace itself.

Here in the 21st Century synthetic skin is available for grafting and is an industry all by itself. During the production of TACM in the 1950s skin grafting techniques were relatively primitive and stem cells were very poorly understood so this technology would not have been available to them.

Body fluids

A doctor examining Manning says, "he's already lost enough body fluid to be fatal". Skin keeps fluids within the body and when skin is destroyed or becomes leaky then important and vital body fluids can ooze and leak out and can be life-threatening if severe enough. Body fluid or bodily fluids are liquids such as blood, saliva, sweat, urine, bile, milk, etc. that are located inside bodies. The dominant body fluid is water and approximately 60-65% of water in our body is contained within individual cells whereas the remaining 35-40% of body water is outside cells. There are three main compartments of fluids within our bodies.

One is the plasma of circulating blood (extracellular fluid), the second is the interstitial fluids between cells, and the third is that fluid located within cells (intracellular fluid). When the skin is destroyed as seen with burn victims then all of these compartments are compromised and life-threatening fluid loss can be an issue.

Radiation induced shock

One of the attending physicians commented that Manning will most likely, "die of shock before morning". Shock is a life-threatening condition that occurs when the body is not getting enough blood flow and this can damage multiple organs. People in shock usually have extremely low blood pressure. Shock requires immediate medical treatment and can get worse very rapidly. Shock can be caused by any condition that reduces blood flow, including heart malfunctions (like a heart attach or heart failure; cardiogenic shock), low blood volume (as with heavy bleeding or dehydration as seen with burn victims), physical changes in blood vessels (as in infections (septic shock) or severe allergies; anaphylactic shock), some medicines, spinal injuries (neurogenic shock), and heavy external or internal bleeding (hypovolemic shock). Another example of shock from an infection is toxic shock syndrome. For all these, hypovolemic shock, heavy external or internal bleeding, would be Manning's worst problem. Depending on the specific cause and type of shock, symptoms will include one or more of the following: anxiety, bluish lips and fingernails, chest pain (which Manning seems to suffer throughout the film), confusion, dizziness, pale and clammy skin, low to no urine output, profuse sweating, a rapid but weak pulse, shallow breathing, and probably unconsciousness. Throughout the film, Manning shows just about all of these symptoms.

The placing of moist bandages over the burnt skin of Manning is standard care for burn victims. This is to primarily prevent further fluid loss and dehydration and to lessen infections. For both infections and fluid loss issues Manning was given "penicillin and cortisone around the clock". At one time, especially during the 1950s era when TACM was produced, penicillin was considered a wonder drug. Now, several decades later here in the 21st Century, penicillin is hesitantly prescribed due to overuse resulting in the development of resistant strains (such as MRSA, pronounced "mersa", which is methicillin resistant Stapylococcus aureus bacteria; methicillin is an analog of penicillin) making it now a "no wonder drug". Cortisone, a hormone, suppresses the immune system thereby reducing inflammation and attendant pain and swelling at the site of the injury. Too much use of cortisone does have its side effects such as diabetes and bone problems.

Right after Manning was packed in bandages he was taken into an isolation ward and kept under an oxygen tent, a common practice for burn patients. The primary purpose of this is to serve as a sterile environment to help prevent further infections and to protect the health care workers, nurses and doctors, from being

contaminated from the radiation in Manning's body. Next to his bed was a hanging bottle of blood to replenish what he lost. The next view, supposedly the next morning, is when a nurse looks in on the patient and notices his remarkable skin improvement. At this time the hanging bottle of blood is nearly empty. Is this the same bottle seen earlier or one after a night of replacing bottle after bottle? (Most likely, if a true burn victim, then Manning would have received bottle after bottle; both units of blood plus fluids such as plasma and a glucose solution to help provide nutrients and replace missing fluids.) The nurse, when questioned, said Manning had "cortisone administered continuous through the night in plasma containers". This means Manning received the cortisone treatment mixed with plasma fluids via intravenous (i.v.) tubing. Plasma contains many vital nutrients, electrolytes, and proteins to help stabilize the circulatory system and help prevent shock.

After noticing Manning's remarkable improvement the physicians removed the bandages from his head and upper chest noting, "he developed new skin" followed by, "isn't even a scar". Quite remarkable indeed, especially the part about their being no scars, since newly grown skin from burn victims would have some scarring. However, as the scene was filmed you could easily see a moisture sheen of both sweat and natural body oils on Manning's face and upper chest, indicative of new skin still undergoing development.

In the next major scene of the film occurred a remarkable exchange between a so-called government bureaucrat and Dr Linstrom when the doctor wonders, "how Glen Manning was able to survive the explosion". The government man answered with a simple (and quite ignorant), "chance". Then when the doctor asked specifically about Manning's new skin development the bureaucrat responded with a jaw-dropping ignorance of "what possible connection could there be to the bomb?" This was then followed with the equally ignorant, "a man survives a plutonium explosion and then for some reason or other (!) his skin heals more rapidly than usual. What is the mystery?" With this kind of reasoning that bureaucrat should be with someone else's government and not ours! Finally, after the doctors make their valid point the bureaucrat finally concedes, "something out there is beyond the limits of our knowledge". (I would say the limit of the bureaucrat's knowledge would appear to be about 1.5 inches beyond the tip of his nose…)

The Heart of the Matter

The heart of a normal sized man is about the size of your fist, typically between 7 to 15 ounces (200 to 425 grams) or, as Dr. Linstrom says, is about the "size of the distance from his nose to his chin". In each day the heart averages 100,000 beats and pumps about 2,000 gallons (~7,570 liters) of blood. At the end of a normal life span the heart probably beat more than 3.5 billion times.

The human heart is located in the middle of your chest between the lungs and behind and slightly to the left of your sternum or breastbone. The heart is

encased in a double-layered sac called the pericardium that not only allows attachment via ligaments to the spinal column for support but also provides the freedom for the heart to move as it beats.

Human hearts have four chambers. The upper chambers are called the left and right atria and the lower chambers are called the left and right ventricles and all four are separated by a muscle called the septum. The left ventricle is the largest and strongest chamber because it is this chamber that pushes blood out the heart and into the rest of your body. And that is the main job of the heart, to pump blood throughout the body to the organs, tissues, and every cell in your body. (Blood delivers oxygen and nutrients to every cell in your body and removes waste products including carbon dioxide from those cells.) By the force of the heart beating blood is pumped through a complex network of arteries, arterioles, and capillaries and subsequently returned through the vein and venules network. If all the arteries and veins in your body were laid out end-to-end they would be around 60,000 miles long (96,500 kilometers). This is long enough to circle the earth more than twice. And for the 60' tall Manning this network of blood vessels would be even longer! This means that Manning's small heart would have to pump extra hard to adequately deliver all the necessary blood and nutrients to those many miles of his circulatory system.

The circulatory system in relation to growth
Dr. Linstrom tries to further explain Manning's condition to Carol, Manning's fiance, by saying, "all the parts are enlarging at the same ratio, except for the heart. When it was normal size the heart measured approximately the size of the distance from his nose to his chin. At the size he is now the heart measures the same as the distance from his lips to his chin. In other words, the heart has increased one half as much as the other parts of the body. All the parts of the body consisted of millions of tiny cells that were rapidly and uncontrollably multiplying. Today, we learned this theory does not apply to Glenn's heart. Its growing but at a much slower rate. The reason for this is technical [note: never trust a scientist when you hear this. It is his job to explain the material to even the most simplist of people]. To give you a simplified layman's explanation…since the heart is made up of a single cell [note: in the above mentioned book, KWTS, author Bill Warren appropriately called this comment, "hogwash"], for all practical purposes (for NO practical purposes!), instead of millions of cells like the rest of the organs of the body, its reacting in an entirely different manner to this unknown force or stimulus that's behind this whole thing." Quite a mouthful. After hearing all that the fiance says, "no wonder he's always complaining about these sharp pains in his chest. What does it mean?" The doctor responds, "his heart won't be able to carry the load any longer. Then he will die." Then Carol asks, "how will it happen?" The doctor responds, "his mind will go first and then his heart will literally explode." As Manning himself said to Carol at one exchange, the "beating of my heart gets louder and louder", indicating he is aware of his cardiology issues and knows his heart is having problems.

In Manning's case, with a small heart, in addition to the rest of his body's needs, not enough blood was being pumped to the brain so the colossal man also suffered brain trauma and became psychotic as a result. The brain needs a constant supply of nutrients (mostly in the form of glucose as a metabolic energy source) and oxygen to function normally and if deprived of them for more than 8 minutes this can then result in permanent brain damage. In Manning's case he had a slow reduction of brain oxygen as his body grew but proportionately not his heart so he would of had slow episodes of brain injury that only increased in severity over time as he grew.

From the hospital Manning was then transferred to the US Army Rehabilitation and Research Center, Summit, NV for further testing and privacy. If Manning grew "8 to 10 feet a day" then where did all the mass come from? He needed to eat. Initially, Dr. Linstrom said, "…intravenous feeding", meaning a feeding tube was directly connected to one of Manning's veins (probably in the crook of the arm) and he was given nutrient fluids via this tubing system. Later, a civilian truck (from the Swift truck company) arrives at the research center with "25 sides of beef". That would certainly pack the pounds on Manning. Later, we see Manning eat a large cooked turkey so he was getting plenty of food to fuel his growth. To maintain his "8 to 10 feet a day" pace he must have been eating and drinking 24 hrs a day. Initially, his urine output would have been diminished due to all the cortisone he was getting to help alleviate his condition. After Manning was taken from the hospital to the isolated government hospital facility he was no longer seen with an i.v. bottle so he would have been off the cortisone treatments by then. At one point Manning was seen drinking from a large container of water and he must have been doing this several times a day to keep up with his growth.

Medical Exams

From the moment Manning is brought into a hospital after the blast he undergoes various medical tests. He is a well studied and well cared for patient. A few times it is noted that he had a rapid respiration (a symptom of his medications to counter the shock) eventhough the room was kept at a balmy 82^{o}F. As a result of his excessive growth Manning is bald with no visible body hair, except for his eyebrows and eyelashes, a condition called alopecia. Since Manning has no body hair this would suggest that not all of his cells are behaving normally so the radiation did have some permanent damage to some cells.

With the rapid growth it is stated that Manning was, "growing from 8 to 10 feet a day. Eighteen feet tall, tomorrow 26 feet, 35 feet maybe 40." And each new day brought new and repeated medical tests. In trying to explain Manning's condition to his fiance the doctor says, "the body is like a factory, continually producing new cells to replace the older cells, damaged cells, or destroyed cells. Now this happens in all the different parts of the body. Bone cells grow new bone cells, skin cells grow new skin cells and so forth throughout the body. New cells

replacing the damaged ones…it is this delicately balanced process of new cells replacing dying cells or damaged cells that is causing the growth problem with Glen." [all of the above is true] Manning's fiance then asks, "how can this make his whole body grow?" A fair question. The doctor replies, "this process is out of balance. For some unknown reason new cells are growing at an accelerated or speeded up rate while at the same time the old cells are refusing to die. This is what makes Glen grow. That's what made the new skin." This is essentially the same principle seen in cancer in which new cells are growing faster without any dieing off so there is an increase in the number of cells and a buildup of too many of one type of cell can ultimately cause death. In cancer, one type of cell grows unchecked like this whereas in Manning's case ALL of his cells are equally growing faster than those dieing off. It's like every cell in his body equally has cancer and none of them are dieing off. To underscore this moment in the film it was noted that Manning was now over 30 feet tall and weighed 2,987 pounds.

Since Manning's heart did not grow proportionately with the rest of his body it was under a lot of stress to pump all that blood through his body. This explains all the chest pains Manning experienced. However, since this is an SF film, maybe all his rearranged and mutated DNA from the blast could have provided him with another survival advantage. So you know, python snakes have the ability to increase their heart size after a meal by placing more fat or lipid into specialized heart cells. Pythons with a bigger heart can then "feed" the rest of their body and more efficiently metabolize their newly ingested meal. After the feeding/digesting period then the python's heart reduces back to a smaller size. In Manning's case, with just the right number of mutated heart genes, his heart could also have increased after a meal and once digested then it reverted back to a smaller size. When the doctors examined Manning perhaps they tested him just before big meals (such as "25 sides of beef") when his heart was smaller and not yet increased due to the lipid metabolism after a large meal. In SF films mutated DNA can do anything.

Galvanic Skin Response

Galvanic reflexes performed by Dr. Coulter were said to be "inconclusive". This is not a too surprising result. The galvanic skin response (GSR) is a method purported to measure three physiological reactions. The first is muscular activity; GSR can measure the bioelectrical changes in muscle. The second is vascular changes in which the dilation or constriction of blood vessels is measured. The third is secretory changes (sweat gland activity) of measuring the electrical conductance of the skin in response to reactions to stimuli, such as anxiety or stress. And the electrical conductance of the skin varies with the moisture level of the skin so those with higher skin moisture (more stress and anxiety) have a measurably different GSR than those with minimal skin moisture (less stress and anxiety). The skin's sweat glands control the skin's moisture level which in turn is controlled by the sympathetic nervous system so a galvanic response of the skin is an indication of physical or psychological arousal. To measure a GSR, or a change in the electrical properties of skin, either the electrical resistance of the

skin can be measured or the weak currents generated by the body can be measured. Also, the GSR can slow with age. Currently, the most common use of a GSR is from polygraph tests, also known as a lie detector, which can record bodily changes associated with stress (read: lying).

In Manning's case the GSR was probably used to measure how he responded to the various medicines the doctors used. All in all a poor indicator but, nevertheless, the one used in this film. If the GSR was high, indicating a higher skin resistance or excessive moisture, then Manning was possibly responding to the treatment. If Manning's GSR was low then this would suggest he was not responding. Since Manning's GSR results were "inconclusive" then it is difficult to say what his skin moisture content really meant or what it indicated. At various times during the film we see Manning with excessive sweat on his face so his skin moisture level must have been high. With his rapid growth of "8 to 10 feet per day" then his metabolism was working overtime and highly metabolic states are stressful on the body and do result in skin moisture buildup. Even so, all of this was seen as inconclusive.

Sulfa compounds

Here is an interesting verbal exchange between Dr Linstrom and his colleague Dr Coulter. After a long night of research Dr Coulter says, "the answer is in the bone marrow. We were so close we couldn't see it." Dr Linstrom immediately sensed what he was saying and responds with, "inject sulfa hydral compounds into the bone marrow." [Note his use of the plural of that word.] To keep all you gentle readers updated sulfa drugs were first discovered in 1935 and consist of a family of antibiotics that are used to treat bacterial and some fungal infections. Sulfa drugs work by interfering with bacteria and fungi metabolism and were considered "wonder drugs" before penicillin was developed. Sulfa drugs concentrate in the urine before being excreted which is why they are primarily used today to treat urinary tract infections. Lastly, though there are a number of sulfa drugs available none of them are named "sulfa hydral" so it is anyones guess as to what that is and what it does to bone marrow.

Dr. Coulter then says, "the thing that fooled us was we were looking for some unknown quantity in the plutonium radiation while all the time it was acting to a degree the same as a hydrogen exposure. (whatever that means.) The secret was in the degree of exposure." Dr. Linstrom replies with, "then the injection of the sulfa hydral compounds should correct the body's regenerative balance…it may stop his growth but it won't diminish his size." Dr. Coulter added, "the stimulation of the hormone secretions in the pituitary or growth controlling glands will take care of that." To prove his point Dr. Coulter shows the miniature camel and elephant (see below) and continues with, "I used high frequency stimulation of the pituitary gland causing the hormone secretions to reverse the growth process." Dr. Linstrom then adds, "first injections of the sulfa hydral compounds into the bone marrow." Dr. Coulter responds with, "that will stop the growing." Then Dr. Linstrom replies, "then stimulate the pituitary gland to reduce size."

Well, to repeat Bill Warren's comment above, "hogwash!", for frequency stimulation of the pituitary to reduce size.

Pituitary Gland

In humans, the pituitary gland or hypophysis is a hormone gland about the size of a pea, though located at the bottom of the hypothalamus in the lower center of the brain, it is not a part of the brain. The pituitary gland consists of two components, the anterior pituitary and the posterior pituitary, and in total secretes 9 different hormones. The hypothalamus releases various growth factors to the pituitary gland which in turn stimulates the release of the pituitary hormones. As such, the pituitary is known as the 'master endocrine gland'. Some of the hormones the pituitary gland secretes are the somatotrophins (also known as HGH or human growth hormone; more on this below), thyroid-stimulating hormone (TSH), endorphins, prolactin, melanocyte-stimulating hormone (influences skin pigmentation), vasopressin, and oxytocin (increases labor contractions in women).

Using high frequency to stimulate the pituitary gland will in reality serve no purpose. However, Dr. Coulter reasoned that by stimulating the pituitary gland this would in turn reverse the effects of the growth hormone thereby causing a decrease in an animal's size. Coulter reasoned that if HGH can increase a human's growth then stopping the production of HGH will stop Manning's growth and could even reverse the growth (not true).

The Science of Shrinkology

His proof of this were his shrinkology experiments by making smaller camel and elephant animals in testing his hypothesis. Shrinkology is the study of being and becoming small. Film examples of this are THE DEVIL DOLL (1936) and THE INCREDIBLE SHRINKING MAN (1957) in which full sized animals, including humans, are made smaller or shrunk. In going small there are two ways to go. If the number of cells in an organism are the same when it shrinks then its weight will be unchanged; the cells are simply just smaller, more compact and therefore more dense (think of the DC comics character, The Atom, who can reduce his size but not his mass or weight). However, shrinking by having fewer cells of the organism, such as if someone reverted back to adolescence when smaller in stature, then he will weigh proportionately less. Without trying to invoke some sort of weird biology or physics the second version of fewer cells would be preferred because cells remain cells and not some sort of super dense version.

To test his hypothesis of injecting sulfa hydral compounds directly into bone marrow (to stop growth) with subsequent high frequency treatment of the pituitary gland (to reverse growth) Dr. Coulter experimented on larger animals. He made smaller versions of a camel (a two humped camel as seen in the film is called a Bactrian; one humped camels are Dromedaries) and an Indian elephant (their ears are smaller than the African elephants) by reversing growth using his high

frequency treatment. For this to actually happen there would have to be a unilaterally uniform decrease in size of all parts of each animal.

This then brings up the question that with smaller brains do they have the same mental capacity as full grown adults? This pertains to the above shrinkology discussion of whether smaller is a qualitative or a quantitative difference: smaller cells or fewer cells? It would be biologically easier to create larger versions of a growing animal (keep giving them growth hormones) than it would be to make a fully grown animal proportionately smaller in size. Afterall, this is what is done in the animal husbandry industry where many species, such as cows and steer, are made larger (and not smaller) through the use of growth hormones.

The work of doctors Coulter and Linstrom at the research center is done in a well-equipped lab. Present are copious amounts of glassware, several lit Bunsen burners, two (average) microscopes, and several cages of rabbits. A back room houses a camel and an elephant. Much of the glassware is for distillation setups indicating the good doctors are analyzing and testing small chemical compounds, such as “sulfa hydrals”. Later it was shown that Coulter himslef had a separate lab where some sophisticated electronic pieces of equipement were kept as well as a bench well cluttered with the work at hand. The electronic equipment could have been used in generating the necessary high frequency to alter the pituitary gland.

While Manning is ravaging Las Vegas a colonel says, “10 times the height of a normal man, weighs about 18,000 pounds.” Ten times the normal height would put Manning around 60 feet tall weighing 9 tons. That is quite a load on those ankles. And quite a jump from an earlier 30 feet tall and 2,987 pounds so this represents a doubling of his height and a 6-fold increase in his weight. It would take a lot of “25 sides of beef” to do that.

Give Him the Needle

The large hypodermic needle is in need of discussion. To inject the sulfa hydral compounds directly into Manning’s bone marrow they would need a long needle to penetrate the few feet of skin, tissue, muscle, and bone in his lower leg. It is amusing that what is used is simply a large version of a standard syringe of the day. However, it is noted that for fluid volumes on the syringe cylinder the words, “3 quarts” is the maximum indicated volume. Quaint. Hypodermic needles are labeled with volumes using metric nomenclature such as milliliters or liters and not the antiquated avoirdupois system of pints and quarts. This prop was made by the amazingly creative and ever resourceful special effects wizard Paul Blaisdell.

Mental decay

During Manning’s growth several progressive mental changes occur and during the course of the film his mental decay becomes more and more of an issue. The mental decay occurs slowly which would be in keeping with his overall

gradual health changes. His increased size with a suboptimal heart meant not enough blood and therefore not enough oxygen was getting to his brain. Over time a slow decrease in brain oxygen could give rise to slowly developing mental issues. His self pity and other behavior changes, such as his dismissal of his fiance, would also be in keeping with his coming to grips with his situation. Ultimately, Manning went on a psychotic rampage in the Las Vegas area indicating his mental deteriation had significantly changed his behavior. During this he is seen grasping his head and wincing suggesting headaches and an inability to cope with his situation so he releases his frustrations on the town and people that ultimately results in his being “destroyed” at Boulder Dam (its original name that was later changed to the current Hoover Dam). Note: if Manning’s body is still radioactive and contains radioactivity, highly likely, then some of this from his body would contaminate the Colorado river and everything else downstream for centuries.

Summary

As a result of a good Samaritan act Colonel Glenn Manning was directly exposed to a plutonium bomb blast and was literally showered with radioactive alpha, beta, and gamma particles as well as x-rays and other radioisotopes. These radioactive particles were inhaled, injested, and entered open burn wounds and caused Manning’s DNA to sufficiently mutate thereby making him grow into a proportionately equal giant, eventually becoming 60 feet tall. Unfortunately, Manning’s heart was growing at a slower pace and could not keep up with the demands of his gigantic body. As a result of decreased blood flow from the smaller heart Manning suffered many physiological and psychological traumas that ultimately resulted in his being shot off Boulder Dam and into the Colorado river (and subsequently surfaced in the sequel).

Thank you for reading. We had a colossal good time. It back to the lab for me. Stay healthy and eat right.