NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

MOBILE PHONES, ELECTROMAGNETIC WAVES AND EFFECTS TO HUMAN BEING HEALTH

Graduation Project

Student: Tolga Merlen (20022099)

Supervisor: Prof. Dr. Fakhreddin Mamedov

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ABSTRACT

In the study of Electromagnetics today the analysis of wave theory as indepth as it may be has a topic of interest some what overlooked until the middle to late twentieth century.

This topic is the consideration of Electromagnetic waves and the effects they have on human health. In the world today electromagnetic waves some or mostly of minor effect make contact with humans everyday. Some of these ways be it radio waves or of what ever category they may be are always around human beings. On a day to day basis modern day living has brought many divices into our homes and has made life easier.

One of the most recent phenomenon in the late 20th century has been the mobile phone, of whose place in society is now a way of life. Now in taking into account what was mention about studies into mobile phone usage on a daily rate and Electromagnetic Wave theory play the main role in this project.

Effects of Mobile Phones radiation on Human Health is a consern when taking into consideration ;

1. The number of Mobile Phone Users.
2. The daily amount of time of which an individual is in contact with a mobile phone.

Noting that the study of the two and the topic of radiation and its effect on human health is of benefit and guideline for any problems which may occur in the future. Without their being dangerous epidemic consiquences.

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INTRODUCTION

The study of Electromagnetic Waves in Engineering covers all aspects of life be it for health entertainment education and communication without electromagnetic wave theory these would not be possible. The major disadvantages is the emition of radiation and rays which affect human beings.

Mobile phones are low power radio devices that transmit and receive microwave radiation at frequencies of about 900 Megahertz (MHz) and 1800 MHz. There are many other sources of radio waves. Television broadcasts in the UK operate at frequencies between 400 MHz and 860 MHz and microwave communication links (dishes) operate at frequencies above 1000 MHz. Cellular radio systems involve communication between mobile telephones and fixed base stations. Each base station provides coverage of a given area, termed a cell. While cells are generally thought of as regular hexagons, making up a 'honeycomb' structure, in practice they are irregular due to site availability and topography. Depending on the base station location and mobile phone traffic to be handled, base stations may be from only a few hundred meters apart in major cities, to several kilometers apart in rural areas. If a person with a mobile phone moves out of one cell and into another, the controlling network hands over communications to the adjacent base station.

This project studies the effect of mobile phones and their effect on human health it consists of an introduction three chapters and the conclusion.

Chapter 1 Covers the basis of the Electromagnetic Spectrum form Radio Waves to Gamma Rays and Explain undetail how each wave occurs and how it is identified.

Chapter 2 This chapter delves into Mobile Phones and the Base Station it involves a look at the history and definition of Mobile Telecommunication.

Chapter 3 Studies the effects of Electromagnetic High Frequency waves present in Mobile Telecommunications and the effect they may pose on human beings from all walks of life.

1. ELECTROMAGNETIC WAVES

1.1 Overview

Although they seem different, radio waves, microwaves, x-rays, and even visible light are all waves of energy called electromagnetic waves. They are part of the electromagnetic spectrum, and each has a different range of wavelengths, which cause the waves to affect matter differently. The electromagnetic waves have amplitude, wavelength, velocity, and frequency. The creation and detection of the wave depends much on the range of wavelengths.

1.1.2. Characteristics of electromagnetic waves

Electromagnetic waves are transverse waves, similar to water waves in the ocean or the waves seen on a guitar string. This is as opposed to the compression waves of sound. As it is described in Wave Motion, all waves have amplitude, wavelength, velocity, and frequency.

a- Amplitude

The amplitude of electromagnetic waves relates to its intensity or brightness (as in the case of visible light).

With visible light, the brightness is usually measured in lumens. With other wavelengths the intensity of the radiation, which is power per unit area or watts per square meter is used. The square of the amplitude of a wave is the intensity.

b- Wavelength

The wavelengths of electromagnetic waves go from extremely long to extremely short and everything in between. The wavelengths determine how matter responds to the electromagnetic wave, and those characteristics determine the name given to that particular group of wavelengths.

c- Velocity

The velocity of electromagnetic waves in a vacuum is approximately 186,000 miles per second or 300,000 kilometers per second, the same as the speed of light. When these waves pass through matter, they slow down slightly, according to their wavelength.

d- Frequency

The frequency of any waveform equals the velocity divided by the wavelength. The units of measurement are in cycles per second or Hertz.

e- Creation and detection

When electrons move, they create a magnetic field. When electrons move back and forth or oscillate, their electric and magnetic fields change together, forming an electromagnetic wave. This oscillation can come from atoms being heated and thus moving about rapidly or from alternating current (AC) electricity.

The opposite effect occurs when an electromagnetic wave hits matter. In such a case, it could cause atoms to vibrate, creating heat, or it can cause electrons to oscillate, depending on the wavelength of the radiation.

f- Sources of electromagnetic radiation

Electromagnetic radiation is emitted from all matter with a temperature above absolute zero. Temperature is the measure of the average energy of vibrating atoms and that vibration causes them to give off electromagnetic radiation. As the temperature increases, more radiation, and shorter wavelengths of electromagnetic radiation are emitted.

g- Sources of long wavelengths

Microwaves, radio, and television waves are emitted from electronic devices. Sparks and alternating current cause vibrations at the appropriate frequencies.

h- Sources of visible light

Visible light is emitted from matter hotter than about 700 degrees Celsius. This matter is said to be incandescent. The sun, a fire, and the ordinary light bulb are incandescent sources of light.

As the element in an electric stove gets warms, it gives off infrared radiation, and then when it gets hotter than 700 degrees, it starts to glow. Visible light is being emitted from the hot element. (See Visible Light for more information.)

j- Sources of short wavelengths

X-rays are formed by smashing high-energy electrons into other particles, such as metals. (See X-rays for more information.)

Gamma rays are emitted from nuclear reactions, atomic bombs, and explosions on the Sun and other stars.

k- Detectors of electromagnetic radiation

There are a number of different types of detectors of electromagnetic radiation. The common ones known for detecting visible light are: the eye, camera film, and the detectors on some calculators. Human skin can also detect both visible light and infrared heat rays.

Electronic devices are necessary to detect most of the longer waves, such as radio waves. Special film can detect shorter wavelengths such as X-rays.

1.2. Electromagnetic spectrum

The range of wavelengths for electromagnetic waves—from the very long to the very short—is called the Electromagnetic Spectrum:

- **Radio** and **TV** waves are the longest usable waves, having a wavelength of 1 mile (1.5 kilometer) or more.
- **Microwaves** are used in telecommunication as well as for cooking food.
- **Infrared** waves are barely visible. They are the deep red rays one gets from a heat lamp.
- **Visible light** waves are the radiation, which can be seen with the naked eye. Their wavelength is in the range of 1/1000 centimeter.
- **Ultraviolet** rays are what give people sunburn and are used in "black lights" that make objects glow.
- **X-rays** go through the body and are used for medical purposes.
- **Gamma rays** are dangerous rays coming from nuclear reactors and atomic bombs. They have the shortest wavelength in the electromagnetic spectrum of about 1/10,000,000 centimeter.

1.2.1. Radio Waves

Radio waves have the longest wavelengths in the electromagnetic spectrum. These waves can be longer than a football field or as short as a football. Radio waves do more than just bring music to radios. They also carry signals for televisions and cellular phones.

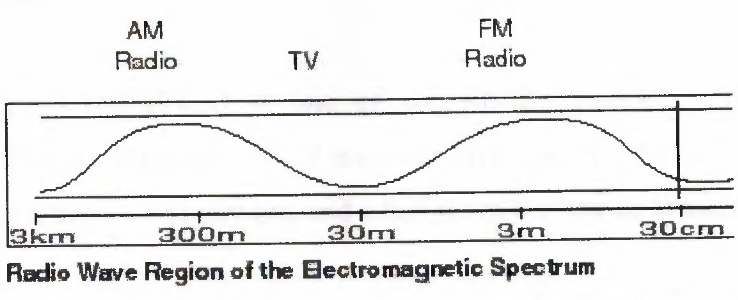


Figure 1.1. Radio Wave Region of the Electromagnetic Spectrum.

The antenna on a television set receives the signal, in the form of electromagnetic waves that is broadcasted from the television station. It is displayed on television screens.

Cable companies have antennae or dishes, which receive waves broadcasted from local TV stations. The signal is then sent through a cable to houses.

Cellular phones also use radio waves to transmit information. These waves are much smaller that TV and FM radio waves.

Objects in space, such as planets and comets, giant clouds of gas and dust, and stars and galaxies, emit light at many different wavelengths. Some of the light they emit has very large wavelengths - sometimes as long as a mile! These long waves are in the radio region of the electromagnetic spectrum.

Because radio waves are larger than optical waves, radio telescopes work differently than telescopes that are used for visible light (optical telescopes). Radio telescopes are dishes made out of conducting metal that reflect radio waves to a focus point. Because the wavelengths of radio light are so large, a radio telescope must be physically larger than an optical telescope to be able to make images of comparable clarity. For example, the Parkes radio telescope, which has a dish 64 meters wide, cannot give a clearer image than a small backyard telescope!

In order to make better and clearer (or higher resolution) radio images, radio astronomers often combine several smaller telescopes, or receiving dishes, into an array. Together, the dishes can act as one large telescope whose size equals the total area occupied by the array.

The Very Large Array (VLA) is one of the world's premier astronomical radio observatories. The VLA consists of 27 antennas arranged in a huge "Y" pattern up to 36 km (22 miles) across -- roughly one and a half times the size of Washington, DC.

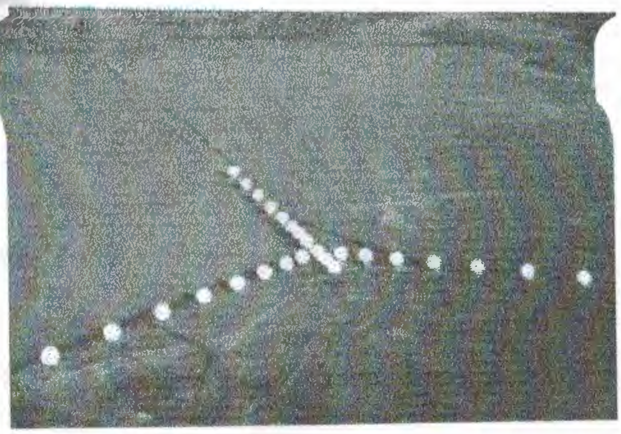


Figure 1.2. The Very Large Array (VLA) is one of the world's premier astronomical radio observatories.

The VLA, located in New Mexico, is an interferometer; this means that it operates by multiplying the data from each pair of telescopes together to form interference patterns. The structure of those interference patterns, and how they change with time as the earth rotates, reflect the structure of radio sources in the sky.

The above image shows the Carbon Monoxide (CO) gases in the Milky Way galaxy. Many astronomical objects emit radio waves, but that fact wasn't discovered until 1932. Since then, astronomers have developed sophisticated systems that allow them to make pictures from the radio waves emitted by astronomical objects.

Radio telescopes look toward the heavens at planets and comets, giant clouds of gas and dust, and stars and galaxies. By studying the radio waves originating from these sources, astronomers can learn about their composition, structure, and motion. Radio astronomy has the advantage that sunlight, clouds, and rain do not affect observations.

1.2.2. Microwaves

Microwaves have wavelengths that can be measured in centimeters! The longer microwaves, those closer to a foot in length, are the waves, which heat food in a microwave oven.

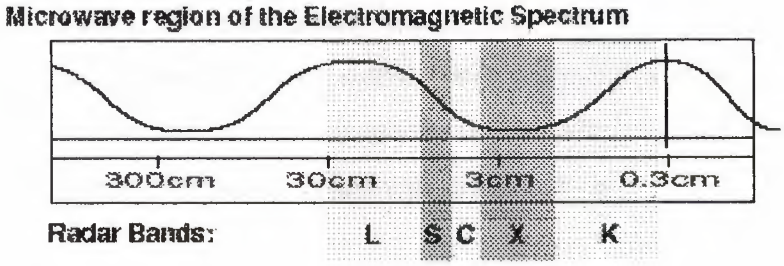


Figure 1.3. Microwave region of the Electromagnetic Spectrum.

Microwaves are good for transmitting information from one place to another because microwave energy can penetrate haze, light rain, and snow, clouds, and smoke.

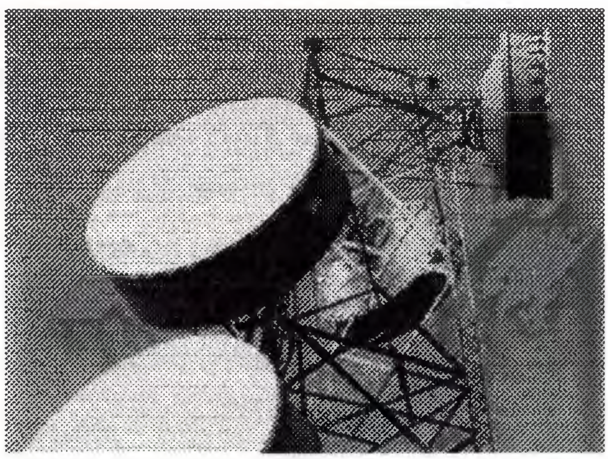


Figure 1.4. The Microwaves are used for radar like the Doppler radar.

Shorter microwaves are used in remote sensing. These microwaves are used for radar like the Doppler radar used in weather forecasts. Microwaves, used for radar, are just a few inches long.

This microwave tower can transmit information like telephone calls and computer data from one city to another.

Radar is an acronym for "radio detection and ranging." Radar was developed to detect objects and determine their range (or position) by transmitting short bursts of microwaves. The strength and origin of "echoes" received from objects that were hit by the microwaves is then recorded.

Because radar senses electromagnetic waves that are a reflection of an active transmission, radar is considered an active remote sensing system. Passive remote sensing refers to the sensing of electromagnetic waves, which did not originate from the satellite or sensor itself. The sensor is just a passive observer.

Because microwaves can penetrate haze, light rain, and snow, clouds and smoke, these waves are good for viewing the Earth from space.

This is a radar image acquired from the Space Shuttle. It also used a wavelength in the L-band of the microwave spectrum.

In the 1960's a startling discovery was made quite by accident. A pair of scientists at Bell Laboratories detected background noise using a special low noise antenna. The strange thing about the noise was that it was coming from every direction and did not seem to vary in intensity much at all. If this static were from something on our world, like radio transmissions from a nearby airport control tower, it would only come from one direction, not everywhere. The scientists soon realized they had discovered the cosmic microwave background radiation. This radiation, which fills the entire Universe, is believed to be a clue to it's beginning, something known as the Big Bang.

1.2.3. The Infrared

Infrared light lies between the visible and microwave portions of the electromagnetic spectrum. Infrared light has a range of wavelengths, just like visible light has wavelengths that range from red light to violet. "Near infrared" light is closest in wavelength to visible light and "far infrared" is closer to the microwave region of the electromagnetic spectrum. The longer, infrared wavelengths are about the size of a pinhead and the shorter, near infrared ones are the size of cells, or are microscopic.

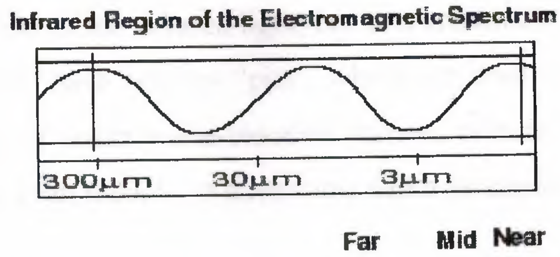


Figure 1.5. Infrared Region of the Electromagnetic Spectrum.

Far infrared waves are thermal. In other words, we experience this type of infrared radiation every day in the form of heat. The heat that people feel from sunlight, a fire, a radiator, or a warm sidewalk is infrared. The temperature-sensitive nerve endings in human skin can detect the difference between inside body temperature and outside skin temperature.

Infrared light is even used to heat food sometimes - special lamps that emit thermal infrared waves are often used in fast food restaurants!

Shorter, near infrared waves are not hot at all - in fact they cannot even be felt. These shorter wavelengths are the ones used by TV's remote control.

Since the primary source of infrared radiation is heat or thermal radiation, any object, which has a temperature, radiates in the infrared. Even objects that are thought of as being very cold, such as an ice cube, emit infrared. When an object is not quite hot enough to radiate visible light, it will emit most of its energy in the infrared. For example, hot charcoal may not give off light but it does emit infrared radiation, which humans feel as heat. The warmer the object, the more infrared radiation it emits.

Humans, at normal body temperature, radiate most strongly in the infrared at a wavelength of about 10 microns. (A micron is the term commonly used in astronomy for a micrometer or one millionth of a meter.)

To make infrared pictures like the one above, we can use special cameras and film that detect differences in temperature, and then assign different brightness or false colors to them. This provides a picture that the eye can interpret.

Humans may not be able to see infrared light, but it is known that snakes in the pit viper family, like rattlesnakes, have sensory "pits", which are used to image infrared light? This allows the snake to detect warm-blooded animals, even in dark burrows. Snakes with 2 sensory pits are even thought to have some depth perception in the infrared!

Many things besides people and animals emit infrared light - the Earth, the Sun, and far away things like stars and galaxies as well. For a view from Earth orbit, looking out into space or down at Earth, on board satellites instruments are used.

Satellites like GOES 6 and Landsat 7 look at the Earth. Special sensors, like those aboard the Landsat 7 satellite, record data about the amount of infrared light reflected or emitted from the Earth's surface.

Other satellites, like the Infrared Astronomy Satellite (IRAS) look up into space and measure the infrared light coming from things like large clouds of dust and gas, stars, and galaxies.

This is an infrared image of the Earth taken by the GOES 6 satellite in 1986. A scientist used temperatures to determine which parts of the image were from clouds and which were land and sea. Based on these temperature differences, he colored each separately using 256 colors, giving the image a realistic appearance.

Why use infrared to image the Earth? While it is easier to distinguish clouds from land in the visible range, there is more detail in the clouds in the infrared. This is great for studying cloud structure. For instance, note that darker clouds are warmer, while lighter clouds are cooler. Southeast of the Galapagos, just west of the coast of South America, there is a place where you can distinctly see multiple layers of clouds, with the warmer clouds at lower altitudes, closer to the ocean that's warming them.

Looking at an infrared image of a cat, that many things emit infrared light. However, many things also reflect infrared light, particularly near infrared light. Near infrared radiation is not related to the temperature of the object being photographed - unless the object is very, very hot.

Infrared film 'sees' the object because the Sun (or some other light source) shines infrared light on it and it is reflected or absorbed by the object. One could say that this reflecting or absorbing of infrared helps to determine the object's 'color' - its color being a combination of red, green, blue, and infrared!

This image of a building with a tree and grass shows how Chlorophyll in plants reflects near infrared waves along with visible light waves. Even though it can't be seen the infrared waves, are always there.

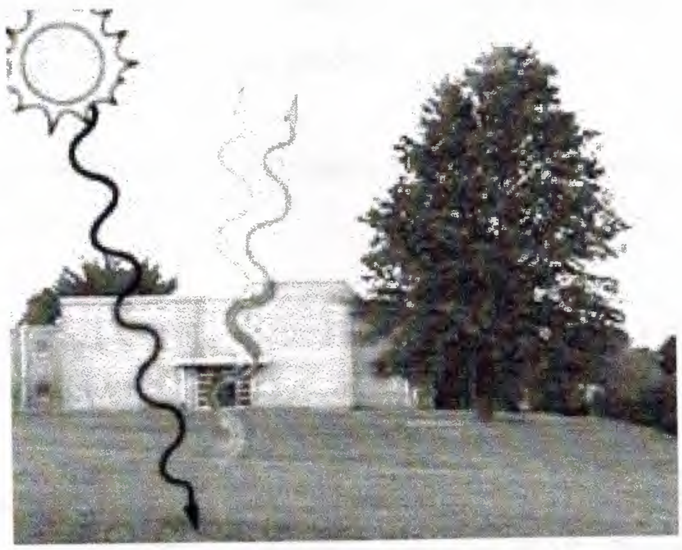


Figure 1.6. The visible light waves drawn on this picture are green, and the infrared ones are pale red.

This image was taken with special film that can detect invisible infrared waves. This is a false-color image, just like the one of the cat. False-color infrared images of the Earth frequently use a color scheme like the one shown here, where infrared light is mapped to the visible color of red. This means that everything in this image that appears red is giving off or reflecting infrared light. This makes vegetation like grass and trees appear to be red.

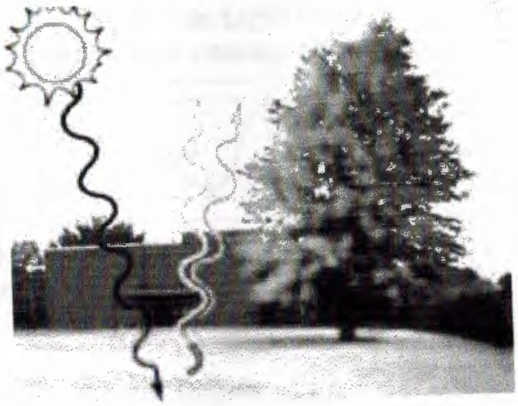


Figure 1.7. The visible light waves drawn on this picture are green, and the infrared ones are darker red.

The light areas are areas with high reflectance of near infrared waves. The dark areas show little reflectance.

This image shows the infrared data (appearing as red) composited with visible light data at the blue and green wavelengths.

Instruments on board satellites can also take pictures of things in space. The image below of the center region of our galaxy was taken by IRAS. The hazy, horizontal S-shaped feature that crosses the image is faint heat emitted by dust in the plane of the Solar System.

1.2.4. Visible Light Waves

Visible light waves are the only electromagnetic waves we can see. These waves are visible as the colors of the rainbow. Each color has a different wavelength. Red has the longest wavelength and violet has the shortest wavelength. When all the waves are seen together, they make white light.

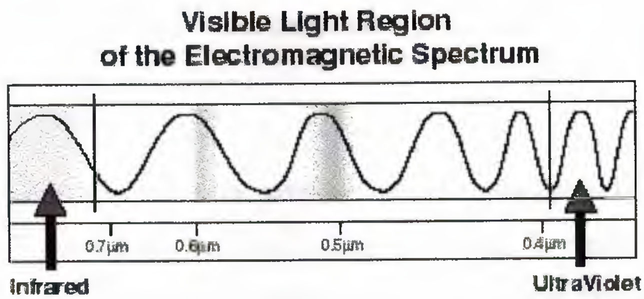


Figure 1.8. Visible Light Region of the Electromagnetic Spectrum.

When white light shines through a prism or through water vapor like this rainbow, the white light is broken apart into the colors of the visible light spectrum.

Figure 1.9. The reflection of this sunlight.

Cones in the human eye are receivers for these tiny visible light waves. The Sun is a natural source for visible light waves and the eye sees the reflection of this sunlight off the objects around us.

The color of an object seen by naked eye is the color of light reflected. All other colors are absorbed.

There are two types of color images that can be made from satellite data - true-color and false-color. To take true-color images, like this one, the satellite that took it used sensors to record data about the red, green, and blue visible light waves that were reflecting off the earth's surface. The data were combined later on a computer. The result is similar to what the eye sees.

A false-color image is made when the satellite records data about brightness of the light waves reflecting off the Earth's surface. This brightness is represented by numerical values - and these values can then be color-coded. It is just like painting by number! The colors chosen to "paint" the image are arbitrary, but they can be chosen to either make the object look realistic, or to help emphasize a particular feature in the image. Astronomers can even view a region of interest by using software to change the contrast and brightness on the picture, just like the controls on a TV! Below both images are of the Crab Nebula, the remains of an exploded star!

The true-color has been processed to show Uranus, as human eyes would see it from the vantage point of the Voyager 2 spacecraft, and is a composite of images taken through blue, green, and orange filters. The false color and extreme contrast enhancement in the image on the right, brings out subtle details in the polar region of Uranus. The very slight contrasts visible in true color are greatly exaggerated here, making it easier to studying Uranus' cloud structure. Here, Uranus reveals a dark polar hood surrounded by a series of progressively lighter concentric bands. One possible explanation is that a brownish haze or smog, concentrated over the pole, is arranged into bands by zonal motions of the upper atmosphere.

It is true that the naked eye cannot observe many wavelengths of light. This makes it important to use instruments that can detect different wavelengths of light to help study the Earth and the Universe. However, since visible light is the part of the electromagnetic spectrum that the eyes can see, our whole world is oriented around it. In addition, many instruments that detect visible light can see father and more clearly than our eyes could alone. That is why satellites are used to observe the Earth, and telescopes to observe the Sky.

People not only look at Earth from space but can also look at other planets from space. This is a visible light image of the planet Jupiter. It is in false color - the colors were chosen to emphasize the cloud structure on this banded planet - Jupiter would not look like this to your eyes.

1.2.5. Ultraviolet Waves

Ultraviolet (UV) light has shorter wavelengths than visible light. Though these waves are invisible to the human eye, some insects, like bumblebees, can see them.

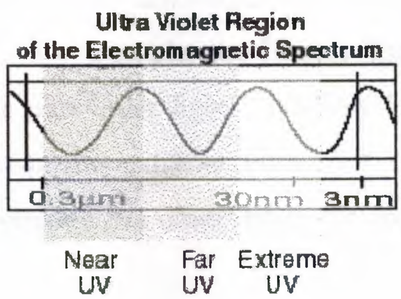


Figure 1.10. Ultraviolet Region of the Electromagnetic Spectrum.

Scientists have divided the ultraviolet part of the spectrum into three regions: the near ultraviolet, the far ultraviolet, and the extreme ultraviolet. The three regions are distinguished by how energetic the ultraviolet radiation is, and by the "wavelength" of the ultraviolet light, which is related to energy.

The near ultraviolet, abbreviated NUV is the light closest to optical or visible light. The extreme ultraviolet, abbreviated EUV, is the ultraviolet light closest to X-rays, and is the most energetic of the three types. The far ultraviolet, abbreviated FUV, lies between the near and extreme ultraviolet regions. It is the least explored of the three regions.

Sun emits light at all the different wavelengths in electromagnetic spectrum, but it is ultraviolet waves that are responsible for causing our sunburns. To the left is an image of the Sun taken at an Extreme Ultraviolet wavelength - 171 Angstroms to be exact. (An Angstrom is a unit length equal to 10^{-10} meters.)

Though some ultraviolet waves from the Sun penetrate Earth's atmosphere, most of them are blocked from entering by various gases like Ozone. Some days, more ultraviolet waves get through our atmosphere. Scientists have developed a UV index to help people protect themselves from these harmful ultraviolet waves.

It is good for the human race as it is protected from getting too much ultraviolet radiation, but it is bad for scientists! Astronomers have to put ultraviolet telescopes on satellites to measure the ultraviolet light from stars and galaxies - and even closer things like the Sun!

Many different satellites help us study ultraviolet astronomy. Many of them only detect a small portion of UV light. For example, the Hubble Space Telescope observes stars and galaxies mostly in near ultraviolet light. NASA's Extreme Ultraviolet Explorer satellite is currently exploring the extreme ultraviolet universe. The International Ultraviolet Explorer (IUE) satellite has observed in the far and near ultraviolet regions for over 17 years.

Stars galaxies and earth can be studied by the UV light they give off. Below is an unusual image - it is a picture of Earth taken from a lunar observatory! This false-color picture shows how the Earth glows in ultraviolet (UV) light.

The part of the Earth facing the Sun reflects much UV light. Even more interesting is the side facing away from the Sun. Here, bands of UV emission are also apparent. These bands are the result of aurora caused by charged particles given off by the Sun. They spiral towards the Earth along Earth's magnetic field lines.

Many scientists are interested in studying the invisible universe of ultraviolet light, since the hottest and the most active objects in the cosmos give off large amounts of ultraviolet energy.

1.2.6 X-rays

As the wavelengths of light decrease, they increase in energy. X-rays have smaller wavelengths and therefore higher energy than ultraviolet waves. X-rays can be referred to in terms of their energy rather than wavelength. This is partially because X-rays have very small wavelengths. It is also because X-ray light tends to act more like a particle than a wave. X-ray detectors collect actual photons of X-ray light - which is very different from the radio telescopes that have large dishes designed to focus radio waves!

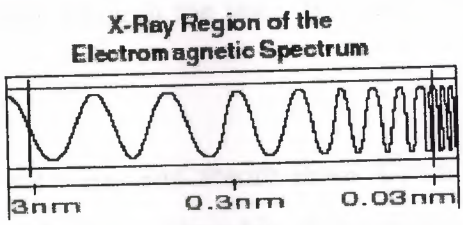


Figure 1.11. X-Ray Region of the Electromagnetic Spectrum.

X-rays were first observed and documented in 1895 by Wilhelm Conrad Roentgen, a German scientist who found them quite by accident when experimenting with vacuum tubes.

A week later, Wilhelm Conrad Roentgen took an X-ray photograph of his wife's hand, which clearly revealed her wedding ring and her bones. The photograph electrified the general public and aroused great scientific interest in the new form of radiation. Roentgen called it "X" to indicate it was an unknown type of radiation. The name stuck, although (over Roentgen's objections), many of his colleagues suggested calling them Roentgen rays. They are still occasionally referred to as Roentgen rays in German-speaking countries.

The Earth's atmosphere is thick enough that virtually no X-rays are able to penetrate from outer space all the way to the Earth's surface. This is good for us but also bad for astronomy. X-ray telescopes and detectors have to be installed on satellites. Because it is not possible to conduct X-ray astronomy from the ground.

The human eye wouldn't be able to see through people's clothes, no matter what the ads for X-ray glasses tell. If human eye could see X-rays, it would be possible to see things that either emit X-rays or halt their transmission. Human Eyesight would be like the X-ray film used in hospitals or dentist's offices. X-ray film "sees" X-rays, like the ones that travel through your skin. It also sees shadows left by things that the X-rays can't travel through (like bones or metal).

When an X-ray is taken at a hospital, X-ray sensitive film is put on one side of the body, and X-rays are shot through. At a dentist, the film is put inside the mouth, on one side of teeth, and X-rays are shot through the jaw. It doesn't hurt at all. Because X-rays cannot be felt.

Because bones and teeth are dense and absorb more X-rays then skin does, silhouettes of bones or teeth are left on the X-ray film while skin appears transparent.

When the Sun shines on the human skin at a certain angle, our shadow is projected onto the ground. Similarly, when X-ray light shines on a person, it goes through the skin, but allows shadows of the bones are to be projected onto and captured by film.

Satellites with X-ray detectors are used for X-ray astronomy. In astronomy, things that emit X-rays (for example, black holes) are like the dentist's X-ray machine, and the detector on the satellite is like the X-ray film. X-ray detectors collect individual X-rays (photons of X-ray light) and things like the number of photons collected, the energy of the photons collected, or how fast the photons are detected, it identifies things about the object that is emitting them.

To the right is an image of a real X-ray detector. This instrument is called the Proportional Counter Array and it is on the Rossi X-ray Timing Explorer (RXTE) satellite. It looks very different from anything that might be seen at a dentist's office.

Many things in space emit X-rays; among them are black holes, neutron stars, binary star systems, supernova remnants, stars, the Sun, and even some comets.

The Earth glows in many kinds of light, including the energetic X-ray band. Actually, the Earth itself does not glow - only aurora produced high in the Earth's atmosphere. These auroras are caused by charged particles from the Sun.

The area of brightest X-ray emission is red. The energetic charged particles from the Sun that cause aurora also energize electrons in the Earth's magnetosphere. These electrons move along the Earth's magnetic field and eventually strike the Earth's ionosphere, causing the X-ray emission. These X-rays are not dangerous because they are absorbed by lower parts of the Earth's atmosphere. (The above caption and image are from the Astronomy Picture of the Day for December 30, 1996.)

Recently, having learnt that even comets emit X-rays! This image of Comet Hyakutake was taken by an X-ray satellite called ROSAT, short for the Roentgen Satellite. (It was named after the discoverer of X-rays.)

The Sun also emits X-rays - here is what the Sun looked like in X-rays on April 27th, 2000. This image was taken by the Yokoh satellite.

Many things in deep space give off X-rays. Many stars are in binary star systems - which mean that two stars orbit each other. When one of these stars is a black hole or a neutron star, material is pulled off the normal star. This materials spirals into the black hole or neutron star and heats up to very high temperatures. When something is heated to over a million degrees, it will give off X-rays!

The above image is an artist's conception of a binary star system - it shows the material being pulled off the red star by its invisible black hole companion and into an orbiting disk.

This image is special - it shows a supernova remnant - the remnant of a star that exploded in a nearby galaxy known as the Small Magellanic Cloud. The false-colors show what this supernova remnant looks like in X-rays (in blue), visible light, (green) and radio (red). This is the same supernova remnant but this image shows only X-ray emission.

1.2.7. Gamma-rays

Gamma rays have the smallest wavelengths and the most energy of any other wave in the electromagnetic spectrum. These waves are generated by radioactive atoms and in nuclear explosions. Gamma rays can kill living cells, a fact which medicine uses to its advantage, using gamma rays to kill cancerous cells.

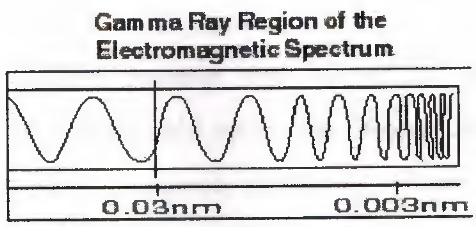


Figure 1.12. Gamma Ray Region of the Electromagnetic Spectrum.

Gamma rays travel to us across vast distances of the universe, only to be absorbed by the Earth's atmosphere. Different wavelengths of light penetrate the Earth's atmosphere to different depths.

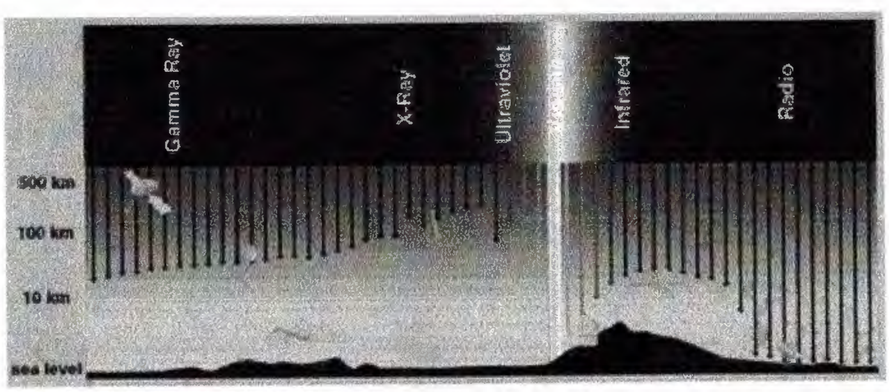


Figure 1.13. Instruments aboard high-altitude balloons and satellites like the Compton Observatory provide the only view of the gamma-ray sky.

Gamma rays are the most energetic form of light and are produced by the hottest regions of the universe. They are also produced by such violent events as supernova explosions or the destruction of atoms, and by less dramatic events, such as the decay of radioactive material in space. Things like supernova explosions (the way massive stars die), neutron stars and pulsars, and black holes are all sources of celestial gamma rays.

Gamma-ray astronomy did not develop until it was possible to get our detectors above all or most of the atmosphere, using balloons or spacecraft. The first gamma-ray telescope, carried into orbit on the Explorer XI satellite in 1961, picked up fewer than 100 cosmic gamma-ray photons!

Unlike optical light and X-rays, gamma rays cannot be captured and reflected in mirrors. The high-energy photons would pass right through such a device. Gamma-ray telescopes use a process called Compton scattering, where a gamma ray strikes an electron and loses energy, similar to a cue ball striking an eight ball.

This image shows the CGRO satellite being deployed from the Space Shuttle orbiter. This picture was taken from an orbiter window. The two round protrusions are one of CGRO's instruments, called "EGRET."

If gamma rays were visible, these two spinning neutron stars or pulsars would be among the brightest objects in the sky. This computer-processed image shows the Crab Nebula pulsar (below and right of center) and the Geminga pulsar (above and left of center) in the "light" of gamma rays.

If human beings could see gamma rays, the night sky would look strange and unfamiliar.

The gamma-ray moon just looks like a round blob - lunar features are not visible. In high-energy gamma rays, the Moon is actually brighter than the quiet Sun. This image was taken by EGRET.

The familiar sights of constantly shining stars and galaxies would be replaced by something ever-changing. Ones gamma-ray vision would peer into the hearts of solar flares, supernovae, neutron stars, black holes, and active galaxies. Gamma-ray astronomy presents unique opportunities to explore these exotic objects. By exploring the universe at these high energies, scientists can search for new physics, testing theories and performing experiments, which are not possible in earth-bound laboratories.

If gamma rays were visible, these two spinning neutron stars or pulsars would be among the brightest objects in the sky. This computer-processed image shows the Crab Nebula pulsar (below and right of center) and the Geminga pulsar (above and left of center) in the "light" of gamma rays.

The Crab nebula, shown also in the visible light image, was created by a supernova that brightened the night sky in 1054 A.D. In 1967, astronomers detected the remnant core of that star; a rapidly rotating, magnetic pulsar flashing every 0.33 seconds in radio waves.

Perhaps the most spectacular discovery in gamma-ray astronomy came in the late 1960s and early 1970s. Detectors on board the Vela satellite series, originally military satellites, began to record bursts of gamma rays -- not from Earth, but from deep space!

Today, these gamma-ray bursts, which happen at least once a day, are seen to last for fractions of a second to minutes, popping off like cosmic flashbulbs from unexpected directions, flickering, and then fading after briefly dominating the gamma-ray sky.

Gamma-ray bursts can release more energy in 10 seconds than the Sun will emit in its entire 10 billion-year lifetime! So far, it appears that all of the bursts we have observed have come from outside the Milky Way Galaxy. Scientists believe that a gamma-ray burst will occur once every few million years here in the Milky Way, and in fact may occur once every several hundred million years within a few thousand light-years of Earth.

1.3. SUMMARY

To summarized having covered 7 types of waves and rays that make up the electromagnetic spectrum. The in-depth study of each gives an idea and an understanding where and how each wave and ray is found and how it works in principle.

The scope covers radio to TV, and from Satellite infrared to visible light rays all of which are essential for everyday use by human beings. This also includes ultraviolet rays which the naked eye cannot see, so as the full spectrum of waves are documented the picture of how vast electromagnetic waves are and how much they represent is apparent.

2. MOBILE PHONE AND BASE STATION

2.1. Overview

Digital wireless and cellular roots go back to the 1940s when commercial mobile telephony began. Compared with the furious pace of development today, it may be peculiar and odd those mobile wirelesses haven't progressed further in the last 60 years. There were many reasons for this delay but the most important ones were technology, cautiousness, and federal regulation.

As the loading coil and vacuum tube made possible the early telephone network, the wireless revolution began only after low cost microprocessors and digital switching became available. The Bell System, producers of the finest landline telephone system in the world, moved hesitatingly and at times with disinterest toward wireless. Anything AT&T produced had to work reliably with the rest of their network and it had to make economic sense, something not possible for them with the few customers permitted by the limited frequencies available at the time. Frequency availability was in turn controlled by the Federal Communications Commission, whose regulations and unresponsiveness constituted the most significant factors hindering radiotelephone development, especially with cellular radio, delaying that technology in America by perhaps 10 years.

In Europe and Japan, though, where governments could regulate their state run telephone companies less, mobile wireless came no sooner, and in most cases later than the United States. Japanese manufacturers, although not first with a working cellular radio, did equip some of the first car mounted mobile phone services, their technology equal to whatever America was producing. Their products enabled several first commercial cellular telephone systems, starting in Bahrain, Tokyo, and Osaka, Mexico City.

2.2. Pre-History

As is found already, and as with the telephone, a radio is an electrical instrument. A thorough understanding of electricity was necessary before inventors could produce a reliable, practical radio system. That understanding didn't happen quickly. Starting with the work of Oersted in 1820 and continuing until and beyond Marconi's successful radio system of 1897, dozens of inventors and scientists around the world worked on different parts of the radio puzzle. In an era of poor communication and non-systematic research, people duplicated the work of others, misunderstood the results of other inventors, and often misinterpreted the results they themselves had achieved. While puzzling over the mysteries of radio, many inventors worked concurrently on power generation, telegraphs, lighting, and, later, telephone.

In 1820 Danish physicist Christian Oersted discovered electromagnetism, the critical idea needed to develop electrical power and to communicate. In a famous experiment at his University of Copenhagen classroom, Oersted pushed a compass under a live electric wire. This caused its needle to turn from pointing north, as if acted on by a larger magnet. Oersted discovered that an electric current creates a magnetic field. However, could a magnetic field create electricity? If so, a new source of power beckoned. In addition, the principle of electromagnetism, if fully understood and applied, promised a new era of communication.

In 1821 Michael Faraday reversed Oersted's experiment and in so doing discovered induction. Michael Faraday got a weak current to flow in a wire revolving around a permanent magnet. In other words, a magnetic field caused or *induced* an electric current to flow in a nearby wire. In so doing, Faraday had built the world's first electric generator. Mechanical energy could now be converted to electrical energy. Is that clear? This is a very important point. The simple act of moving ones' hand caused current to flow. Mechanical energy into electrical energy. However, current was produced only when the magnetic field was in motion, that is, when it was changing.

Faraday worked through different electrical problems in the next ten years, eventually publishing his results on induction in 1831. By that year many people were producing electrical dynamos. However, electromagnetism still needed understanding. Someone had to show how to use it for communicating.

In 1830 the great American scientist Professor Joseph Henry transmitted the first practical electrical signal. A short time before Henry had invented the first efficient electromagnet. He also concluded similar thoughts about induction before Faraday but he didn't publish them first. Henry's place in electrical history however, has always been secure, in particular for showing that electromagnetism could do more than create current or pick up heavy weights -- it could communicate.

In a stunning demonstration in his Albany Academy classroom, Henry created the forerunner of the telegraph. Henry first built an electromagnet by winding an iron bar with several feet of wire. A pivot mounted steel bar sat next to the magnet. A bell, in turn, stood next to the bar. From the electromagnet Henry strung a mile of wire around the inside of the classroom. Having completed the circuit by connecting the ends of the wires at a battery. Where by the steel bar swung toward the magnet, of course, striking the bell at the same time. Breaking the connection released the bar and it was free to strike again. In addition, while Henry did not pursue electrical signaling, helping someone who did. That man was Samuel Finley Breese Morse.

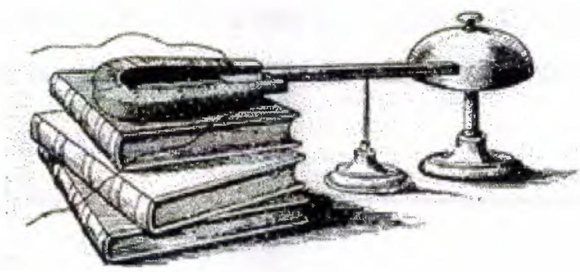


Figure 2.1. Henry's Primate Telegraph.

From the December, 1963 American Heritage magazine, "a sketch of Henry's primitive telegraph, a dozen years before Morse, reveals the essential components: an electromagnet activated by a distant battery, and a pivoted iron bar that moves to ring a bell."

In 1837 Samuel Morse invented the first practical telegraph, applied for its patent in 1838, and was finally granted it in 1848. Joseph Henry helped Morse build a telegraph relay or repeater that allowed long distance operation.

The telegraph united the country and eventually the world. Not a professional inventor, Morse was nevertheless captivated by electrical experiments. In 1832 he had heard of Faraday's recently published work on inductance, and was given an electromagnet at the same time to ponder over. An idea came to him and Morse quickly worked out details for his telegraph.

As depicted below, his system used a key (a switch) to make or break the electrical circuit, a battery to produce power, a single line joining one telegraph station to another and an electromagnetic receiver or sounder that upon being turned on and off, produced a clicking noise. Having completed the package by devising the Morse code system of dots and dashes. A quick key tap broke the circuit momentarily, transmitting a short pulse to a distant sounder, interpreted by an operator as a dot. A lengthier break produced a dash.

Telegraphy became big business as it replaced messengers, the Pony Express, clipper ships, and every other slow paced means of communicating. The fact that service was limited to Western Union offices or large firms seemed hardly a problem. After all, communicating over long distances instantly was otherwise impossible. Morse also experimented with wireless, but not in a way one might think. Morse didn't pass signals though the atmosphere but through the earth and water. Without a cable.

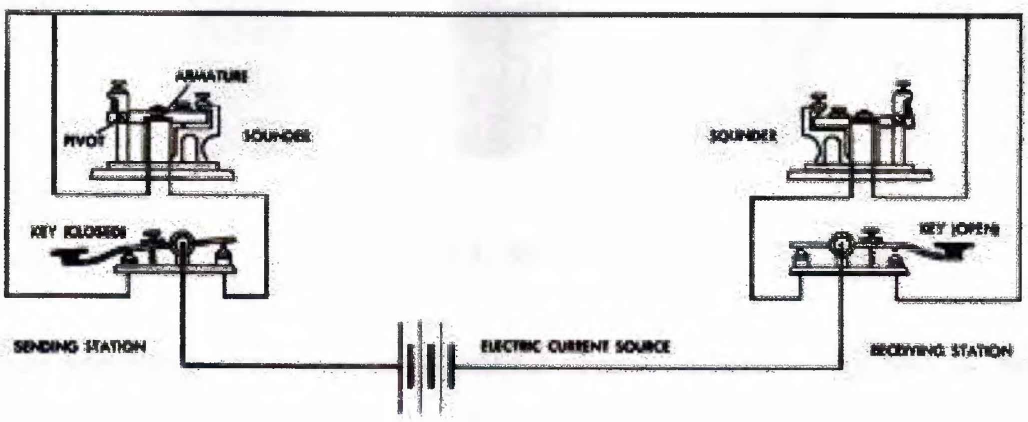


Figure 2.2. The first practical telegraph.

2.3. Mobile Phones

Mobile telephones are designed in such a way that they can remain in contact with the nearest base station with the least possible power. Whether this capability is fully used depends on the design of the network. The prime reason for the existence of this facility is to utilize the limited amount of energy in the battery as effectively as possible. In addition, the capacity of the network is thereby increased. The mobile telephone's power regulation means that the strength of the electromagnetic field around the telephone may vary from place to place and over time. Generally speaking, it can be said that the poorer the link, the higher the transmission power needed by the telephone to link to the base station. Conversely, it is also the case that the more antennas there are, the lower the transmission power required by the telephone will band therefore also the lower the strength of the electromagnetic field at the telephone will be. Under ideal, free-field conditions, mobile telephones have a maximum range of several dozens of kilometers.

Figure 2.3. Mobile Phones.

Mobile telephones, sometimes called cellular phones or handies, are now an integral part of modern telecommunications. In some parts of the world, they are the most reliable or only phones available. In others, mobile phones are very popular because they allow people to maintain continuous communication without hampering freedom of movement. In many countries, over half the populations already use mobile phones and the market is still growing rapidly. The industry predicts that there will be as many as 1.6 billion mobile phone subscribers worldwide in the year 2005. Because of this, increasing numbers of mobile base stations have had to be installed. Base stations are low-powered radio antennae that communicate with users' handsets. In early 2000 there were about 20,000 base stations in operation the United Kingdom and about 82,000 cell sites in the United States, with each cell site holding one or more base stations.

The telecommunications industry is experiencing rapid growth on a global scale. This is a direct consequence of technological development and has in turn facilitated the application of new technologies and a consequent increase in economic activity. Within this sector, one of the greatest growth areas of recent years has been the development of mobile or wireless telecommunications.

The first land mobile services were introduced into the UK in the 1940s, but the significant expansion of services offered to the general public, including the introduction of mobile phones, began in the mid-1980s, and rapidly attracted a small but significant number of subscribers. Developments in the early 1990s, such as the introduction of digital networks and the entry of additional service providers into the market, fuelled further increases in the numbers of subscribers.

It is now predicted that within a few years around half the population of the UK will be routinely using mobile telecommunications (see Figure 2.4) and that this will become the dominant technology for telephony and other applications such as Internet access. This wide use of a relatively new technology raises the question of whether there are any implications for human health.

There are conflicting reports relating to possible adverse health effects and these have Understandably led to some concern. The Minister for Public Health recognized the importance of this issue and, following consultation with the Ministers at the Department of Trade and Industry, decided to seek the advice of an independent group as to the safety of mobile telecommunications technology, and asked the Chairman of the National Radiological Protection Board (NRPB) to establish an Independent Expert Group on Mobile Phones (IEGMP).

Following widespread consultation with interested parties, the Expert Group was set up under the chairmanship of Sir William Stewart FRS, FRSE. Membership of the Expert

Group represented a wide spectrum of expertise with leading figures from physics, radio engineering, biology, medicine, and epidemiology, in addition to lay members.

The Expert Group held its first full meeting in September 1999 and determined from the outset that it must consult widely. To this end, advertisements were placed in national newspapers and scientific journals inviting individuals or organizations to submit evidence for consideration. Public meetings were arranged in Belfast, Cardiff, Edinburgh, Liverpool, and London.

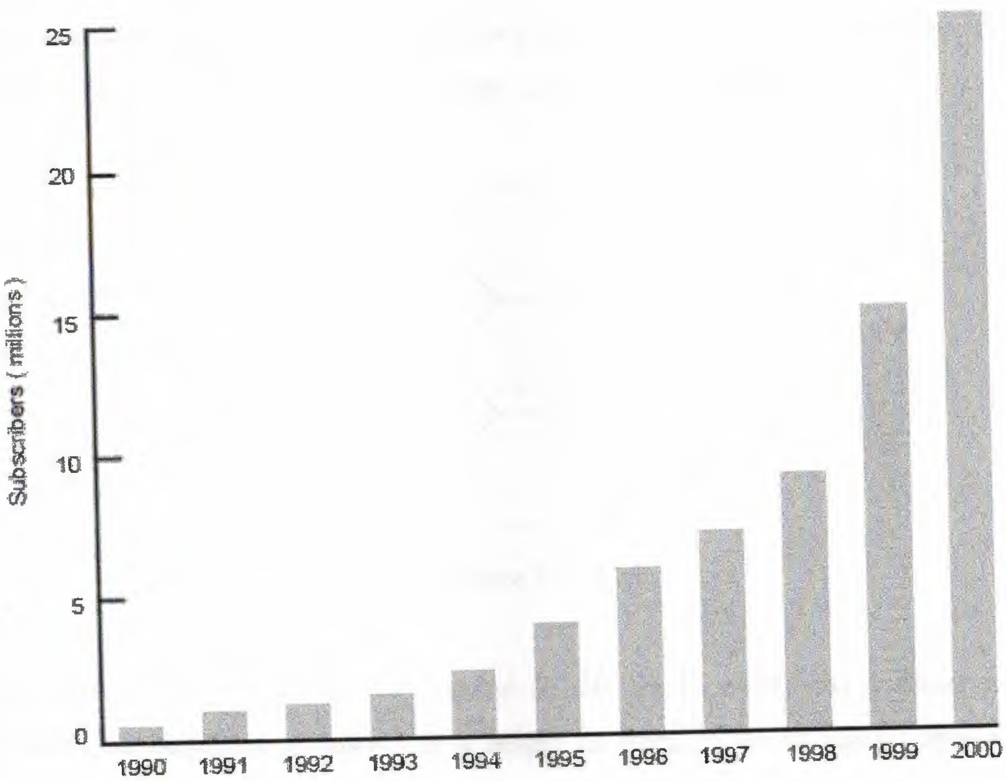


Figure 2.4. Growth in mobile phone subscribers in the UK between 1990 and 2000 (Based on data from Federation of the Electronics Industry, FEI)

A number of individuals and organizations accepted invitations to present evidence to closed meetings of the Group.

This report describes the work of the Expert Group. It presents the wide picture of mobile telecommunications and it's impact on the general public, and recognizes the contribution of mobile telecommunications to the quality of life and to the UK economy. It considers the underlying technology and the characteristics of the RF fields generated by present and near future (3–5 years) handsets and base stations, with particular reference to the magnitude of the fields. It provides an appraisal of the experimental and theoretical work that has been carried out which has a bearing on human health, and makes a number of recommendations to Government.

2.4. Base Stations

Base stations transmit power levels from a few watts to 100 watts or more, depending on the size of the region or "cell" that they are designed to service.

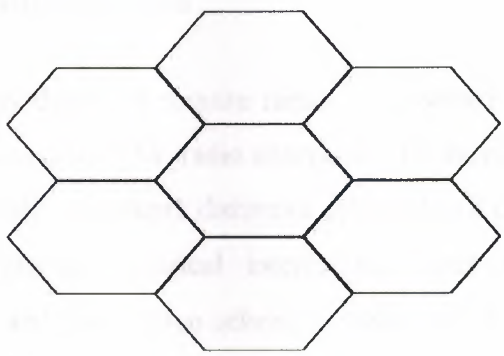


Figure 2.5. Cell

Base station antenna are typically about 20-30 cm in width and a meter in length, mounted on buildings or towers at a height of from 15 to 50 meters above ground. These antennae emit RF beams that are typically very narrow in the vertical direction but quite broad in the horizontal direction. Because of the arrow vertical spread of the beam, the RF field intensity at the ground directly below the antenna is low. The RF field intensity increases slightly as one move away from the base station and then decreases at greater distances from the antenna.


Figure 2.6. Base Station and Antennas.

2.5. Wireless and Radio Defined

Communicating wirelessly does not require radio. Everyone's noticed how appliances like power saws cause havoc to A.M. radio reception. By turning a saw on and off one can communicate wirelessly over short distances using Morse code, with the radio as a receiver. However, causing electrical interference does not constitute a radio transmission. Inductive and conductive schemes, which will be looked at shortly, also communicate wirelessly but are limited in range, often difficult to implement, and do not fulfill the need to reliably and predictably communicate over long distances. So let's see what radio is and then go over what it is not.

Weik defines radio as:

> "1. A method of communicating over a distance by modulating electromagnetic waves by means of an intelligence bearing-signal and radiating these modulated waves by means of transmitter and a receiver.
> 2. A device or pertaining to a device, that transmits or receives electromagnetic waves in the frequency bands that are between 10kHz and 3000 GHz."

Interestingly, the United States Federal Communications Commission does not define radio but the U.S. General Services Administration defines the term simply:

1. Telecommunication by modulation and radiation of electromagnetic waves. 2. A transmitter, receiver, or transceiver used for communication via electromagnetic waves. 3. A general term applied to the use of radio waves.

Radio thus requires a modulated signal within the radio spectrum, using a transmitter and a receiver. Modulation is a two-part process, a current called the carrier, and a signal bearing information. A continuous, high frequency carrier wave is generated, and then modulated or that current is varied with the signal that is wished to be sent.

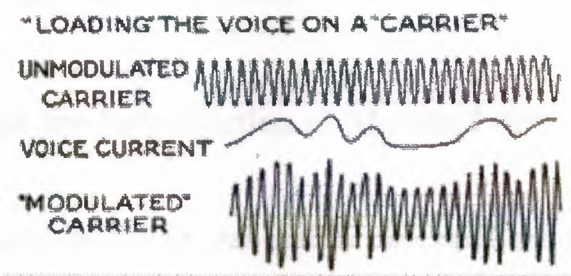


Figure 2.7. “Loading” the voice on a “carrier.”

This technique to modulate the carrier is called amplitude modulation. Amplitude means strength. A.M. means a carrier wave is modulated in proportion to the strength of a signal. The carrier rises and falls instantaneously "with each high and low of the conversation. The voice current, in other words, produces an immediate and equivalent change in the carrier.

For voice this is exactly the same way a telephone works, using the essential principle of variable resistance. A voice in telephony modulates the current of a telephone line. Compared to a telephone line, the unmodulated carrier in radio is simply the steady and continuous current the transmitter generates. When one talks the radio puts, superimposes, or impresses one's conversation's signal on the current the radio is transmitting. Conversation causes the current's resistance to go up and down, that is, one's voice varies or modulates the carrier. The only difference between a telephone and radio is that the transmitter is called a microphone. Now that we've quickly looked at radio, let's go on to its early development.

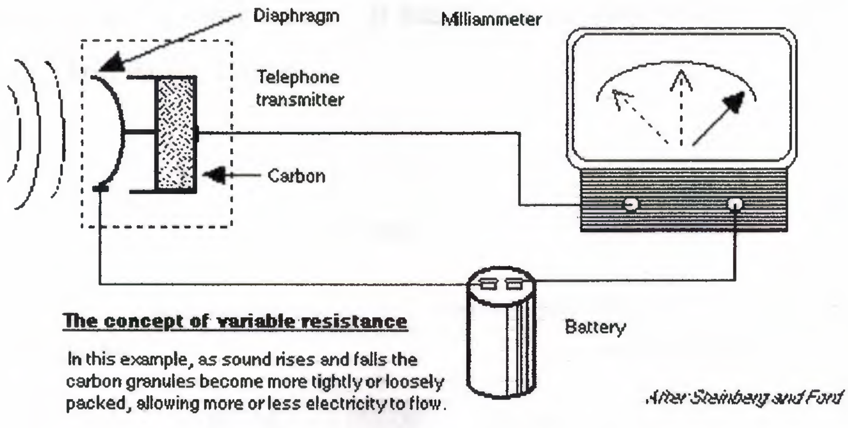


Figure 2.8. The concept of variable resistance.

2.6. Background to the Introduction of Mobile Telecommunications

The UK telecommunications system was initially developed and operated as part of the General Post Office (GPO). In 1981, this situation changed with the passing of the British Telecommunications Act, which effectively separated the telecommunications and postal businesses of the GPO, and led to the creation of British Telecom (BT). The next stage in telecommunications development was the creation of a competitive marketplace governed by a new regulatory body, the Office of Telecommunications (OFTEL), which was established in 1984. These changes paved the way for the introduction of cellular telecommunications in a competitive environment. Initially two companies were granted operating licenses, Telecom Securicor Cellular Radio Limited (Cellnet) and a subsidiary of Racal Electronics plc (Vodafone). In January 1985, both these companies launched national networks based on analogue technology.

However, in the late 1980s there was a move to develop standards for a second generation of mobile telecommunications throughout Europe in order to provide a seamless service for subscribers. This was achieved with the development and deployment of a new operating standard called the Global System for Mobile Telecommunications (GSM), which employs digital technology and is now the operating system for 340 networks in 137 countries (Figure 2.5). Although this system is now used worldwide, the European geographical area is still the dominant user, with more subscribers than any other region. It has, however, been widely accepted in other areas such as the Asia Pacific region.

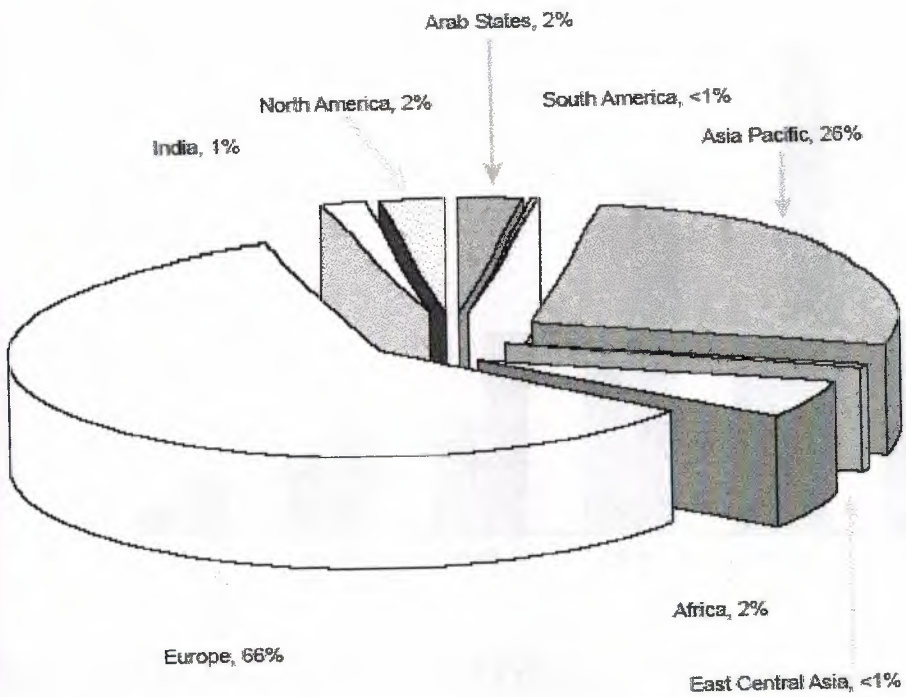


Figure 2.9. Distribution of GSM subscribers by geographical location (based on data from the GSM Association)

In the UK, the new GSM networks became operational in July 1992 (Vodafone), September 1993 (One 2 One), December 1993 (Cellnet), and April 1994 (Orange) the companies involved being referred to in this report as the network operators. The original analogue networks are still operational, but the Government has indicated that the analogue system should be removed from service by 2005.

On a worldwide scale, there has been a rapid growth in both the numbers of countries with operational networks and the number of mobile phone operators (Figure 2.6). There are a further 39 networks under construction for the GSM system alone.

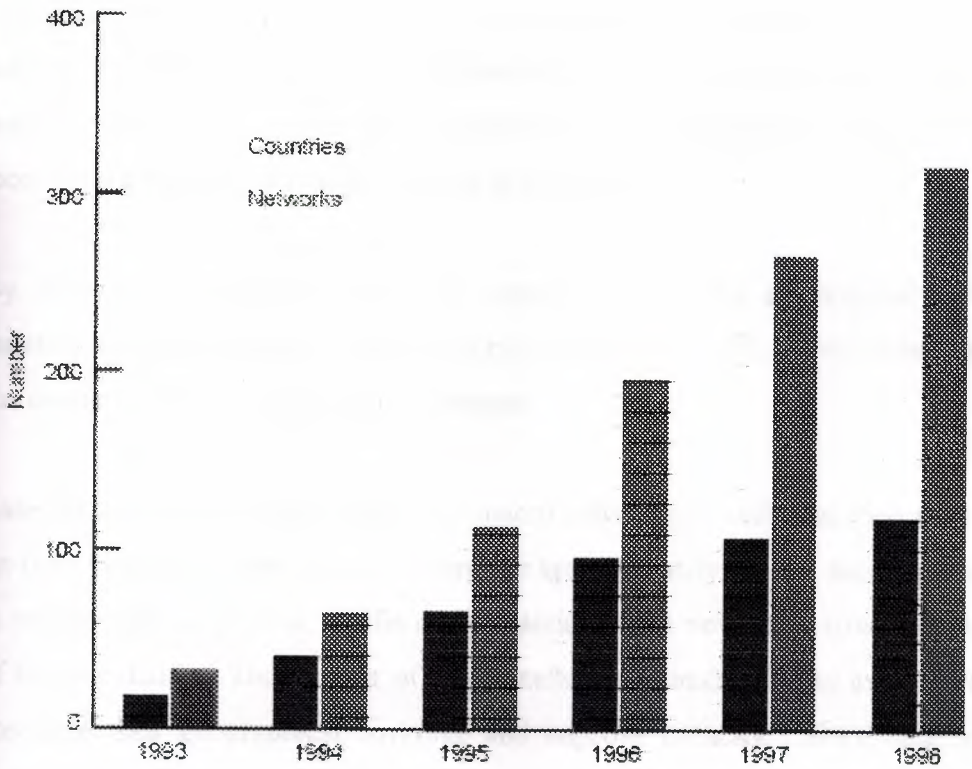


Figure 2.10. Growth of GSM networks throughout the world (based on data from the GSM Association)

2.7. Mobile Phone Networks and Communication

Individual mobile phones operate by communicating with fixed installations called base stations. These have a limited range and mobile phone operators have to establish national base station networks to achieve wide coverage. It takes many years to establish a network that will provide both complete coverage and adequate capacity across the country and, even today, none of the UK networks provides complete coverage. However, since operators invest a great deal of money to purchase licenses and establish networks and other infrastructure, they need to offer potential subscribers an effective communication system as quickly as possible.

Moreover, operators were required, as a condition of their operating licenses, to provide a minimum level of coverage within a given time frame. They established operational networks designed to allow most subscribers to access a base station most of the time.

The initial phase of construction of such a network involves the installation of base stations in urban areas with high population densities, and along major transport routes such as motorways. These basic networks are then extended to provide coverage in more rural areas and increased capacity in urban areas.

By developing networks in this way, operators can offer a functional system to the majority of the population. The more rural areas of the UK, particularly in the west of the country, still have rather poor coverage.

Base stations can be categorized into macro cells, micro cells and Pico cells depending on their size and power output. There are approximately 20,000 macro cells in the UK at present and, in general, all the major operators can now offer coverage to over 97% of the population. The number of macro cells is continuing to rise as operators seek to complete their geographical coverage and improve capacity. Since each base station can only handle a limited number of connections at any one time, operators need to install more base station units in densely populated areas to cope with increasing demand. It seems likely that these will mainly be micro cells and Pico cells. The overall number of base stations is likely to double within the next few years.

2.8. Present and Future Use of Mobile Phones

Initial market penetration by mobile phones was modest, with less than 1% of the UK population subscribing by the end of the 1980s. However, the advent of the more advanced GSM technology, in conjunction with greater competition in the market place, led to continuing growth in the number of subscribers throughout the 1990s (Figure 2.4).

At present there are approximately 25 million subscribers in the UK, which is equivalent to a market penetration of around 40%. Within the next five years it is expected that this will have increased to 75% market penetration or 45 million subscribers. At present it is estimated that around 45% of subscribers have a pre-paid mobile phone. Although it might be expected that many of these phones would not be used on a routine basis, the operators believe that around 90% of them are in regular use.

Within the next three years the "Third Generation" of mobile phones will be launched. This will employ a new operating standard called the Universal Mobile Telecommunication System and will enable operators to offer a full range of multimedia services. The introduction of these new services will require access to additional RF spectrum, and the UK Government has recently auctioned licenses for the use of new spectrum. Five licenses are to be issued.

The growth in the mobile phone market that has been observed in the UK reflects similar trends in Europe and elsewhere in the world. In Europe the greatest market penetration has occurred in the Scandinavian countries and in Finland is approaching 60%. However, all Western European countries have experienced a rapid growth in mobile phone use in recent years (Figure 2.7).

It is expected that the recent trends in the use of mobile phone technology will continue for the foreseeable future, with the number of GSM subscribers worldwide predicted to increase by a factor of three or more over the next five years (Figure 2.8).

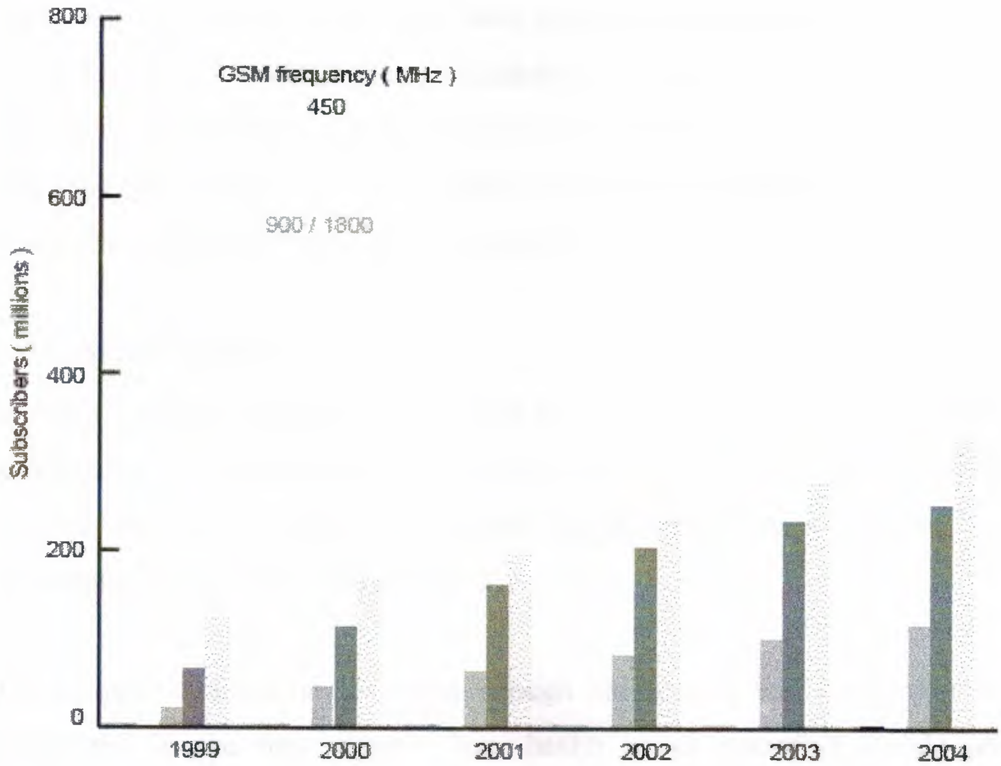


Figure 2.11. Predicted growth in the number of GSM subscribers worldwide. The different GSM frequencies are used in different systems around the world.

2.9. Benefits of Mobile Telecommunications Technology

An active mobile telecommunications sector brings a number of economic benefits to the UK in terms of employment and tax revenue. There are also, however, a number of other advantages to be derived from application of this technology. Mobile telecommunications play an increasingly important role in general commercial activity and thereby make an indirect contribution to the national economy. This is difficult to quantify, but is likely to be significant.

It is already apparent that mobile telecommunications also offer benefits in emergency situations. For example, the use of a mobile phone may reduce the time taken to notify the emergency services of road traffic accidents and other dangerous situations including crimes. An assessment of this aspect in Australia has recently been given by Chapman and Schofield (1998a,b). There have also been several accounts of individuals using mobile phones to alert rescue services following mountaineering or skiing accidents. Mobile phone availability may also be helpful during much rarer large-scale emergencies. For example, it is believed that many lives were saved following the earthquake in Kobe, Japan, because those trapped under rubble were able to use their mobile phones to alert rescue teams.

2.10. SUMMARY

Mobile Communications having grown in the last 25 years to the mega status that it is today has a vast history and network of information to cover. The above chapter has covered the history and the general design and development of mobile and telecommunications up to the present day.

The chapter is aimed at providing enough background and knowledge in order to understand in the next chapter how health issues regarding mobile phones and electromagnetic waves are related.

3. MOBILE PHONES, ELECTROMAGNETIC WAVES AND EFFECTS TO HUMAN BEING HEALTH

3.1. Overview

Mobile phones are low power radio devices that transmit and receive microwave radiation at frequencies of about 900 Megahertz (MHz) and 1800 MHz. There are many other sources of radio waves. Television broadcasts in the UK operate at frequencies between 400 MHz and 860 MHz and microwave communication links (dishes) operate at frequencies above 1000 MHz. Cellular radio systems involve communication between mobile telephones and fixed base stations. Each base station provides coverage of a given area, termed a cell. While cells are generally thought of as regular hexagons, making up a 'honeycomb' structure, in practice they are irregular due to site availability and topography. Depending on the base station location and mobile phone traffic to be handled, base stations may be from only a few hundred meters apart in major cities, to several kilometers apart in rural areas. If a person with a mobile phone moves out of one cell and into another, the controlling network hands over communications to the adjacent base station. The use of mobile phones is developing rapidly and at present there are about 14 million users in the UK with about 20,000 base stations. There is a consensus amongst international bodies that exposure guidelines for radio waves should be set to prevent adverse health effects caused by either whole or partial body heating. Some of the energy in the radio waves emitted by mobile phones is absorbed in the head of the user, mostly in superficial tissues. Exposure guidelines relevant to mobile phones are therefore expressed in terms of absorbed energy in a small mass of tissue in the head. The limit for exposure of the head recommended by NRPB and adopted by the Government for use in the UK, is 0.1 watt of power absorbed in any 10 g of tissue (time averaged over 6 min Calculations suggest this could result in a utes). Maximum rise in temperature of less than one degree centigrade in the head, even after prolonged exposure. In practice, the output from mobile phones used in the UK results in only a fraction of this amount of energy being deposited in the tissues of the head, and therefore the rise in temperature would only be a fraction of a degree. This is similar to the normal daily fluctuations in body temperature and such small changes in heat load are considered to be too low to cause adverse effects. At positions where the public are normally exposed to fields from base stations antennas, exposure is likely to be more uniform over the whole body. The restriction averaged over the whole body mass is 0.4 watts per kilogram (time averaged over 15 minutes). The radio waves produced by transmitters used for mobile phones are sufficiently weak that the guidelines can only be exceeded if a person is able to approach to within a few meters directly in front of the antennas. Radio wave strengths at ground level and in regions normally accessible to the public are many times below hazard levels and no heating effect could possibly be detected. NRPB staff has made many measurements to support this view. Concerns about other possible, so-called athermal effects arising from exposure to mobile phone frequencies have also been raised. These include suggestions of subtle effects on cells that could have an effect on cancer development or influences on electrically excitable tissue that could influence the function of the brain and nervous tissue. Radio waves do not have sufficient energy to damage genetic material (DNA) in cells directly and cannot therefore cause cancer. There have been suggestions that they may be able to increase the rate of cancer development (i.e. influence cancer promotion or progression). The NRPB Advisory Group on Non-Ionizing Radiation concluded, however, at a meeting in May 1999: that there was no human evidence of a risk of cancer resulting from exposure to radiations that arise from mobile phones. Furthermore, the evidence from biological studies on possible effects on tumor promotion or progression, including work with experimental animals, is not convincing. The lack of evidence does not, however, prove the absence of a risk and more specific research is warranted. There has also been concern about whether there could be effects on brain function, with particular emphasis on headaches and memory loss. Few studies have yet investigated these possibilities, but the evidence does not suggest the existence of an obvious health hazard. In view of the limited amount of high quality experimental and epidemiological studies published to date, NRPB has supported the need for further research as outlined by an Expert Group, which reported to the European Commission (EC) in 1996. This recommended a comprehensive program covering cellular studies, experimental investigations in animals together with human volunteer studies and epidemiology. The Group stressed the need to replicate studies suggesting the possibility of effects. This program is being developed within the Fifth Framework Program of the EC.

3.2. Cell Phone Radiation

Just by their basic operation, cell phones have to emit a small amount of electromagnetic radiation. If one has read How Cell Phones Work, then it should be known that cell phones emit signals via radio waves, which are comprised of radio-frequency (RF) energy, a form of electromagnetic radiation. There's a lot of talk in the news recently about whether or not cell phones emit enough radiation to cause adverse health effects. The concern is that cell phones are often placed close to or against the head during use, which puts the radiation in direct contact with the tissue in the head. There's evidence supporting both sides of the argument.

3.2.1 Source of Radiation

When talking on a cell phone, a transmitter takes the sound of one's voice and encodes it onto a continuous sine wave (see How Radio Works to learn more about how sound is transmitted). A sine wave is just a type of continuously varying wave that radiates out from the antenna and fluctuates evenly through space. Sine waves are measured in terms of frequency, which is the number of times a wave oscillates up and down per second. Once the encoded sound has been placed on the sine wave, the transmitter sends the signal to the antenna, which then sends the signal out. Radiation in cell phones is generated in the transmitter and emitted through the antenna. Cell phones have low-power transmitters in them. Most car phones have a transmitter power of 3 watts.

A handheld cell phone operates on about 0.75 to 1 watt of power. The position of a transmitter inside a phone varies depending on the manufacturer, but it is usually in close proximity to the phone's antenna. The radio waves that send the encoded signal are made up of electromagnetic radiation propagated by the antenna. The function of an antenna in any radio transmitter is to launch the radio waves into space; in the case of cell phones, a receiver in the cell-phone tower picks up these waves. Electromagnetic radiation is made up of waves of electric and magnetic energy moving at the speed of light, according to the Federal Communications Commission (FCC). All electromagnetic energy falls somewhere on the electromagnetic spectrum, this ranges from extremely low frequency (ELF) radiation to X-rays and gamma rays. How these levels of radiation affect biological tissue will be explained further down.

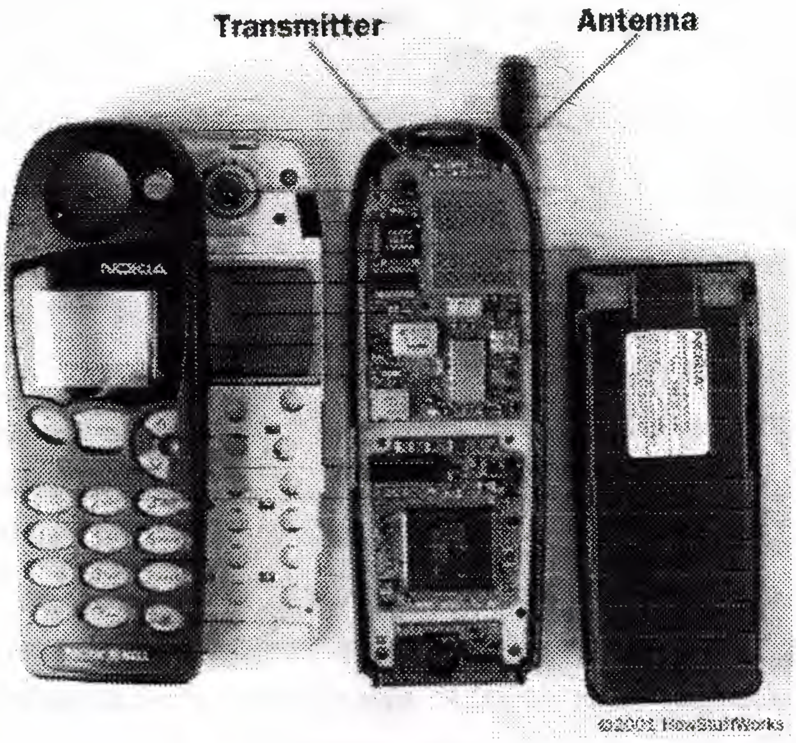


Figure 3.1. Source of Radiation.

When talking on a cell phone, most users place the phone against the head. In this position, here is a good chance that some of the radiation will be absorbed by human tissue. The next section will look at why some scientists believe that cell phones are harmful, and it will be shown what effects those ubiquitous devices may have.

3.2.2. Potential Health Risks

In the late 1970s, concerns were raised that magnetic fields from power lines were causing leukemia in children. Subsequent epidemiological studies found no connection between cancer and power lines. Around the same time, similar cancer fears arose about computer monitors. While there is some radiation emitted from computer monitors, studies have shown that they don't raise cancer rates. The latest health scare related to everyday technology is the potential for radiation damage caused by cell phones. Studies on the issue continue to contradict one another. All cell phones emit some amount of electromagnetic radiation. Given the close proximity of the phone to the head, it is possible for the radiation to cause some sort of harm to the 118 million cell-phone users in the United States. What is being debated in the scientific and political arenas is just how much radiation is considered unsafe, and if there are any potential long-term effects of cell-phone radiation exposure.

3.2.3. There are Two Types of Electromagnetic Radiation.

Ionizing radiation - This type of radiation contains enough electromagnetic energy to strip atoms and molecules from the tissue and alter chemical reactions in the body. Gamma rays and X-rays are two forms of ionizing radiation. It is known that they cause damage, which is why a lead vest is worn when X-rays are taken. Non-ionizing radiation - Non-ionizing radiation is typically safe. It causes some heating effect, but usually not enough to cause any type of long-term damage to tissue. Radio-frequency energy, visible light and microwave radiation are considered non-ionizing. On its Web site, the FDA states that "the available scientific evidence does not demonstrate any adverse health effects associated with the use of mobile phones." However, that doesn't mean that the potential for harm doesn't exist. Radiation can damage human tissue if it is exposed to high levels of RF radiation, according to the FCC. RF radiation has the ability to heat human tissue, much like the way microwave ovens heat food. Damage to tissue can be caused by exposure to RF radiation because the body is not equipped to dissipate excessive amounts of heat. The eyes are particularly vulnerable due to the lack of blood flow in that area. Cell-phone use continues to rise, which is why scientists and lawmakers are so concerned about the potential risks associated with the devices. The added concern with non-ionizing radiation, the type of radiation associated with cell phones, is that it could have long-term effects. Although it may not immediately cause damage to tissue, scientists are still unsure about whether prolonged exposure could create problems. This is an especially sensitive issue today, because more people are using cell phones than ever before. In 1994, there were 16 million cell-phone users in the United States alone. As of July 17, 2001, there were more than 118 million.

Here are a few illnesses and ailments that have potential links to cell-phone radiation:

- **Cancer**
- **Brain tumors**
- **Alzheimer's**
- **Parkinson's**
- **Fatigue**
- **Headaches**

Studies have only muddled the issue. As with most controversial topics, different studies have different results. Some say that cell phones are linked to higher occurrences of cancer and other ailments, while other studies report that cell-phone users have no higher rate of cancer than the population as a whole. No study to date has provided conclusive evidence that cell phones can cause any of these illnesses. However, there are ongoing studies that are examining the issue more closely. See the links page at the end of this article for more information on these studies. At high levels, radio-frequency energy can rapidly heat biological tissue and cause damage such as burns, according to a recent report from the U.S. General Accounting Office (GAO), a nonpartisan congressional agency that audits federal programs. The report went on to state that mobile phones operate at power levels well below the point at which such heating effects would take place. The amount of radiation emitted from the devices is actually minute.

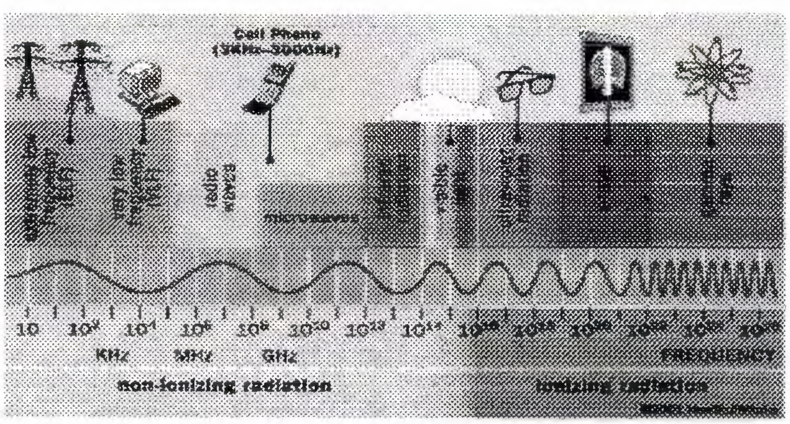


Figure 3.2. Cell-Phone Radiation.

3.3 Antenna radiation and types used in GSM

The 2002 report from the Health Council of the Netherlands the differences between cell phones, PCS phones, and other types of portable (mobile) phones matter when evaluating the potential impacts of base station antennas on human health No. There are many technical differences between cell phones, PCS phones, and the types of "mobile" phones used in other counties but for evaluation of possible health hazards, the only distinction that matters is that they operate at slightly different frequencies. The RF radiation from some base stations (e.g., those for the older 800 MHz mobile phones used in the U.S.) may be absorbed by humans somewhat more than the RF radiation from other types of base stations (e.g., those for the 1800-2000 MHz "PCS" phones used in the U.S.) However, once the energy is absorbed the effects are the same. the differences between base station antennas and other types of radio and TV broadcast antennas matter when evaluating their potential impacts on human health The RF radiation from some antennas (particularly FM and VHF-TV broadcast antennas) are absorbed more by humans than the RF radiation from other sources (such as mobile phone base station antennas); but once the energy is absorbed the effects are basically the same. FM and TV antennas send out 100 to 5000 times more power than base station antennas, but are usually mounted on much higher towers (typically 800 to 1200 ft). Mobile phone base station antennas produce radiation Mobile (cellular) phones and their base station antennas are two-way radios, and produce radio frequency (RF) radiation that's how they work. This radio frequency radiation is "non-ionizing," and its biological effects are fundamentally different from the "ionizing" radiation produced by x-ray machines. There are safety guidelines for mobile phone base station antennas and there are national and international safety guidelines for exposure of the public to the RF radiation produced by mobile phone base station antennas. The most widely accepted standards are those developed by the Institute of Electrical and Electronics Engineers and American National Standards Institute (ANSI/IEEE) the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the National Council on Radiation Protection and Measurements (NCRP). These radio frequency standards are expressed in "plane wave power density," which is measured in mW/cm-sq (milliwatts per square centimeter). For PCS (about 1800-2000 MHz) antennas, the 1992 ANSI/IEEE exposure standard for the general public is 1.2 mW/cm-sq. For analog mobile phones (about 900 MHz), the ANSI/IEEE exposure standard for the general public is 0.57 mW/cm-sq. The ICNIRP standards are slightly lower and the NCRP standards are essentially identical. In 1996 the U.S. Federal Communications Commission (FCC) released radio frequency guidelines for the frequencies and devices they regulate, including mobile phone base station antennas .The FCC standards for mobile phone base station antennas are essentially identical to the ANSI/IEEE standard The public exposure standards apply to power densities averaged over relatively short periods to time, 30 minutes in the case of the ANSI/IEEE, NCRP, and FCC standards (at mobile phone frequencies). Where there are multiple antennas, these standards apply to the total power produced by all antennas. In addition, there is a scientific basis for these radio frequency radiation safety guidelines when scientists examined all the published literature on the biological effects of RF radiation they found that the literature agreed on a number of key points:

1. The research on RF radiation is extensive, and is adequate for establishing safety guidelines.
2. Exposure to RF radiation can be hazardous if the exposure is sufficiently intense. Possible injuries include cataracts, skin burns, deep burns, heat exhaustion, and heat stroke. See Reeves for a discussion of the known effects of overexpose to RF radiation in humans.
3. Biological effects of RF radiation depend on the rate of energy absorption; and within a broad range of frequencies (1 to 10,000 MHz), the frequency matters very little.
4. Biological effects of RF radiation are proportional to the rate of energy absorption; and the duration of exposure matters very little.
5. No biological effects have been consistently shown below a certain rate of whole body energy absorption (this rate is called the specific absorption rate or SAR).

Based on this scientific consensus, different agencies and countries took different approaches to setting safety guidelines. A typical approach was that used by ANSI/IEEE and the FCC. To establish occupational exposure guidelines, ANSI/IEEE and FCC applied a 10-fold safety margin to the lowest energy absorption rate shown to have biological effects. They then applied an additional 5-fold safety margin for continuous exposure of the general public. Finally, detailed studies were done to establish the relationship of power density, which can be routinely measured, to the energy absorption rate (SAR), which really matters .The result was a highly conservative public exposure guideline that was set at a level that is only 2% of the level where replicated biological effects have actually been observed. There are differences between the standards. ANSI/IEEE, ICNIRP, NCRP, and FCC all use the same biomedical data, and the same general approach to setting safety guidelines. However, there are differences in the models used by the different groups, and hence there are slight differences in the final numbers. No biological significance should be associated with these slight differences. A number of countries have their own regulations for public exposure to RF radiation from mobile phone base station antennas. While most of these regulations follow the same patterns and rationales used by ANSI/IEEE and ICNIRP, they do differ. The U. S. has safety guidelines for mobile phone base stations. Until 1996 the U. S. Federal Communications Commission (FCC) used an out-dated (1982) ANSI standard. In 1996 the FCC adopted a new standard that was based on a combination of the 1992 ANSI standard and the 1986 NCRP guidelines. The new FCC standard for mobile phone base stations is 0.57 mW/cm-sq at 900 MHz and 1.0 mW/cm-sq at 1800-2000 MHz. This 1996 FCC standard applied to all new transmitters licensed after 15-Oct-97, but pre-existing facilities had until 1-Sep-2000 to demonstrate compliance. The FCC power-density standards described above apply to whole-body public exposure to radio-frequency radiation from mobile phone base stations; they do not apply to exposure from the phones themselves or to occupational exposure. For a discussion of exposure from the phones or a discussion of occupational RF radiation exposure see FCC OET Bulletin 56, the FCC guideline itself, and Foster and Moulder. Mobile phone base station antennas meet the safety guidelines With proper design, mobile phone base station antennas can meet all safety guidelines by a wide margin A mobile phone base station antenna, mounted 10 meters (33 ft) off the ground and operated at the maximum possible intensity, might produce a power density as high as 0.01 mW/cm-sq on the ground near the antenna site; but ground level power densities will more often be in the 0.00001 to 0.0005 mW/cm-sq range. These power densities are far below all the safety guidelines, and the standards themselves are set far below the level where potentially hazardous effects have been seen. Within about 200 meters (650 ft) of the base of the antenna site, the power density may be greater at elevations above the base of the antenna site (for example, at the second floor of a building or on a hill). Even with multiple antennas on the same tower, power densities will be less than 5% of the FCC guidelines at all heights and at all distances of more than 55 meters (180 ft) from an antenna site. Further than about 200 meters (650 ft) from the antenna site power density does not rise with increased elevation. Power density inside a building will be lower by a factor of 3 to 20 than outside. Petersen et al measured power densities around mobile phone base stations. The measurements were for 1600 W (ERP) antennas on towers that ranged from 40 to 83 meters (130 to 275 ft) in height. The maximum power density on the ground was 0.002 mW/cm-sq, and the maximum was at 20 to 80 meters (65-265 feet) from the base of the towers. Within 100 meters (330) feet of the base of the towers, the average power density was less than 0.001 mW/cm-sq. These maximum RF power densities are all less than 1% of the FCC, ANSI/IEEE, NRPB, and ICNIRP standards for public exposure. In 1999 in Vancouver Canada, Thansandote et al measured RF levels in five schools, three of which had base stations on them or near them. All schools met Canadian, US, and international RF standards by a wide margin.

Table 3.1. The maximum readings are shown in the following table.

School	Base Station Location	Maximum RF Level
1	PCS base station across street	0.00016 mW/cm-sq
2	Analog base station on roof	0.0026 mW/cm-sq
3	Analog base station across street	0.00022 mW/cm-sq
4 and 5	No antennas nearby	Less than 0.00001 mW/cm-sq

In 2000, the U.K. National Radiation Protection Board measured radio frequency radiation levels at 118 publicly accessible sites around 17 mobile phone base stations. The maximum exposure at any location was 0.00083 mW/cm-sq (on a playing field 60 meters from a school building with an antenna on its roof). Typical power densities were less than 0.0001 mW/cm-sq (less than 0.01% of the ICNIRP public exposure guidelines). Power densities indoors were substantially less than power densities outdoors. When radio frequency radiation from all sources (mobile phone, FM radio, TV, etc.) was taken into account the maximum power density at any site were less than

0.2% of the ICNIRP public exposure guidelines.

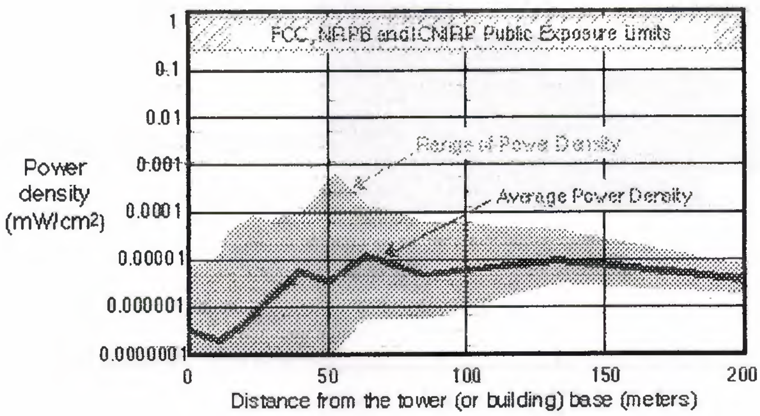


Figure 3.3. Radio frequency Radiation Levels Near Mobile Phone Base Stations in the UK.

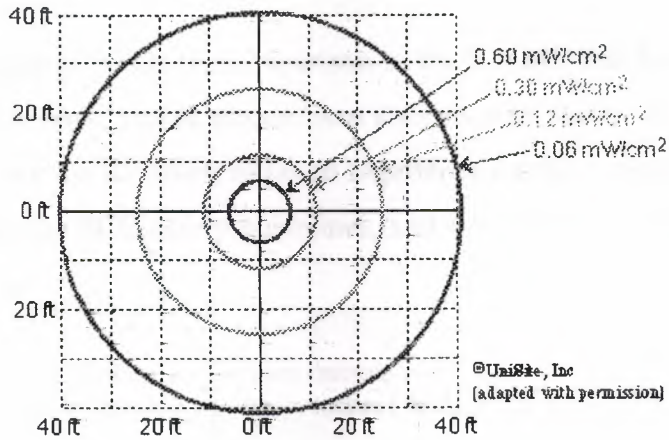


Figure 3.4. Low-gainer.

The relationship between the RF power density and distance from the base of the tower or building on which the mobile phone base antenna was located. Adapted from Mann et al. In 2001, the Radiocommunications Agency of the UK Department of Trade and Industry measured RF radiation levels at 100 schools that had mobile phone base stations near them. The maximum RF level measured at any school was less than 1% of the ICNIRP standard for public areas; the maximum in most schools was less than 0.1% of that standard.

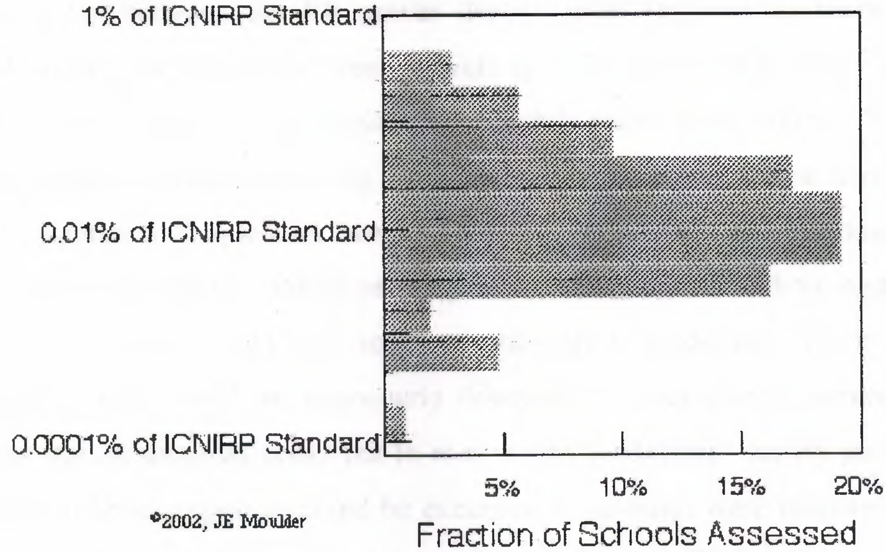


Figure 3.5. Radio frequency radiation levels in schools near mobile phone base stations in the UK (in comparison to the ICNIRP guidelines for public areas).

Maximum RF radiation levels (in comparison to the ICNIRP standard for public areas) in UK schools that have mobile phone base stations near them. Adapted from. The relationship between the RF levels required to produce known biological effects, the RF levels specified in the FCC safety guidelines, and the RF levels found around mobile phone base stations.

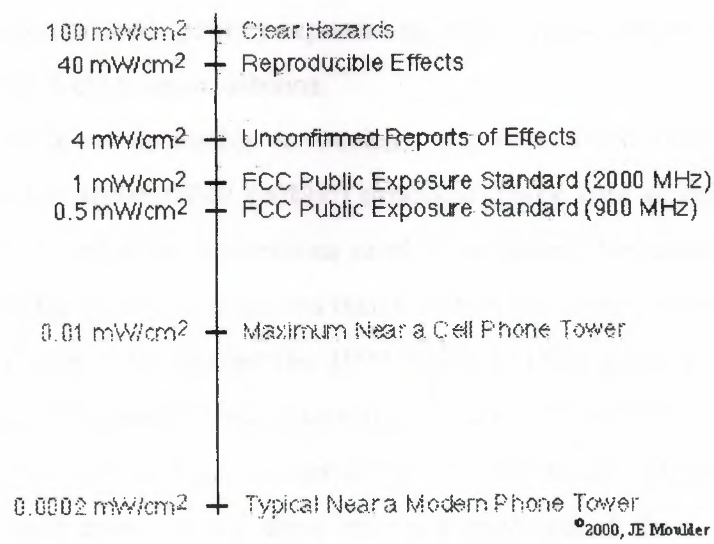


Figure 3.6. Standards for mobile phone base stations

The relationship between the RF power density level required to produce known biological effects, the RF power density levels specified in the FCC safety guidelines, and the RF power density levels found around mobile phone base stations. Because the RF power density required producing biological effects is dependent on frequency, this figure only applies to frequencies between 800 and 2200 MHz (that is, those currently used by analog and digital mobile phones). The circumstances where mobile phone base station antennas could fail to meet the safety guidelines There are some circumstances under which an improperly designed (or inadequately secured) mobile phone base station antennas could fail to meet safety guidelines. Safety guidelines for uncontrolled (public) exposure could be exceeded if antennas were mounted in such a way that the public could gain access to areas within 6 meters/20 feet (horizontal) of the antennas themselves. This could arise for antennas mounted on or near the roofs of buildings. Petersen et al, for example, found those 2-3 feet (1 meter) from a 1600 W (ERP) rooftop antenna; the power density was as high as 2 mW/cm-sq (compared to the ANSI public exposure standard of 1.2 to 0.57 mW/cm-sq). For antennas mounted on towers, it is very difficult to imagine a situation that would not meet the safety guidelines. Some general siting criteria:

1. Antenna sites should be designed so that the public cannot access areas that exceed the 1992 ANSI or FCC guidelines for public exposure. As a general rule, the uncontrolled (public) exposure guideline cannot be exceeded more than 6 meters (20 feet) from an antenna.
2. If there are areas accessible to workers that exceed the 1992 ANSI or FCC guidelines for uncontrolled (public) exposure, make sure workers know where the areas are, and what precautions need to be taken when entering these areas. In general, this would be areas less than 6 meters (20 feet) from the antennas.
3. If there are areas that exceed the 1992 ANSI or FCC guidelines for controlled (occupational) exposure, make sure that workers know where these areas are, and that they can (and do) power-down (or shut down) the transmitters when entering these areas. Such areas may not exist; but if they do, they will be confined to areas within 3 meters (10 feet) of the antennas.

If there are questions about whether these guidelines are met, compliance should be verified by measurements done after the antennas are activated. The FCC guidelines require detailed calculations and/or measurement of radio frequency radiation for some high-power rooftop transmitters, and some high-power transmitters whose antennas are mounted on low towers .In general, the above guidelines will always be met when antennas are placed on their own towers. Problems, when they exist, are generally confined to:

- Antennas placed on the roofs of buildings; particularly where multiple base station antennas for different carriers are mounted on the same building;
- Antennas placed on structures that require access by workers (both for regular maintenance, and for uncommon events such as painting or roofing).

3.4. The difference between a high-gain antenna and a low-gain antenna:

There are many different types of base station antennas, and the RF radiation patterns from them can be quite different. The most basic difference is between high-gain antennas and low-gain antennas. Because siting and safety issues for high- and low-gain antennas are different, it is important to be able to tell them apart. In the early days of mobile phones, one could usually tell by looking. Unfortunately, the development of newer antenna designs and the variety of different ways to stealth (hide) antennas now often makes it impossible to determine what kind of antenna has been installed just by looking.

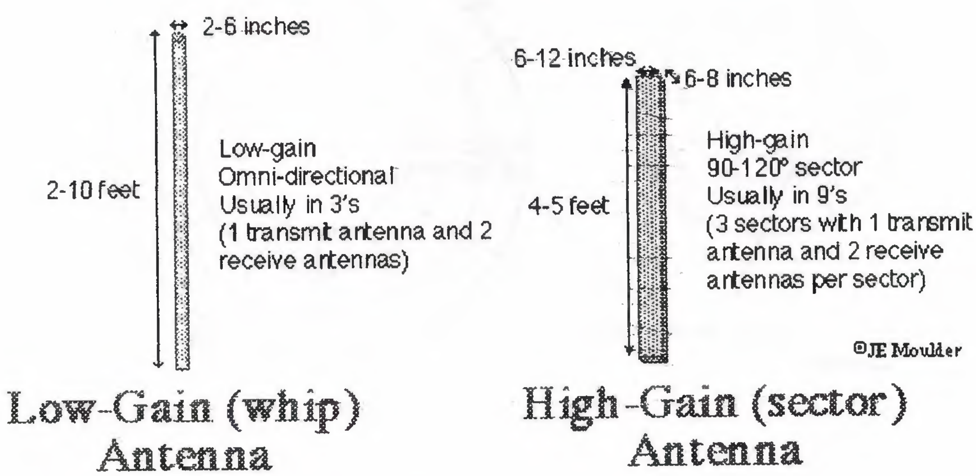


Figure 3.7. Low-gain antenna and high gain antenna.

The phrases "antenna gain," "transmitter power" and "effective radiated power (ERP)" mean: The power of a mobile phone base station is usually described by its effective radiated power (ERP), which is given in watts (W). Alternatively, the power can be given as transmitter power (in watts) and the antenna gain. Transmitter power is a measure of total power, while ERP is a measure of the power in the main beam. If an antenna were omni-directional and 100% efficient, then transmitter power and ERP would be the same. However, mobile phone base station antennas (like all antennas) are not omni-directional; they are moderately (low-gain antennas) too highly (high-gain antennas) directional. The fact that they are directional means that they concentrate their power in some directions, and give out much less power in other directions. Antenna gain is a measure of how directional an antenna is, and it is measured in decibels. As a result, a 20-50 W base station transmitter with a high-gain antenna could produce an ERP of anywhere from several hundred watts to over 1000 watts. Perhaps the concept of "gain" and "ERP" are best explained by analogy to light bulbs. Compare a regular 100 W light bulb and a 100 W spot light. Both have the same total power, but the spot light is much brighter when one is in its beam and very weaker when outside its main beam. A mobile phone base antenna (particularly a high-gain sector antenna) is like the spot light, and ERP is equivalent to the power in the spot light's main beam.

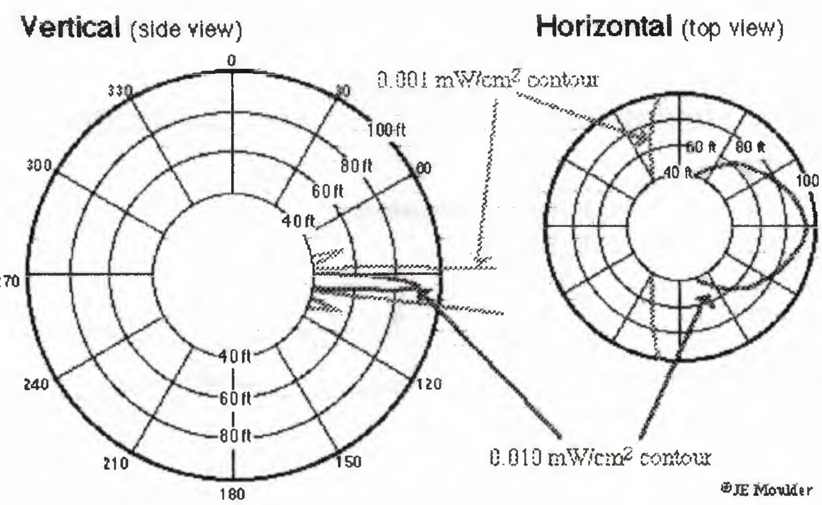


Figure 3.8. High-gain.

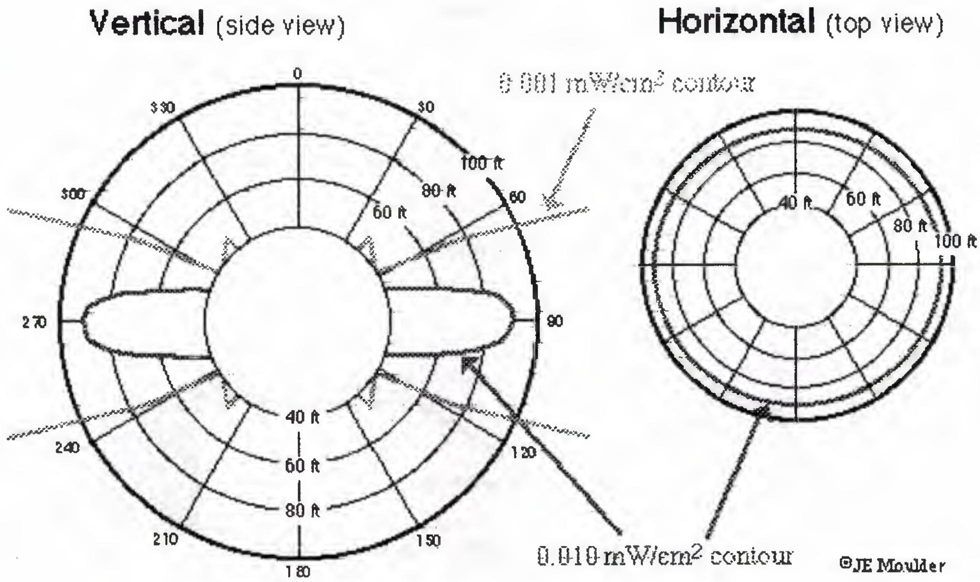


Figure 3.9. Low-gain.

3.5. The difference between the RF patterns for high-gain and low-gain antennas:

The RF patterns for different types of antennas are very different. For a low-gain antenna with a 1000 W ERP of the type formerly used by many mobile phone base stations, the pattern can look like this:

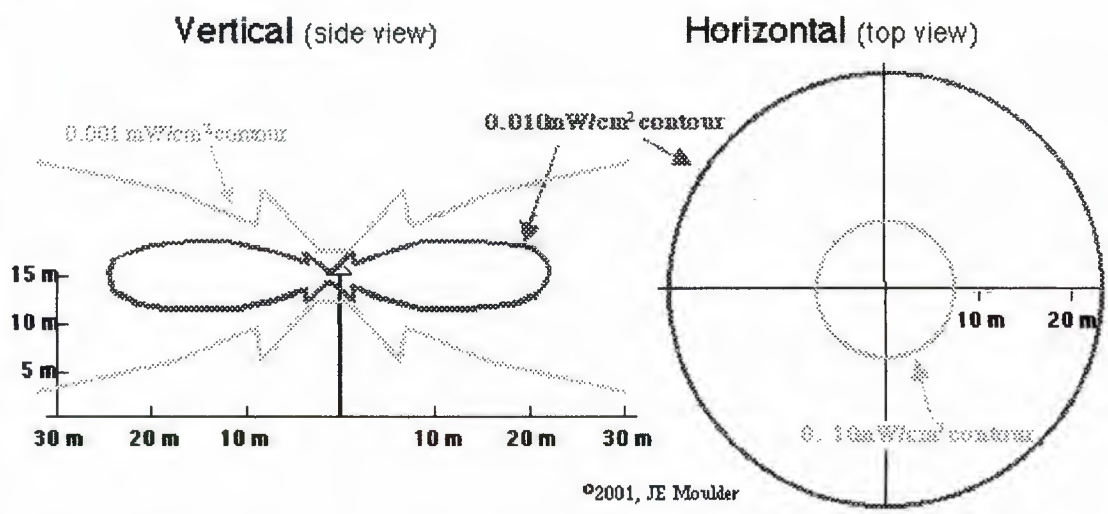


Figure 3.10. RF Radiation from a 1000 W ERP Low-Gain Antenna on a 15 m Tower.

For a high-gain (sector) antenna of the type used in many of the newer base stations, the pattern can look like this:

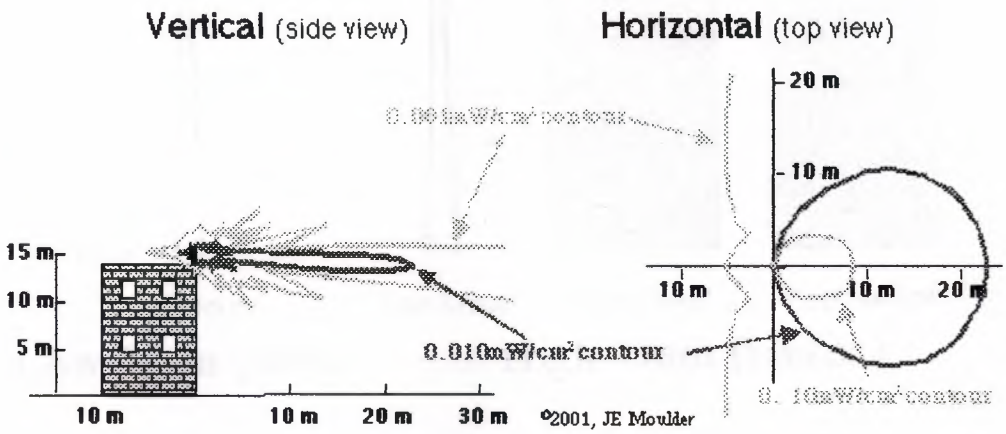


Figure 3.11. RF Radiation from a Single 1000 W ERP High-Gain Antenna Mounted 2 m above the Roof of a 13 m Building.

Keep in mind that mobile phone base station that use high-high-gain sectored antennas will usually use 3 (or occasionally 4) of these transmission antennas, all pointing in different directions. The data for the above figure were adapted (with permission) from drawings provided by UniSite Inc. of Tampa, Florida. The safe to live on the top floor of a building that has a mobile phone base station antenna on it In general this will not be a problem.

1. As can be seen from the antenna patterns, neither high- or low-gain antennas radiate much energy straight down.
2. The roof of the building will absorb large amounts of the RF energy. Typically a roof would be expected to decrease signal strength by a factor of 5 to 10 (or more for a reinforced concrete or metal roof).
3. FCC will require RF evaluations of all but the most low-powered roof-top transmitters Even a worst-case calculation predicts that power density on the floor below an antenna will meet all current RF safety guidelines
4. Actual measurements in top floor apartments and corridors confirm the power density will be far below all current RF safety guidelines.

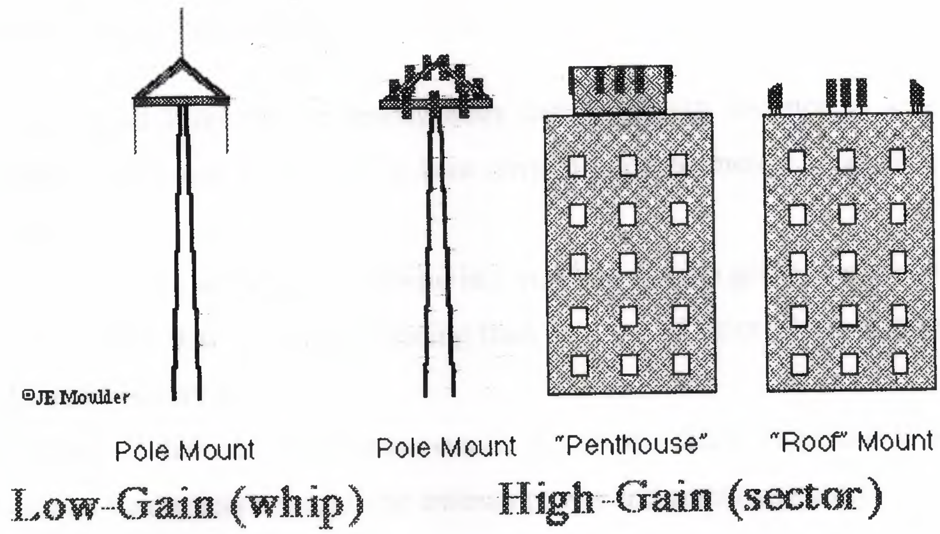


Figure 3.12. The safe to live on the top floor of a building.

Using restrictions or "set-backs" required around mobile phone base station antenna sites and what is the "minimum safe distance":

Radio frequency safety guidelines do not require either setbacks or use restrictions around mobile phone base station antenna sites, since power levels on the ground are never high enough to exceed the guidelines for continuous public exposure As discussed, there may be circumstances where use restrictions will have to be placed around the antennas themselves The "Minimum Safe Distance" from a mobile phone base antenna is described by the FDA/FCC as follows:

"To be exposed to levels at or near the FCC limits for cellular or PCS frequencies an individual would essentially have to remain in the main transmitted radio signal (at the height of the antenna) and within a few feet from the antenna... In addition, for sector-type antennas RF levels to the side and in back are insignificant." Note that the above quote about safe distances applies to the actual radiating antenna, not to the tower the antenna is on. For a mobile phone base station antenna mounted on tower that is 5+ meters high, there should be no areas that will come anywhere close to the RF radiation safety guidelines, so the concept of a "minimum safe distance" really doesn't mean anything. Some people have argued that base stations should be kept some distance away from "sensitive" areas.

There is little logic to this argument:

1. the ground level power density does not drop with distance in any regular manner until one gets about at least several hundred meters away from a base station.
2. People living, working or studying in a building usually get less exposure from a base station that is on their building than they would from a base station several hundred meters away
3. Horizontal distance from a base station is less of a factor in ground level power density than antenna height, the antenna power and antenna pattern.

In addition, moving base antennas away from an area where there are mobile phone users may:

1. Increase the exposure of the users from their handsets.
2. Require the base antenna power to be increased.
3. Require the base antennas to be placed further above the ground.
4. Increase the cell size and limit the number of users.

3.6. Specific Antenna Installation Guidelines:

For roof-mounted antennas, elevate the transmitting antennas above the height of people who may have to be on the roof.

1. For roof-mounted antennas, keep the transmitting antennas away from the areas where people are most likely to be (e.g., roof access points, telephone service points, HVAC equipment).
2. For roof-mounted directional antennas, place the antennas near the periphery and point them away from the building.
3. Consider the trade off between large aperture antennas (lower maximum RF) and small aperture antennas (lower visual impact).
4. Remember that RF standards are stricter for lower-frequency antennas (e.g., 900 Mhz) than for higher-frequency antennas (e.g., 1800 MHz).

5. Take special precautions to keep higher-power antennas away from accessible areas.
6. Keep antennas at a site as far apart as possible; although this may run contrary to local zoning requirements.

3.7 Investigators claimed that there is evidence that living near TV or FM radio broadcast towers causes an increase in cancer:

Such claims have been made, but so far none of these claims have been confirmed. Hocking and colleagues published an "ecological" epidemiology study that compares municipalities "near TV towers" to those further away. No RF radiation exposures were actually measured, but the authors calculate that exposures in the municipalities "near TV towers" were 0.0002 to 0.008 mW/cm-sq. No other sources of exposure to RF are taken into account, and the study is based on only a single metropolitan area. The authors report an elevated incidence of total leukemia and childhood leukemia, but no increase in total brain tumor incidence or childhood brain tumor incidence. In 1998, McKenzie and colleagues repeated the Hocking study. McKenzie and colleagues looked at the same area, and at the same time period; but they made more precise estimates of the exposure to RF radiation that people got in various areas. They found increased childhood leukemia in one area near the TV antennas, but not in other similar areas near the same TV antennas; and they found no significant correlation between RF exposure and the rate of childhood leukemia. They also found that much of the "excess childhood leukemia" reported by Hocking occurred before high-power 24-hour TV broadcasting had started. This replication study, plus the failure to find any effect in the larger UK studies, suggests that correlation reported by Hocking et al was an artifact. In 1997, Dolk and colleagues investigated a reported leukemia and lymphoma cluster near a high-power FM/TV broadcast antenna at Sutton Coldfield in the UK. They found that the incidence of adult leukemia and skin cancer was elevated within 2 km of the antenna, and that the incidence of these cancers decreased with distance. No associations at all were seen for brain cancer, male or female breast cancer, lymphoma, or any other type of cancer. Because of this finding, Dolk, and colleagues extended their study to 20 other high-power FM/TV broadcast antennas in the UK. Cancers examined were adult leukemia, skin melanoma and bladder cancer, and childhood leukemia and brain cancer. No elevations of cancer incidence were found near the antennas, and no declines in cancer incidence with distance were seen. This large study does not support the results found in the much smaller studies by the same authors at Sutton Coldfield or by Hocking et al in Australia. In 2002, Michelozzi et al reported that the incidence of childhood leukemia was elevated within 6 km of Vatican Radio (31 transmitters at 4-44 kHz and 0.5-1.6 MHz, with power of up to 600,000 W). The authors also report elevated leukemia in adult men residing near the transmitters, but not in adult women. In 2002, Hallberg and Johansson speculated that the increase in melanoma seen in Sweden (and industrialized countries) since 1960 is due to exposure to FM radio broadcasting. How an Israeli epidemiologist claimed that there is evidence that low-level RF exposure causes a variety of health effects, In a 1995 article labeled an "opinion piece", Goldsmith argues that there is evidence that RF exposure is associated with mutations, birth defect, and cancer. This review is based largely on what the author admits to be "non-peer-reviewed sources," most of which are stated to be "incomplete" and to lack "reliable dose estimates." The author further states that "no systematic effort to include negative reports is made; thus this review has a positive reporting bias." In an article based on a 1996 meeting presentation Goldsmith argues that epidemiological studies "suggest that RF exposures are potentially carcinogenic and have other health effects." His conclusions are based largely on:

- studies of RF exposure at the US embassy in Moscow;
- the "geographical correlation" studies of Hocking et al and Dolk et al
- the study of Korean war radar operators by Robinette et al

Few scientists agree with the opinions expressed by Goldsmith; and even fewer would be willing to base a conclusion on the types of data sources that Goldsmith relies on. A University of Washington (Seattle, U.S.A) researcher claimed that there is evidence that RF exposure from base stations is hazardous, Dr. Henry Lai (Department of Bioengineering, University of Washington, Seattle) has claimed at meetings that "low intensity" RF radiation has effects on the nervous system of rats. Dr. Lai has further claimed at meetings that there are published studies showing that RF radiation can produce "health effects" at "very low field" intensities. Dr. Lai's own research has no obvious relevance to the safety of mobile phone base stations since most of his studies were conducted with RF radiation intensities far above those that would be encountered near base stations. In general, Dr. Lai's studies were done with at a power density of 1 mW/cm-sq and an SAR of 0.6 W/kg, This RF radiation intensity is over 100 times greater than that would be encountered in publicly-accessible areas near FCC-compliant base stations, and substantially exceeds the SAR limit that forms the basis of the FCC and ANSI safety guidelines for public exposure .For further discussion of the research on possible effects of RF radiation on the nervous system see reviews by Lai and Juutilainen and de Seze . At a meeting in Vienna in 1998, and in a letters sent to public officials, Dr. Lai referenced six studies in support of his claim that there is data showing that RF radiation can produce "health effects" at "very low field" intensities. These studies were:

1. Changes in the blood-brain barrier (Salford et al, 1997). An unpublished meeting presentation; for earlier work from this group see Salford et al, 1994.
2. Changes in cell proliferation (Kwee and Rasmark, 1997). This is an unpublished study that may be the same as that published by Kwee and Rasmark in 1998.
3. Decreased fertility in mice (Magras and Xenos, 1997).
4. Decreased eating and drinking in mice (Ray and Behari, 1990)
5. Changes in calcium transport in cells (Dutta et al, 1989)
6. DNA damage (Phillips et al, 1998)

A review of the above studies finds little actual support for Dr. Lai's claim.

- One of the studies, the report of effects on the blood-brain barrier by Salford et al, has never been published and cannot be evaluated. Note that in 2000-2002, Tsurita et al and Finnie et al reported that RF radiation had no effect on the blood-brain barrier of rats or mice.
- Two of the studies do not actually report any statistically significant effects.
    - Ray and Behari reported that exposed animals "tended" to eat and drink less than the controls, and that the effect disappeared by the end of the exposure period.
    - Phillips et al reported that exposure caused increased DNA damage in 3 of 12 exposure regimens and decreased DNA damage in 4 of the other 9 regimens. The study found no overall effect and no pattern.

- The statistical significance of the "effects" reported in two other studies is open to question, as the effects reported are very small and appear in only some experiments.
    - Dutta et al reported increased calcium efflux for only 6 of the 19 exposure regimens that were tested. Since the increases were unrelated to exposure intensity or frequency, they may be a multiple comparison artifact.
    - The "effect" reported by Kwee and Rasmark is a 5-10% decrease in cell growth that was statistically significant in only 5 of 9 trials.
- Two of the studies have inadequate control groups, so that if there is an effect, there is no way to be certain that it was due to the RF.
    - Magras and Xenos compared mouse fertility in breeding pairs kept in an "antenna park" with those kept in a laboratory. The conclusion that the effect on breeding was due to the RF rather than other environmental factors is purely speculative.

    Ray and Behari tightly confined their animals during exposure, but did not appear to similarly confine their controls. This type of "confinement stress" is known to cause changes in physiology and behavior .

- Several of the studies also use RF radiation intensities that substantially exceed anything that would be found in public areas near an FCC-compliant base station.
- Many of the "effects" reported have no known relationship to any human health hazard. For example, neither the changes in calcium efflux reported by Dutta et al the small decreases in cell growth reported by Kwee and Rasmark nor the small changes in food consumption reported by Ray and Behari have any known significance for human health.
- All of the "effects" quoted by Dr. Lai have been the subject of other studies that have shown no such effects, including studies done at substantially higher field intensities.

The claims on British, American and French TV that there is new data suggesting that mobile phones might cause cancer: There appears to have been no real scientific basis for these claims. In the summer and fall of 1999 (and repeated in 2000), programs on

British, American, and French TV claimed that there was new data suggesting that RF radiation from mobile phones could cause injury to humans. Four sources of "new" information were generally cited:

1. The study by Hardell et al
2. The study by Preece et al.
3. A new and then unpublished genotoxicity study.
4. A new and then unpublished epidemiology study.

The last two of these "new" studies were only vaguely described in the TV reports, but they appear to be references to studies sponsored by the mobile phone industry in the US (under the program called WTR). The WTR epidemiology study was presented at a meeting in June of 1999, and has now been published in the peer-reviewed literature. The published version reports no significant association between malignant or benign brain cancer and the use of hand-held mobile phones. The WTR genotoxicity study was presented at a meeting in March of 1999. Parts of this WTR study were published in early 2002 .The published version reports that RF radiation at 5 or 10 W/kg was capable of causing a one specific type of genotoxic injury (increased micronucleus formation); but did not enhance DNA strand breaks. Vijayalaxmi et al, Bisht et al, and McNamee et al have reported that they cannot replicate the micronucleus findings. The authors of the WTR genotoxicity study speculate that their reported effect on micronucleus formation may be due to heating. The epidemiological studies showing that RF exposure from base stations is safe, While there have been no epidemiology studies of cancer and mobile phone base stations, there have been epidemiology studies of cancer and other types of exposure to radio frequency radiation. Epidemiology studies of RF radiation from base stations have generally been concluded to be "infeasible, as there is no possibility to estimate individual exposure accurately enough."

3.8 Mobile phones and cancer

At what side of your brain you want to add your "Microwave phone" :

Did you know that . . . .

Table 3.2. Mobile Phones and Cancer.

The Left Part of Your Brain Controls:	The Right Part of Your Brain Controls:
• Number Skills • Written Language • Spoken Language • Scientific Skills • Right-hand Control	• Insight 3-D forms • Imagination • Music Awareness • Left-hand Control • Art Awareness

- The brain is the thinking organ of the body.
- The brain is the main part of the nervous system.
- The nervous system is made up of... The central system contains the brain. Contains the spinal cord.
- The peripheral system Composed of the nerves throughout the rest of the body.
- The size of the brain does not matter.
- The human brain weighs a mere 3 pounds, but it is more powerful than the larger brain of an elephant.
- There are 3 divisions of the brain...
- The cerebrum Most important
- Biggest part of the brain Divided into two sections
- The cerebellum Back of the skull Controls one's ability to balance and coordinate the muscles
- The mid brain Size of the end of the thumb Controls actions which happen by themselves. For example one's breathing and heartbeat

Figure 3.13. Brain view.

3.9. Cellular Phones are Unsafe

A diagnosis of cancer can be devastating. And there is good reason for this fear -- Cancer is the second leading cause of death in the United States next to heart disease, and will claim more than half a million lives this year. What we think of as "Cancer" is actually a group of more than one hundred separate diseases. These diseases are all characterized by an abnormal and unregulated growth of cells. This growth destroys surrounding body tissues and may spread to other parts of the body in a process that is known as metastasis. All kinds of different types of cancer are well known, but the focus here will be on BRAIN CANCER (brain tumor): Cancer can develop anywhere in the body, and at any age. Cancer is usually caused by genetic damage that happens inside an individual cell. When cells divide at an accelerated rate, they often begin to form a mass of tissue called a tumor. The tumor is fed by nutrients that diffuse through neighboring blood vessels and can also grow by forming a substance called tumor angiogenesis (vessel forming) factor. This factor stimulates the growth Tumors invade tissues and organs directly (direct extension), often damaging or disabling them in the process.

Tumors make invaded tissues and/or organs susceptible to infection. Tumors can also release substances that destroy tissues in close proximity to them. What Causes Cancer (brain tumor) Mutations in tumor suppressor genes are another common cause of cancer. As one might expect, a tumor suppressor gene is supposed to prevent tumors. However, when these genes are damaged, they can allow cancer to develop instead of preventing it. One of these genes, p53, normally prevents cells with abnormal DNA from surviving. When p53 is defective, these cells with abnormal DNA survive and can multiply, increasing the probability of developing cancer (brain tumor).

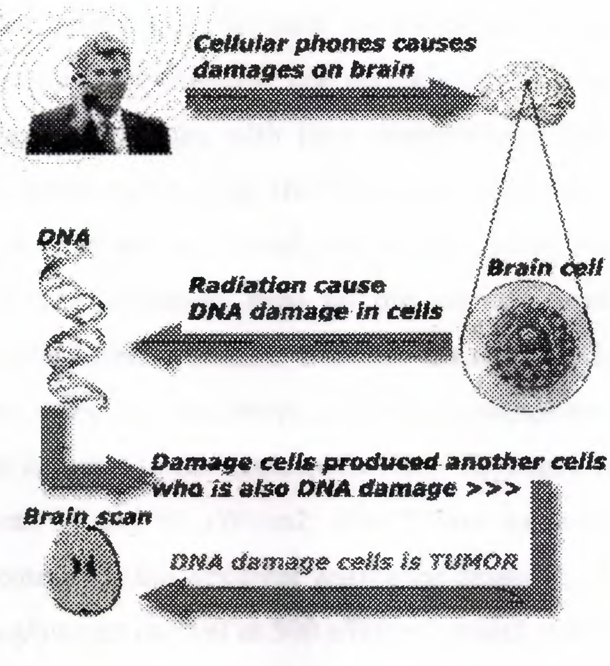


Figure 3.14. Simple image above how brain tumor start.

3.10. Blood

Changes have been reported in the cellular composition of the blood of rats, mice, dogs, guinea pigs, and rabbits following exposure to both high and low frequency EMFs (7-15). Graves (7) exposed mice continuously to 25 and 50 kv/m for 6 weeks and found that the white blood cell count (WBC) was increased by 20% and 66% respectively. The red blood cell count (RBC) decreased by 6% and 12% at the respective fields, but these changes were not reported statistically significant. Rats exposed intermittently (30 min/day) to 100 kv/m, 50° Hz, for 8 weeks, exhibited elevated neutrophil levels and depressed Iymphocyte levels (8). The same results were found following 2, 5, and 7 weeks' exposure at 5 hours/day. In dogs, alteration of the blood profile was seen following exposure at 10-25 kv/m (8). Meda (9) found an Iymphocyte decrease and a neutrophil and eosinophil increase in rats after a single 6-hour exposure to 100 kv/m, 50 Hz. A similar blood picture was found in mice after 500- and 1000-hour exposures to 100 kv/m (9). A significant increase in WBC was found in rabbits that had been exposed to 50 kv/m, 50 Hz, for 3 months (14). As has been the case with almost all biological indicators, the time course of the changes in blood parameters following EMF exposure was not the same in each test animal (11). Guinea pigs were exposed to 3GHz, 10 min/day, for 30 days (11), and both the irradiated and the sham-exposed animals were sampled before and after each daily exposure bout. The sham-exposed group revealed no significant changes, but animals exposed to 25 or 50 µW/cm2 exhibited EMF-induced alterations with time dependencies that differed with each animal. For a given exposure duration, the WBC was above the normal level in some animals, and below it in others; as a result, the average values varied little during the study. At 500 µW/cm2, however, even on the average there was a pronounced leucopoenia and lymphocytosis. Gonshar exposed rats to 2.4 GHz, 7 hours/day for 30 days and studied the effect on the levels of alkaline phosphates and glycogen (two indicators of cellular activity) in the neutrophils (12). Glycogen increased following 3 days' exposure at both 10 and 50 µW/cm2; after 7 days' exposure it decreased to the control level. In contrast to this apparent adaptation response, there was a sustained depressing effect on glycogen content at 500 µW/cm2, which was still observed after 30 days' exposure. At all three intensities, the alkaline phosphates levels first increased then decreased below the control level within 30 days. Ferrokinetic studies demonstrated that iron metabolism was affected and that erythrocyte production (measured by 59Fe incorporation) was significantly decreased in rabbits exposed to 2.95 GHz, 3000µW/cm2, for 2 hours daily (15).

The effects seen after 37 days of irradiation with a pulsed EMF were comparable in magnitude to those seen after 79 days exposure to a continuous-wave EMF. Rats exposed to 130 gauss, 50 Hz, for 4 hours/day, exhibited a 15% reduction in RBC after 1 month's exposure: the RBC level returned to normal within a month after removal of the field (10). Because comparable results were obtained using widely different EMFs, the blood-composition studies suggested to us that the EMF-induced alterations were mostly transient compensatory reactions of the body to a change in the electromagnetic environment. To determine the relation between magnitude and direction of the response and the conditions of application of the external EMF, for changes in hematological parameters of mice were researched due to short-term exposure to a full-body vertical 60 Hz electric field of 5 kv/m (13). To ensure maximum statistical sensitivity every mouse was sampled twice, once after exposure to the field for 2 days and once following a 2-day nonexposure period. There were four consecutive experiments, two with males, and two with females. In each there were two groups: one for which the control period preceded the exposure period (nF-ðF), and one in which the pattern was reversed (F-ðnF). On "day 1" of each experiment the mice were divided into the two groups and the electric field was applied to one-half the population. On "day 3" the blood parameters were measured in each mouse and immediately thereafter the exposed and nonexposed groups were interchanged. On "day 5" the blood parameters were measured again and the mice were killed. Blood was collected from the ophthalmic vessels and it was therefore necessary, before applying the field, to determine the influence of the first blood collection procedure on the values measured after the second such procedure. The blood parameters in two groups of mice were measured, one male and one female, under conditions that were identical in all respects to those employed during the field-exposure portion of the study, and it was found that the method of blood collection had a tendency to produce higher RBC, Hct, and MCV values and lower values of Hb, MCH, and MCHC .

Table3.3. Percent Change In Hematological Parameters.

EXPERIMENT	CONDITION	PERCENTAGE CHANGE					
		RBC	Hct	Hb	MCV	MCH	MCHC
A							
Male Control	nF → nF	1.7	2.0	-4.5*	1.0	-6.2*	-6.3*
Female Control	nF → nF	3.9*	4.1*	1.7	0.2	-5.0*	-5.1*
B							
Male I	F → nF	-4.7*	-5.1	NM	0	NM	NM
	nF → F	-5.2*	-4.9	NM	0.2	NM	NM
Male II	F → nF	-9.0*	-9.1*	-3.3*	-0.4	5.7*	6.0*
	nF → F	-6.5*	-7.0*	-2.4*	-0.7	3.9*	6.1*
Female I	F → nF	-4.1*	-4.6*	-4.2*	-1.2	0.5	1.2
	nF → F	-6.4*	-6.7*	-3.4*	-0.5	3.8	4.8
Female II	F → nF	-5.3*	-6.0*	3.4	-1.2*	8.3*	10.0*
	nF → F	-7.1*	-9.2*	3.5	-2.3*	11.0*	13.6*

NOTE: RBC, red blood cell concentration; Hct, hematocrit; Hb, hemoglobin; MCV, mean cell volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration. *A*, no change in exposure conditions; *B*, change in exposure condition as indicated. NM, not measured.

$p < 0.05$

In each experiment, RBC on "day 5" was significantly less than on "day 3," regardless of whether the interval between "day 3" and "day 5" was an exposure period or a nonexposure period. A decline in Hct paralleled the RBC changes, but Hb showed no consistent changes. MCV showed a tendency to decrease, but the other computed indices both increased, since the cell loss overshadowed any decrease in hemoglobin concentration. The trends in the computed indices, and especially the changes in RBC and Hct, were opposite to those induced by our method of blood collection alone. It follows, therefore, that the applied electric field had a physiological impact. The unique feature of the observed responses is that, for each parameter, a change in the same direction occurred with both the F-δnF and nF-δF groups. An analysis of variance confirmed that in all four experiments there was an effect associated with time but not with the order of field application. This indicated that the animals responded to the change in their electrical environment, not to the electric field itself. There are two reports of the effects of EMF on the blood globulin (16, 17). When rats were exposed to 3000 v/m at 1 KHz for 8 and 20 days (20 min./day), a reduction in coagulation activity (expressed as a lengthening of the rethrombin time, a drop in plasma tolerance for heparin, and a decrease in prothrombin consumption), and a rise in the thromboplastic and fibrinolytic activity of the blood were found (16). It was found that rats exposed to DC electric fields of 2.8-19.7 kv/m had altered blood-protein distributions (17). The general trend was towards elevated albumin and decreased gamma globulin levels (expressed as a percent of the total blood proteins). One of the most common sights seen these days, is that of people with their mobile phones next to their ears. A boon for better communication, cell phone usage nonetheless has many health hazards. Various studies indicate that the emissions from a cell phone can be extremely harmful, causing genetic damage, tumors, memory loss, and increased blood pressure and weakening of the immune system. This is alarming information, and one has to take into account all these factors though there is no evidence of cell phones causing cancer or any such illness, but the suspicion, or fear of the same is not baseless either. The electromagnetic radiation from cell phones does have a potential link to cancer. The fact that this radiation is invisible, intangible, and enters and leaves our bodies without our knowledge makes it even more intimidating.

3.11. Possible hazards

Two minutes of exposure to emissions from mobile phones can disable a safety barrier in blood causing proteins and toxins to leak into the brain, could increase chances of developing Alzheimer's multiple sclerosis and Parkinson's. (Scientists at Sweden's Lund University) Scientists say exposure to the phones' low-level radiation causes red blood cells to leak hemoglobin and can lead to heart disease and kidney stones. Recent studies suggesting a link between cell-phone use and brain tumors, and the possibility that the microwaves could ignite petroleum fumes at gas stations. A cell phone unit, or communications tower, has so many of thee radiation emanating gadgets. This can be a problem for its immediate environment.

3.11.1. Cancer / Tumors

Studies have been conducted suggesting that rats that have been exposed to microwaves similar to the sort generated by mobile phones but more powerful, showed breaks in their DNA, which could indicate an adverse effect. In addition, mice exposed to radiation for 18 months developed brain tumors. Although of course, these studies are not concrete proof.

3.11.2. Blood Pressure

It was observed that people using cell phones were prone to high blood pressure. Again, there isn't any concrete evidence of the same.

3.11.3. Pregnancy

A study at the University of Montpellier in France was carried out on 6000 chick embryos and suggested that the heavily exposed chick eggs were five times less likely to survive than the control group. This study raised questions about possible effects on pregnant women but it has not yet appeared in peer-reviewed scientific literature or been reproduced, so its findings are difficult to assess.

3.11.4. Headaches, Heating Effects, Fatigue

A study brought out that longer the people used mobile phones, the more likely they were to report symptoms such as hot ears, burning skin, headaches and fatigue. The study did not include a control group (that is people who do not use mobile phones, to make a comparison); therefore the symptoms reported could have been caused by any number of other factors in the mobile phones users' environment, such as working with computers, stress, driving or reading.

3.11.5. Memory

There have been various studies into the connection between mobile phones and memory loss. A study looked into the effect of radio frequency (RF) on the section of rats' brains that is linked with the memory. The results showed that RF could modify signals in the cells in a part of the brain that is responsible for learning and short-term memory.

3.11.6. Posture (holding phone between raised shoulder and ear)

Some researchers claim that holding a mobile phone between the raised shoulder and the ear could have a damaging effect on muscles, bones, tendons, and discs. These problems would apply equally to a cordless phone or a landline phone as to a mobile phone and are the effect of bad posture.

3.11.7. Mobile Phones and Children

Because of their smaller heads, thinner skulls and higher tissue conductivity, children may absorb more energy from a given phone than adults. Cell phones should be used for emergencies, and not for long conversations. A small chip-like cell phone microwave radiation protection device is available, which has the ability to absorb electromagnetic energy waves from the mobile phone. It helps in reducing the potential harmful effects of these emissions to the human body. Using a mobile headset is a good idea, one does not have to hold phones next to the ear all the time Use a hands free mobile car kit while driving, without taking your hands off the steering wheel. Mobile phone users should limit their exposure to harmful radio frequencies by cutting the length of calls. Hands-free devices cut exposure by keeping the instrument away from the head and body. Driving cum mobile phone talking should be banned. Mobile phones should not be used in Intensive Care Units of hospitals as they can pose a danger to patients by interfering with the working of pacemakers and defibrillators. People with hearing aids should not use mobile phones. Base stations, which have low powered antennae on their terrace to communicate with cell phones, should not be located near children's schools and playground.

3.12. The Effect of Cellular Phone Use Upon Driver Attention

One of the most popular innovations in automotive travel in the past decade has nothing to do with the automobile itself, the people who drive them, or the roads over which they operate. Rather, it is the ability to carry on telephone conversations while driving.

What CB radios were to the '70s, cellular phones were to the '80s. From early 1984, when the first complete systems became operational, the number of cellular phone users has grown to over two million. By the mid-'90s, when cellular service will be available throughout most population centers in the United States, the number of subscribers is expected to grow to between ten and twenty million. While cellular phones are really elements of communication rather than transportation, their potential impact upon the latter is sizable.

3.12.1. Age Related Effects

The attentional processes that must be shared when placing, receiving, or carrying on telephone conversations while driving are known to be vulnerable to age-related effects. The ability to share attention, as between the phone and the road, has demonstrated a relationship to age in studies by Craik (1973), Parkison, Lindholm and Urell, (1980), Temple (1989), and Ranney and Pulling (1990). Deficiencies in the ability to share attention have also been found in drivers over-involved in accidents (Mihal and Barrett 1976, Kahneman 1973). A somewhat less obvious but also relevant variable would be selective attention, the ability to focus selectively upon one set of stimuli in the presence of others. This ability has also been shown to decline with age (Clay 1956, Layton 1975, Rabbitt 1980 and Temple 1989). The studies by Kahneman and by Mihal and Barrett just cited also found declines in selective attention to be associated with over-representation in accidents. Age has evidenced relationships with a number of psychophysical processes that bear tangentially upon use of cellular phones while driving. Age-related declines have been noted in information processing (Braune et. al. 1985; Welford 198 1; Rackoff 1974; and Ranney and Pulling, 1990), problem solving (Case, Hulbert and Beers, 1970; and Arenberg 1982) and short term memory (Miller 1979; Welford 1981; and Temple 1989).

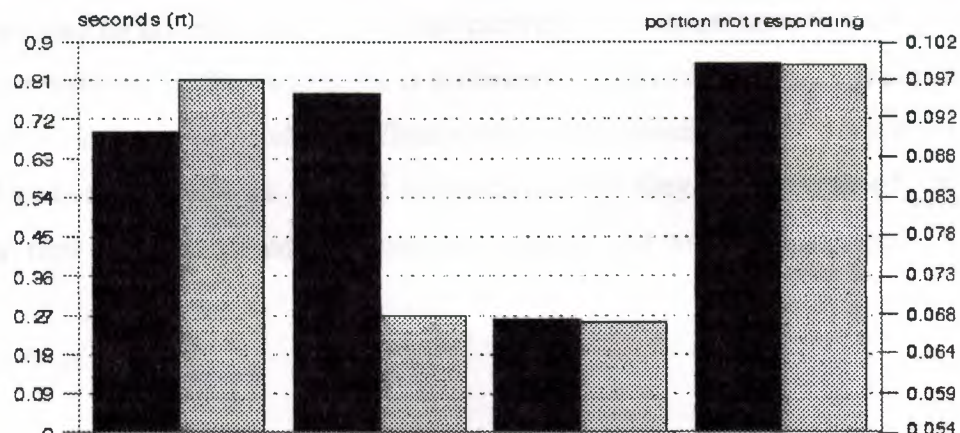
3.12.2. Types of Distraction

The independent variable under study was distraction. In this discussion, the term "distraction" refers to a diversion of attention from driving produced by some situation. The situation of primary concern is, of course, use of a cellular telephone. The car phone itself involves minimum distraction. The only time a driver is distracted by the apparatus is during the act of placing a call. Even when the dialing pad is placed on the dashboard and cut close to the line of sight, attention must be diverted from the path ahead. There is evidence that when people focus their attention upon one stimulus, they may fail to perceive another stimulus separated from the first by but a few degrees of visual angle. To assess the effect of placing a call upon driver attention, subjects were required (at various points of the test procedure) to dial a number given to them orally by the experimenter. The conversations taking place on the telephone are also a possible distraction. As we pointed out in the Introduction, what distinguishes cellular phones from in-person conversations is the higher instance of calls carried on for business rather than social reasons. It seems likely that calls involving business would be somewhat more attention demanding than purely social conversations. To allow differences in the intensity of conversation to evidence any effects upon degree of distraction, conversation took place at two levels, casual conversation, in which subjects talked with the experimenter about a variety of largely inconsequential topics, and intense conversation in which the subjects engaged in a set of problem-solving exercises. Testing distraction at two levels of conversation does not assume that the intense cellular phone conversations are truly more intense than conversations with passengers -only that level of intensity is a variable that warrants study. A distraction with which operation of any in-vehicle equipment is often compared is that of tuning a radio. The comparison is typically invited by someone defending introduction of a particular piece of equipment and using radio tuning as a lawyer might use a legal precedent. It has been used so often as to become something of a benchmark in studying in-car distraction. For this reason, it was included among the "distractions" with which telephone conversations were compared. To gauge the effect of various acts in distracting attention, they need to be compared with a condition that offers no distraction that is, simply driving the car. The people in this situation might find things to occupy their attention other than driving; they would be at least free of any planned distraction. To summarize, the five conditions creating different types and degrees of No Distraction -The absence of any planned distraction Placing a Call -Dialing a telephone number on a key pad located close to the driver's line of sight Casual Conversation - Social chit-chat between subject and experimenter Intense Conversation-Subjects solving problems presented orally by the experimenter Tuning a Radio - Adjusting a car radio to pre-determined station .

3.12.3. Effects of Distractions

For each of the four potential distracters, the level of distraction with respect to response time and whether or not subjects responded. The two distraction variables displayed in the figure are not independent of one another; where subjects failed to respond to a situation, the maximum response time taken by any subject exposed to that particular situation under that distraction was entered as the response time. Had this not been done, the non-responders would not have app eared in the response time data and the results would have been meaningless.

Table 3.4. Increase in Reaction Time and Non-Responses by Distraction Type



	TUNING	CALLING	SIMPLE	COMPLEX
RESPONSE TIME ■	0.694	0.787	0.264	0.847
NOT RESPONDING ▩	0.097	0.068	0.068	0.099

DISTRACTION TYPE

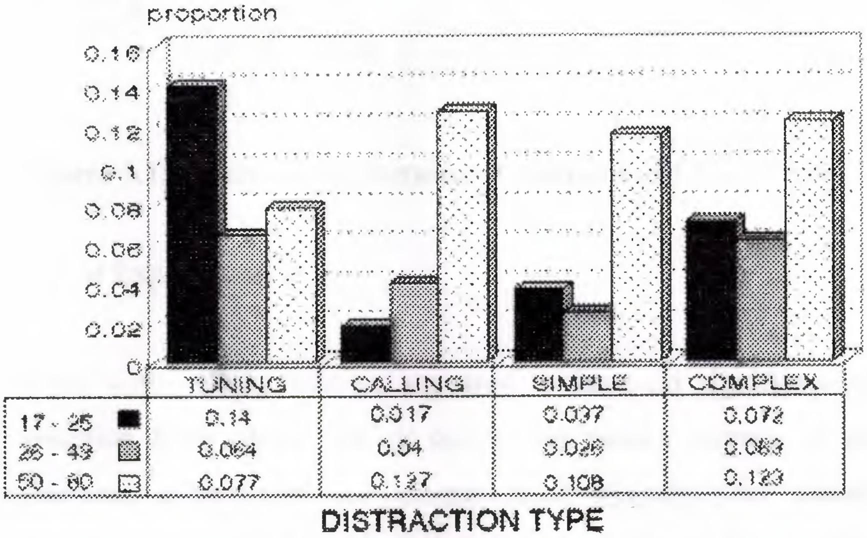
All of the potentially distracting conditions yielded some degree of distraction, that is, they produced reaction times and non-responses that were different from the no distraction condition. The overall level of distraction was highly significant for both non-responses (F = 36.07; DF = 1,136; P<.Ol) and for response time (F = 286.75; DF = 1,136; P<.Ol) and under all four potential distractors (P = <.Ol). Overall, the various distractions increased the length of time needed to respond to highway traffic conditions by from .4 to .9 seconds, and the proportion of situations missed entirely from .06 to .09. When it comes to which condition led to the greatest distraction, the results varied somewhat from one of the two distraction variables to the other. Looking at the proportion of subjects who were distracted from responding at all, the complex conversations yielded the greatest interference, while placing calls and carrying on simple calls yielded the least interference and tuning the radio fell somewhere in between. The differences among all distractors were only marginally significant (F=2.133; DF=3, 1 34; P=.10). However, complex conversations were significantly more distracting than simple conversations (F = 4.12, DF = 1, 134; P =.04). Turning to the time it took to respond, it is seen that placing a telephone call rose from one of the least distracting to one of the most distracting conditions. The differences across distractions are statistically significant (F=4.37;DF=3,134 ;P<.10). Considering that those who failed to respond are included within the response times, it is clear that it is the delay in responding among those who actually responded that account for the difference in outcomes. What the results seem to say is that the act of placing a cellular phone call may be no more distracting than carrying on a casual conversation in so far as noticing highway traffic conditions is a concern. However, it does seem to extend somewhat the delay in responding. When a non-urgent situation arose while a call was being placed, many subjects delayed responding until they had completed the call. However, they did respond, indicating that the situation had not gone unnoticed.

3.12.4. Effects of Age

The figure displays the proportion of drivers failing to respond to highway traffic conditions as subdivided by age. It is evident that drivers in the over-50 category show strikingly higher proportions of failing to respond to highway traffic situations. The overall effect across distraction conditions is not statistically significant (F = 2.22; DF = 2,136; P. 1 13). However, the deficiencies of older drivers significantly exceed those of the other two age groups in telephone calling (F = 7.96; DF = 1, 14 1; P <.Ol), and simple phone calls (F = 5.13; DF = 1, 14 1; P <.05), but not complex phone calls (F =

2.34; DF = 1, 14 1; P =. 13). In addition, in tuning the radio, age differences were not statistically significant (F =.73; DF = 1,141; P =.39). Part of the explanation for the failure of the radio-tuning task to show significant age an effect is the relatively high degree of distraction evidenced by the 17-25 year age group.

Table 3.5. Increase In Reaction By Age And Distraction Type.



The results suggest that this age group is somewhat more preoccupied with tuning the radio than with telephone calls, a hypothesis that most parents having children in this age group would have little difficulty accepting. However, why significant age differences didn't appear in complex cal s lacks a ready explanation. It may be that complex conversations are more or less equally distracting to everyone, while placing calls and carrying on simple conversations only distracts the older subjects. Perhaps a more parsimonious explanation is that age amplifies the effects of all telephone-related distractions and that the differences among the three types of distractions are largely the result of chance. Turning from whether drivers respond to how long it takes them to do so, the figure shows the effects of age to be somewhat attenuated. Over all distraction conditions, the effects of age are statistically non-significant (F = 1. 14; DF = 2,136; P = < ;.32). The only two conditions showing a marked increase in reaction time for the older age group are placing telephone calls and carrying on simple conversations, of which only placing calls achieves significance (F = 3.01; DF = 2,136; P =.05). The effect of phone use upon older drivers seems more to prevent them from noticing various highway traffic conditions rather than to retard their response to them.

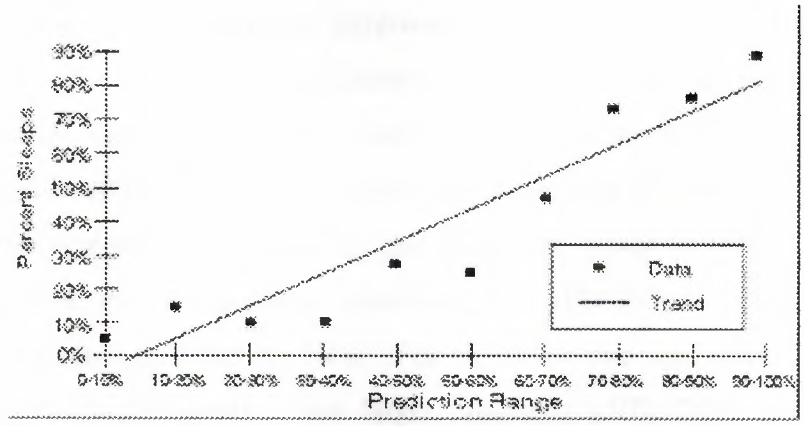


Figure 3.15. Relationship Between Predictions and Sleep Onset.

3.12.5. Effects of Experience

Prior experience with cellular phones appeared to have no significant effect upon distraction resulting from phone use or tuning the radio. Across all distractions, differences between experienced and inexperienced subjects were statistically non significant for response time (F=1.55; DF=4,114; P=<.19), or for the likelihood of responding at all (F=0.39; DF=4,114;P=<.81). What slight differences occurred seemed to favor the inexperienced, although such differences, if they exist, can be attributed to the fact that the experienced subjects tended to respond more quickly when there was no distraction and might therefore tend to evidence a slightly greater difference between the undistracted and distracted conditions. In looking simply at raw reaction times under the various distractions, the experienced subjects responded as quickly or more quickly than the inexperienced subjects. In any case, it is clear that prior experience with cellular phones has no real impact upon the degree to which one is distracted by its use.

3.12.6. Relative Performance Decrements

The decrements in performance that have been discussed amount to greater response time and the probability of not responding as compared with the results obtained in the absence of any distracting condition. Just how bad these decrements are can only be understood in relation to just how slow or unlikely to respond people are in the absence of any distraction. For comparison purposes, it is necessary to know that the mean response time in the absence of any distraction (across all highway traffic conditions) was 4.45 seconds, across all situations, while the proportion not responding at all was .343, again across all situations. Considering the proportion of subjects not responding, the relative decrements experienced by the older age group in placing calls was (. 127/.343 =) 37%, simple telephone conversations (.108/.343 =) 31%, and complex phone conversation (.123/.343 =) 36%. For the other two age groups, performance decrements were much smaller, the largest being a (.072/.343 =) 21 % greater probability of not responding for the 17-25 year age group when making complex phone calls. The condition leading to marked increases in response time was where the oldest age group had an increase of 1.417 seconds in placing calls. Expressed as a percent of the response lag under no distractions, this translates to increase in response time of 32%. Decrements in the remaining cases were considerably smaller, falling largely between .4 seconds (9%) and .8 seconds (18%).

3.12.7. Specific Situations and Distractions

The effect of using the telephone or tuning the radio upon response to highway traffic situations was not uniform across all situations. Interaction between the effects of distractions and various highway traffic situations was evident as a highly significant difference across the five "forms" i.e., the ten combinations of distractions and conditions occurring in the video. Recall that five different forms were needed to allow each of the five phone conditions to be matched with each of the highway traffic conditions without exposing the same subject to the test route more than once. Since the forms do not differ with respect to either distracters or highway traffic situations but only in the way they were combined, the significant differences among forms means that certain combinations of the two variables were particularly problematic. To see if there was any pattern to these aberrant combinations of potential distractors with highway traffic conditions, they were examined individually. Specifically, those combinations leading to proportion of non-response that were discrepant from what would be expected from the effects of the distractors or highway traffic conditions alone were identified through a logic analysis. The results were not at all revealing. The number and nature of aberrant combinations followed a chance pattern. As to the number, only four of 235 combinations fell beyond a .05 confidence interval around the expected results, whereas one would have expected (235 x .05 =) almost 12 by chance alone. As to the nature, no logical pattern could be discerned in the results. It should be noted, that with 150 subjects and five conditions, each condition was only replicated 30 times for a particular highway traffic situation.

3.12.8. Performance on Distractors

Thus far, our concern for the effect of various potential distracters upon response to highway-traffic situations has been limited to whether or not simply engaging in the task influenced driving performance. The distracting effect of cellular phone use or radio tuning tasks upon the response to highway-traffic conditions might be expected to vary as a function of the amount of attention devoted to the tasks. A measure of the amount of attention paid to the distracting tasks would be performance on those tasks themselves. This aspect of performance was assessed as follows:

Radio Tuning -Whether the tuning process was continuous or whether it was interrupted by the associated highway-traffic situation Placing Calls - Length of time required to complete placing the call Simple Conversation -Any interruptions in the conversation coincident with appearance of a highway traffic situation Complex Conversation - Incorrect answers to the problems being solved Time to complete the radio tuning task could not be used as a criterion since it was largely determined by how much the dial had to be manipulated to reach the target station, something that varied by chance from one trial to another.

PROBLEM Without "Protector"

- If one is using a cellular telephone, it must be known that this cellular phone generates an electromagnetic field within a 10 cm radius.
- While one is using the cellular telephone, the head is inside this field and the energy absorbed by several parts of the head causes a heating reaction within the head and brain.

- This heating reaction rises depending on the time of conversation. Several studies have shown that this heating can have extremely negative health effects.

Figure 3.16. PROBLEM Without "Protector"

SOLUTION With "Protector"

The "Protector™" offers the optimal solution. This is because the shield in the "PROTECTOR," located between the head and the cellular telephone, will reduce radiation by 99% without interfering with the operation of the cellular telephone (in fact, in some cases, it actually enhances transmissions and reception). These findings were confirmed by an independent, internationally recognized laboratory, which has been approved by such international institutes as TUV (German Standards Institute), FCC (USA) as well as by IMST in Germany.

Figure 3.17. SOLUTION With "Protector"

3.13. SUMMARY

To summarize it is now evident that the minor radiation levels that mobile phones emit can be enough to cause illnesses as dangerous as cancer. This alone cannot be good for pregnancy but the overall accumulation with respect to the number of mobile users may not be of that much concern at the moment. However, the outbreak of mobile phone related illnesses could have epidemic consequences. If there were certainty to the radiation level being solely responsible for ill health more than other daily radiation levels that human beings are exposed to then matters would be near crisis point as the outbreak of fatal illness would have to change the way all mobile phones are manufactured today.

CONCLUSION

Some twenty years ago when mobile telephones were introduced onto the market no one would have ever quessed that such a revolutionary device would have any kind of problem linked to human health.

It seems the human body has a high degree of technical perfection required for its electronic products. That is to say that even with todays technological advances in components and materials one cannot say that a mobile phone's long term use will not be hazardous, and that mobile phones with zero radiation emmisions is not yet possible.

Taking this into consideration mobile phones could be as hazardous as smoking tobacco, but with such a product which has changed social behavior and made such a positive impact in everyday life is weakened by the fact that something so useful can be so risky to use, or could it be said that using a mobile phone may in the future come with a Government Health Warning; with this in mind certain mobile phone manufactures are investing in research in order to minimize excessive hamful waves.

As to the extent of how far consumers are down the road with mobile telephone health risks it will not be known for many years to come. In the mean time no one risk is too high for people to really have to make changes within their attitude towards mobile telephones.

The project has delved into the hazardous concequences that surround mobile telephone's today. This research into Electromagnetic Waves having began in the 1970's amid rears of power lines emitting too much radioactive signals was the beginning of this more undepth study of the subject, prior to this. This kind of research came from the experimental era with nuclear technology from the 1950's to the later date's of nuclear research.

When one considers the intricate design and sensetivity of the human brain, it's cause for concern by holding an electronic device so close to it that would be able to effect the minute brain currents and neural networks in the brain and posies the ability to breakdown and alter atomical reactions in the human body.

To make matters worse not only are human beings at risk from mobile phones themselves but we may also be at risk from the Radio Frequency waves from the large transmitting antennas all around us with claims that people in high rise buildings blocks may be at more risk than those who may live nearer to the ground. So that as we are surrounded by these danger's during our lines, the price for telecomunications may now even higher. The harrowing thought of this whole topic from my personnal point of view is one of fear, and that the longterm must provide the knowledge, where we as the consumer stand with the issue. Ingoranes today may total consequences in the future and it seems too frightening that the phones we take for granted may be of such a potential health risk, just to conclude and frightening us even further is that this generation of mobile phone users being the earliest and as for what will happen and can happen to present future generations from anyharm requires factual data and background surrounding the issue so where do we stand, are we going to let. This 2 decodes of mobile telecomunication boom signity that for future generations to have safer and better mobile phone conditions make us today the quinea pigs for future generations of mobile users to have safer mobile telephones.

REFERENCES

[1]. Mamedov F.S., Telecomunications, Lecture notes, Near East Universtiy Press, Lefkoşa 2000.

[2]. Kavalcıoğlu Cemal, "Analysis of Wireless Communications Systems and Traffic Modeling" Master Thesis, Graduate School of Applies & Social Sciences, NEU, June 2002.

[3]. Vijay K. Garg, Joseph E. Wilkes, Wireless and Personal Communications Systems, Feher/Prentice Hall Digital and Wireless Communications Series, AT&T Bell Labs, Holmdel, New Jersey, 1996.

[4]. Padgett, Jay E., Gunther, Christoph G., Hattori, Takeshi, " Overview of Wireless Personal Communications". IEEE Communications Magazine, V33, nl, January, 1995:28, 14 pages.

[5]. Lee, W.C.Y., Mobile Cellular Telecommunications Systems, New York: McGraw-Hill, 1989.

[6]. Van Leeuwev, G.M, Lagendijk J.J, Van Leersum B.J., Zwamborn A.P., Hornsleth S. N., Kotte A.N., "Calculation of chance in brain temperatures due to exposure to a mobile phone", Phys. Med. Biol. 1999, 44:2367-2379.

[7]. V. Prasad Kodali, "Engineering Electromagnetic Compatibility", IEEE Press, 1996.

[8]. Science and Technology Committee. Third Report. Scientific advisory system: mobile phones and health volume 1, Report and Proceeding of the Committee. (1999).

[9]. Ahlbom A and Feychting M. Re: Use of cellular phones and the risk of brain tumours: a case–control study. Int J Oncol,(1999).

[10]. Albert E N and Kerns J M. Reversible microwave effects on the blood–brain barrier. Brain Res,(1981).

[11]. Alm H and Nilsson L. The effects of a mobile telephone task on driver behaviour in a car following situation. Accid Anal Prev, (1995)

[12]. Bawin S M, Gavalas-Medici R J and Adey W R. Reinforcement of transient brain rhythms by amplitude-modulated VHF fields. IN Biological and Clinical Effects of Low Frequency Magnetic and Electric Fields (J G Llaurado, A Sances and J H Battocletti, Eds). Springfield, Charles C Thomas, (1974).

[13]. Borbely A A, Huber R, Graf T, Fuchs B, Gallmann E and Achermann P. Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram. Neurosci Lett, (1999).

[14]. Braune S, Wrocklage C Raczek J, Gailus T and Lucking C H.. Radiofrequency electromagnetic field from mobile phones. *Lancet*, (1998b)

[15]. Brookhuis K A, De Vries G and de Waard D. The effects of mobile telephoning on driving performance. Accid Anal Prev, (1991).

[16]. Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt L and Elliott P. Cancer incidence near radio and television transmitters in Great Britain. 1: Sutton Coldfield transmitter. Am J Epidemiol, (1997a).

[17]. Drogichina E A, Konchalovskaya N M, Glotova K V, Sadcikova N M and Snegova G V. On the problems of autonomic and cardiovascular disturbances under the effects of ultrahigh frequency electromagnetic fields. ATD Report 66-124, Library of Congress, Aerospace Technology Division. Gig Tr Prof Zabol, (1966).

[18]. EC (European Commission) Possible Health Effects Related to the Use of Radio telephones. Proposals for a Research Programme by a European Commission Expert Group. Brussels, EC. EC (European Commission) (1999).

[19]. Hermann D M and Hossman K-A. Neurologic effects of microwave exposure related to mobile communication. *J Neurol Sci*, (1997).

[20]. Nagawa H, Tsurita G and Ueno S. Effects of 1.439 MHz microwave exposure on the brain in Sprague-Dawley rats. IN *Health Effects of Mobile Telephones*, Proceedings URSI General Assembly, Toronto, August 1999.

[21]. NRPB. Electromagnetic fields and the risk of cancer. Summary of the views of the Advisory Group on Nonionising Radiation on epidemiological studies published since its 1992 report. *Doc NRPB*, (1993c).

[22]. NRPB. Electromagnetic fields and the risk of cancer. Supplementary report by the Advisory Group on Nonionising Radiation. *Doc NRPB* (1994).

[23]. Taskinen H, Kyyrönen P and Hemminki K. Effects of ultrasound, shortwaves and physical exertion on pregnancy outcome in physiotherapists. J Epidemiol Commun Health,.

[23]. Williams W M, Del Cerro M and Michaelson S M. Effect of 2450 MHz microwave energy on the blood–brain barrier to hydrophilic molecules. B. Effect on the permeability to HRP. Brain Res Rev, (1984).