# Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Read more on: **Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities**)

<table>
<thead>
<tr>
<th>Power Density (Microwatts/centimeter² - uW/cm²)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>As low as (10^{-13}) or 100 femtowatts/cm²</td>
<td>Super-low intensity RFR effects at MW resonant frequencies resulted in changes in genes; problems with chromatin conformation (DNA)</td>
</tr>
<tr>
<td>5 picowatts/cm² (10^{-12})</td>
<td>Changed growth rates in yeast cells</td>
</tr>
<tr>
<td>0.1 nanowatt/cm² (10^{-10}) or 100 picowatts/cm²</td>
<td>Super-low intensity RFR effects at MW resonant frequencies resulted in changes in genes; problems with chromatin condensation (DNA) intensities comparable to base stations</td>
</tr>
<tr>
<td>0.00034 uW/cm²</td>
<td>Chronic exposure to mobile phone pulsed RF significantly reduced sperm count,</td>
</tr>
<tr>
<td>0.0005 uW/cm²</td>
<td>RFR decreased cell proliferation at 960 MHz GSM 217 Hz for 30-min exposure</td>
</tr>
<tr>
<td>0.0006 - 0.0128 uW/cm²</td>
<td>Fatigue, depressive tendency, sleeping disorders, concentration difficulties, cardio-vascular problems reported with exposure to GSM 900/1800 MHz cell phone signal at base station level exposures.</td>
</tr>
<tr>
<td>0.0009 uW/cm²</td>
<td>RFR induced 10%-40% increase in DNA synthesis in glioma cells (brain)</td>
</tr>
<tr>
<td>0.003 - 0.02 uW/cm²</td>
<td>In children and adolescents (8-17 yrs) short-term exposure caused headache, irritation, concentration difficulties in school.</td>
</tr>
<tr>
<td>0.003 to 0.05 uW/cm²</td>
<td>In children and adolescents (8-17 yrs) short-term exposure caused conduct problems in school (behavioral problems)</td>
</tr>
<tr>
<td>0.005 uW/cm²</td>
<td>In adults (30-60 yrs) chronic exposure caused sleep disturbances, (but not significantly increased across the entire population)</td>
</tr>
<tr>
<td>0.005 - 0.04 uW/cm²</td>
<td>Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated)</td>
</tr>
<tr>
<td>0.006 - 0.01 uW/cm²</td>
<td>Chronic exposure to base station RF (whole-body) in humans showed increased stress hormones; dopamine levels substantially decreased; higher levels of adrenaline and nor-adrenaline; dose-response seen; produced chronic physiological stress in cells even after 1.5 years.</td>
</tr>
<tr>
<td>0.01 - 0.11 uW/cm²</td>
<td>RFR from cell towers caused fatigue, headaches, sleeping problems</td>
</tr>
</tbody>
</table>

**Power Density (uW/cm²):**

- **0.01 μW/cm² = 100 μW/m²**

| Stress proteins, IISP, disrupted immune function | Brain tumors and blood-brain barrier |
| Reproduction/fertility effects | Sleep, neuron firing rate, EEG, memory, learning, behavior |
| Oxidative damage/ROS/DNA damage/DNA repair failure | Cancer (other than brain), cell proliferation |
| Disrupted calcium metabolism | Cardiac, heart muscle, blood-pressure, vascular effects |
Table: Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

<table>
<thead>
<tr>
<th>Power Density (Microwatts/centimeter² - uW/cm²)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 - 0.05 uW/cm² Adults (18-91 yrs) with short-term exposure to GSM cell phone radiation reported headache, neurological problems, sleep and concentration problems.</td>
<td>Hutter, 2006</td>
</tr>
<tr>
<td>0.005 - 0.04 uW/cm² Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated)</td>
<td>Thomas, 2008</td>
</tr>
<tr>
<td>0.015 - 0.21 uW/cm² Adults exposed to short-term GSM 900 radiation reported changes in mental state (e.g., calmness) but limitations of study on language descriptors prevented refined word choices (stupified, zoned-out)</td>
<td>Augner, 2009</td>
</tr>
<tr>
<td>0.05 - 0.1 uW/cm² RFR linked to adverse neurological, cardio symptoms and cancer risk</td>
<td>Khurana, 2010</td>
</tr>
<tr>
<td>0.05 - 0.1 uW/cm² RFR related to headache, concentration and sleeping problems, fatigue</td>
<td>Kundi, 2009</td>
</tr>
<tr>
<td>0.07 - 0.1 uW/cm² Sperm head abnormalities in mice exposed for 6-months to base station level RF/MW. Sperm head abnormalities occurred in 39% to 46% exposed mice (only 2% in controls). Abnormalities was also found to be dose dependent. The implications of the pin-head and banana-shaped sperm head. The occurrence of sperm head observed increase occurrence of sperm head abnormalities on the reproductive health of humans living in close proximity to GSM base stations were discussed.</td>
<td>Otitoloju, 2010</td>
</tr>
<tr>
<td>0.38 uW/cm² RFR affected calcium metabolism in heart cells</td>
<td>Schwartz, 1990</td>
</tr>
<tr>
<td>0.8 - 10 uW/cm² RFR caused emotional behavior changes, free-radical damage by super-weak MWs</td>
<td>Akoev, 2002</td>
</tr>
<tr>
<td>0.13 uW/cm² RFR from 3G cell towers decreased cognition, well-being</td>
<td>Zwamborn, 2003</td>
</tr>
<tr>
<td>0.16 uW/cm² Motor function, memory and attention of school children affected (Latvia)</td>
<td>Kolodynski, 1996</td>
</tr>
<tr>
<td>0.168 - 1.053 uW/cm² Irreversible infertility in mice after 5 generations of exposure to RFR from an 'antenna park'</td>
<td>Magras &amp; Zenos, 1997</td>
</tr>
<tr>
<td>0.2 - 8 uW/cm² RFR caused a two-fold increase in leukemia in children</td>
<td>Hocking, 1996</td>
</tr>
<tr>
<td>0.2 - 8 uW/cm² RFR decreased survival in children with leukemia</td>
<td>Hocking, 2000</td>
</tr>
<tr>
<td>0.21 - 1.28 uW/cm² Adolescents and adults exposed only 45 min to UMTS cell phone radiation reported increases In headaches.</td>
<td>Riddervold, 2008</td>
</tr>
</tbody>
</table>

| Stress proteins, IISP, disrupted immune function | Brain tumors and blood-brain barrier |
| Reproduction/fertility effects | Sleep, neuron firing rate, EEG, memory, learning, behavior |
| Oxidative damage/ROS/DNA damage/DNA repair failure | Cancer (other than brain), cell proliferation |
| Disrupted calcium metabolism | Cardiac, heart muscle, blood-pressure, vascular effects |
### Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

1 μW/cm² = 10,000 μW/m²

<table>
<thead>
<tr>
<th>Power Density (Microwatts/centimeter² - uW/cm²)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 uW/cm²</td>
<td>Saunders, 1981</td>
</tr>
<tr>
<td>0.5 - 1.0 uW/cm²</td>
<td>Avendano, 2012</td>
</tr>
<tr>
<td>1.0 uW/cm²</td>
<td>Persson, 1997</td>
</tr>
<tr>
<td>1.0 uW/cm²</td>
<td>Fesenko, 1999</td>
</tr>
<tr>
<td>1.0 uW/cm²</td>
<td>Novoselova, 1999</td>
</tr>
<tr>
<td>1.0 uW/cm²</td>
<td>Eltiti, 2007</td>
</tr>
<tr>
<td>1.25 uW/cm²</td>
<td>Pyrrpasopoulou, 2004</td>
</tr>
<tr>
<td>1.5 uW/cm²</td>
<td>Nittby, 2007</td>
</tr>
<tr>
<td>2 uW/cm²</td>
<td>Kesari, 2008</td>
</tr>
<tr>
<td>2.5 uW/cm²</td>
<td>Wolke, 1996</td>
</tr>
<tr>
<td>2 - 4 uW/cm²</td>
<td>D’Inzeo, 1988</td>
</tr>
<tr>
<td>4 uW/cm²</td>
<td>Tattersall, 2001</td>
</tr>
<tr>
<td>4 - 15 uW/cm²</td>
<td>Chiang, 1989</td>
</tr>
<tr>
<td>5 uW/cm²</td>
<td>Boscolo, 2001</td>
</tr>
<tr>
<td>5.25 uW/cm²</td>
<td>Kwee, 2001</td>
</tr>
<tr>
<td>5 - 10 uW/cm²</td>
<td>Dumansky, 1974</td>
</tr>
<tr>
<td>6 uW/cm²</td>
<td>Phillips, 1998</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress proteins, IISP, disrupted immune function</td>
</tr>
<tr>
<td>Reproduction/fertility effects</td>
</tr>
<tr>
<td>Oxidative damage/ROS/DNA damage/DNA repair failure</td>
</tr>
<tr>
<td>Disrupted calcium metabolism</td>
</tr>
<tr>
<td>Brain tumors and blood brain barrier</td>
</tr>
<tr>
<td>Sleep, neuron firing rate, EEG, memory, learning, behavior</td>
</tr>
<tr>
<td>Cancer (other than brain), cell proliferation</td>
</tr>
<tr>
<td>Cardiac, heart muscle, blood-pressure, vascular effects</td>
</tr>
</tbody>
</table>
# Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

<table>
<thead>
<tr>
<th>Power Density (Microwatts/centimeter² - uW/cm²)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.75 uW/cm² RFR at 900 MHz for 2-12 hours caused DNA breaks in leukemia cells</td>
<td>Marinelli, 2004</td>
</tr>
<tr>
<td>10 uW/cm² Changes in behavior (avoidance) after 0.5 hour exposure to pulsed RFR</td>
<td>Navakatikian, 1994</td>
</tr>
<tr>
<td>10 - 100 uW/cm² Increased risk in radar operators of cancer; very short latency period; dose response to exposure level of RFR reported.</td>
<td>Richter, 2000</td>
</tr>
<tr>
<td>12.5 uW/cm² RFR caused calcium efflux in cells - can affect many critical cell functions</td>
<td>Dutta, 1989</td>
</tr>
<tr>
<td>13.5 uW/cm² RFR affected human lymphocytes - induced stress response in cells</td>
<td>Sarimov, 2004</td>
</tr>
<tr>
<td>14.75 uW/cm² RFR increased biomarker for cell division in glioma brain tumor cells</td>
<td>Stagg, 1997</td>
</tr>
<tr>
<td>20 uW/cm² Increase in serum cortisol (a stress hormone)</td>
<td>Mann, 1998</td>
</tr>
<tr>
<td>28.2 uW/cm² RFR increased free radical production in rat cells</td>
<td>Yurekli, 2006</td>
</tr>
<tr>
<td>37.5 uW/cm² Immune system effects - elevation of PFC count (antibody producing cells)</td>
<td>Veyret, 1991</td>
</tr>
<tr>
<td>45 uW/cm² Pulsed RFR affected serum testosterone levels in mice</td>
<td>Forgacs, 2006</td>
</tr>
<tr>
<td>50 uW/cm² Cell phone RFR caused a pathological leakage of the blood-brain barrier in 1 hour</td>
<td>Salford, 2003</td>
</tr>
<tr>
<td>50 uW/cm² An 18% reduction in REM sleep (important to memory and learning functions)</td>
<td>Mann, 1996</td>
</tr>
<tr>
<td>60 uW/cm² RFR caused structural changes in cells of mouse embryos</td>
<td>Somozy, 1991</td>
</tr>
<tr>
<td>60 uW/cm² Pulsed RFR affected immune function in white blood cells</td>
<td>Stankiewicz, 2006</td>
</tr>
<tr>
<td>60 uW/cm² Cortex of the brain was activated by 15 minutes of 902 MHz cell phone</td>
<td>Lebedeva, 2000</td>
</tr>
<tr>
<td>65 uW/cm² RFR affected genes related to cancer</td>
<td>Ivaschuk, 1999</td>
</tr>
<tr>
<td>92.5 uW/cm² RFR caused genetic changes in human white blood cells</td>
<td>Belyaev, 2005</td>
</tr>
<tr>
<td>100 uW/cm² Changes in immune function</td>
<td>Elekes, 1996</td>
</tr>
<tr>
<td>100 uW/cm² A 24.3% drop in testosterone after 6 hours of CW RFR exposure</td>
<td>Navakatikian, 1994</td>
</tr>
</tbody>
</table>

10 μW/cm² = 100.000 μW/m² — 100 μW/cm² = 1.000.000 μW/m²
# Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

*(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)*

1000 μW/cm² = 1.0000.000 μW/m²

<table>
<thead>
<tr>
<th>Power Density (Microwatts/centimeter² - uW/cm²)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 uW/cm²</td>
<td>A pathological leakage in the blood-brain barrier with 915 MHz cell RF</td>
</tr>
<tr>
<td>500 uW/cm²</td>
<td>Intestinal epithelial cells exposed to 2.45 GHz pulsed at 16 Hz showed changes in intercellular calcium.</td>
</tr>
<tr>
<td>500 uW/cm²</td>
<td>A 24.6% drop in testosterone and 23.2% drop in insulin after 12 hrs of pulsed RFR exposure.</td>
</tr>
</tbody>
</table>

### STANDARDS

<table>
<thead>
<tr>
<th>Limit for uncontrolled public exposure to 800-900 MHz</th>
<th>ANSI/IEEE and FCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 uW/cm²</td>
<td>PCS STANDARD for public exposure (as of September 1,1997)</td>
</tr>
<tr>
<td>5000 uW/cm²</td>
<td>PCS STANDARD for occupational exposure (as of September 1, 1997)</td>
</tr>
</tbody>
</table>

### BACKGROUND LEVELS

<table>
<thead>
<tr>
<th>Background RF levels in US cities and suburbs in the 1990s</th>
<th>Mantiply, 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.003 uW/cm²</td>
<td>Background RF levels in US cities and suburbs in the 1990s</td>
</tr>
<tr>
<td>0.05 uW/cm²</td>
<td>Median ambient power density in cities in Sweden (30-2000 MHz)</td>
</tr>
<tr>
<td>0.1 - 10 uW/cm²</td>
<td>Ambient power density within 100-200' of cell site in US (data from 2000)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress proteins, IISP, disrupted immune function</th>
<th>Brain tumors and blood brain barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reproduction/fertility effects</td>
<td>Sleep, neuron firing rate, EEG, memory, learning, behavior</td>
</tr>
<tr>
<td>Oxidative damage/ROS/DNA damage/DNA repair failure</td>
<td>Cancer (other than brain), cell proliferation</td>
</tr>
<tr>
<td>Disrupted calcium metabolism</td>
<td>Cardiac, heart muscle, blood-pressure, vascular effects</td>
</tr>
<tr>
<td>SAR (Watts/Kilogram)</td>
<td>Biological Effect Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>0.000064 - 0.000078 W/Kg</td>
<td>Well-being and cognitive function affected in humans exposed to GSM-UMTS cell phone frequencies; RF levels similar near cell sites</td>
</tr>
<tr>
<td>0.00015 - 0.003 W/Kg</td>
<td>Calcium ion movement in isolated frog heart tissue is increased 18% (P&lt;.01) and by 21% (P&lt;.05) by weak RF field modulated at 16 Hz</td>
</tr>
<tr>
<td>0.000021 - 0.0021 W/Kg</td>
<td>Changes in cell cycle; cell proliferation (960 MHz GSM mobile phone)</td>
</tr>
<tr>
<td>0.0003 - 0.06 W/Kg</td>
<td>Neurobehavioral disorders in offspring of pregnant mice exposed in utero to cell phones - dose-response impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. Hyperactivity and impaired memory function in offspring. Altered brain development.</td>
</tr>
<tr>
<td>0.0009 W/Kg</td>
<td>Changes in brain glial cells with TDMA 836.55 Mhz frequency</td>
</tr>
<tr>
<td>0.0016 - 0.0044 W/Kg</td>
<td>Very low power 700 MHz CW affects excitability of hippocampus tissue, consistent with reported behavioral changes.</td>
</tr>
<tr>
<td>0.0021 W/Kg</td>
<td>Heat shock protein HSP 70 is activated by very low intensity microwave exposure in human epithelial amnion cells</td>
</tr>
<tr>
<td>0.0024 - 0.024 W/Kg</td>
<td>Digital cell phone RFR at very low intensities causes DNA damage in human cells; both DNA damage and impairment of DNA is reported</td>
</tr>
<tr>
<td>0.0027 W/Kg</td>
<td>Changes in active avoidance conditioned behavioral effect is seen after one-half hour of pulsed radiofrequency radiation</td>
</tr>
<tr>
<td>0.0035 W/Kg</td>
<td>900 MHz cell phone signal induces DNA breaks and early activation of p53 gene; short exposure of 2-12 hours leads cells to acquire greater survival chance - linked to tumor agressiveness.</td>
</tr>
<tr>
<td>0.0095 W/Kg</td>
<td>MW modulated at 7 Hz produces more errors in short-term memory function on complex tasks (can affect cognitive processes such as attention and memory)</td>
</tr>
<tr>
<td>0.001 W/Kg</td>
<td>750 MHz continuous wave (CW) RFR exposure caused increase in heat shock protein (stress proteins). Equivalent to what would be induced by 3 degree C. heating of tissue (but no heating occurred)</td>
</tr>
</tbody>
</table>

**Stress proteins, HSP, disrupted immune function**

**Brain tumors and blood-brain barrier**

**Reproduction/fertility effects**

**Sleep, neuron firing rate, EEG, memory, learning, behavior**

**Oxidative damage/ROS/DNA damage/DNA repair failure**

**Cancer (other than brain), cell proliferation**

**Disrupted calcium metabolism**

**Cardiac, heart muscle, blood-pressure, vascular effects**
<table>
<thead>
<tr>
<th>SAR (Watts/Kilogram)</th>
<th>Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure (Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 W/Kg</td>
<td>Statistically significant change in intracellular calcium concentration in heart muscle cells exposed to RFR (900 MHz/50 Hz modulation)</td>
<td>Wolke, 1996</td>
</tr>
<tr>
<td>0.0021 W/Kg</td>
<td>A significant change in cell proliferation not attributable to thermal heating. RFR induces non-thermal stress proteins (960 MHz GSM)</td>
<td>Velizarov, 1999</td>
</tr>
<tr>
<td>0.004 - 0.008 W/Kg</td>
<td>915 MHz cell phone RFR caused pathological leakage of blood-brain barrier. Worst at lower SAR levels and worse with CW compared to Frequency of pathological changes was 35% in rats exposed to pulsed radiation at 50% to continuous wave RFR. Effects observed at a specific absorption (SA) of &gt; 1.5 joules/Kg in human tissues</td>
<td>Persson, 1997</td>
</tr>
<tr>
<td>0.0059 W/Kg</td>
<td>Cell phone RFR induces glioma (brain cancer) cells to significantly increase thymidine uptake, which may be indication of more cell division</td>
<td>Stagg, 1997</td>
</tr>
<tr>
<td>0.014 W/Kg</td>
<td>Sperm damage from oxidative stress and lowered melatonin levels resulted from 2-hr per day/45 days exposure to 10 GHz.</td>
<td>Kumar, 2012</td>
</tr>
<tr>
<td>0.015 W/Kg</td>
<td>Immune system effects - elevation of PFC count (antibody-producing cells)</td>
<td>Veyret, 1991</td>
</tr>
<tr>
<td>0.02 W/Kg</td>
<td>A single, 2-hr exposure to GSM cell phone radiation results in serious neuron damage (brain cell damage) and death in cortex, hippocampus, and basal ganglia of brain- even 50+ days later blood-brain barrier is still leaking albumin (P&lt;.002) following only one cell phone exposure</td>
<td>Salford, 2003</td>
</tr>
<tr>
<td>0.026 W/Kg</td>
<td>Activity of c-jun (oncogene or cancer gene) was altered in cells after 20 minutes exposure to cell phone digital TDMA signal</td>
<td>Ivaschuk, 1997</td>
</tr>
<tr>
<td>0.0317 W/Kg</td>
<td>Decrease in eating and drinking behavior</td>
<td>Ray, 1990</td>
</tr>
<tr>
<td>0.037 W/Kg</td>
<td>Hyperactivity caused by nitric oxide synthase inhibitor is countered by exposure to ultra-wide band pulses (600/sec) for 30 min</td>
<td>Seaman, 1999</td>
</tr>
<tr>
<td>0.037 - 0.040 W/Kg</td>
<td>A 1-hr cell phone exposure causes chromatin condensation; impaired DNA repair mechanisms; last 3 days (longer than stress response) the effect reaches saturation in only one hour of exposure; electro-sensitive (ES) people have different response in formation of DNA repair foci, compared to healthy individuals; effects depend on carrier frequency (915 MHz = 0.037 W/Kg but 1947 MHz = 0.040 W/Kg)</td>
<td>Belyaev, 2008</td>
</tr>
</tbody>
</table>

- **Stress proteins, HSP, disrupted immune function**
- **Brain tumors and blood-brain barrier**
- **Reproduction/fertility effects**
- **Sleep, neuron firing rate, EEG, memory, learning, behavior**
- **Oxidative damage/ROS/DNA damage/DNA repair failure**
- **Cancer (other than brain), cell proliferation**
- **Disrupted calcium metabolism**
- **Cardiac, heart muscle, blood-pressure, vascular effects**
### Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and ‘Smart’ Meter RF Intensities)

<table>
<thead>
<tr>
<th>SAR (Watts/Kilogram)</th>
<th>Effect Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 W/Kg</td>
<td>Significant increase in firing rate of neurons (350%) with pulsed 900 MHz cell phone radiation exposure (but not with CW) in avian brain cells</td>
<td>Beason, 2002</td>
</tr>
<tr>
<td>0.09 W/Kg</td>
<td>900 MHz study of mice for 7 days, 12-hr per day (whole-body) resulted in significant effect on mitochondria and genome stability</td>
<td>Aitken, 2005</td>
</tr>
<tr>
<td>0.091 W/Kg</td>
<td>Wireless internet 2400 MHz, 24-hrs per day/20 weeks increased DNA damage and reduced DNA repair; levels below 802.11 g Authors say “findings raise questions about safety of radiofrequency exposure from Wi-Fi internet access devices for growing organisms of reproductive age, with a potential effect on fertility and integrity of germ cells” (male germ cells are the reproductive cells= sperm)</td>
<td>Atasoy, 2012</td>
</tr>
<tr>
<td>0.11 W/Kg</td>
<td>Increased cell death (apoptosis) and DNA fragmentation at 2.45 GHz for 35 days exposure (chronic exposure study)</td>
<td>Kesari, 2010</td>
</tr>
<tr>
<td>0.121 W/Kg</td>
<td>Cardiovascular system shows significant decrease in arterial blood pressure (hypotension) after exposure to ultra-wide band pulses</td>
<td>Lu, 1999</td>
</tr>
<tr>
<td>0.13 - 1.4 W/Kg</td>
<td>Lymphoma cancer rate doubled with two 1/2-hr exposures per day of cell phone radiation for 18 months (pulsed 900 MHz cell signal)</td>
<td>Repacholi, 1997</td>
</tr>
<tr>
<td>0.14 W/Kg</td>
<td>Elevation of immune response to RFR exposure</td>
<td>Elekes, 1996</td>
</tr>
<tr>
<td>0.141 W/Kg</td>
<td>Structural changes in testes - smaller diameter of seminiferous</td>
<td>Dasdag, 1999</td>
</tr>
<tr>
<td>0.15 - 0.4 W/Kg</td>
<td>Statistically significant increase in malignant tumors in rats chronically exposed to RFR</td>
<td>Chou, 1992</td>
</tr>
<tr>
<td>0.26 W/Kg</td>
<td>Harmful effects to the eye/certain drugs sensitize the eye to RFR</td>
<td>Kues, 1992</td>
</tr>
<tr>
<td>0.28 - 1.33 W/Kg</td>
<td>Significant increase in reported headaches with increasing use of hand-held cell phone use (maximum tested was 60 min per day)</td>
<td>Chia, 2000</td>
</tr>
<tr>
<td>0.3 - 0.44 W/Kg</td>
<td>Cell phone use results in changes in cognitive thinking/mental tasks related to memory retrieval</td>
<td>Krause, 2000</td>
</tr>
<tr>
<td>0.3 - 0.44 W/Kg</td>
<td>Attention function of brain and brain responses are speeded up</td>
<td>Preece, 1999</td>
</tr>
<tr>
<td>0.3 - 0.46 W/Kg</td>
<td>Cell phone RFR doubles pathological leakage of blood-brain barrier permeability at two days (P=.002) and triples permeability at four days (P=.001) at 1800 MHz GSM cell phone radiation</td>
<td>Schirmacher, 2000</td>
</tr>
</tbody>
</table>

### Additional Biological Effects

- **Stress proteins, HSP, disrupted immune function**
- **Reproduction/fertility effects**
- **Oxidative damage/ROS/DNA damage/DNA repair failure**
- **Disrupted calcium metabolism**

### Associated Health Outcomes

- **Brain tumors and blood-brain barrier**
- **Sleep, neuron firing rate, EEG, memory, learning, behavior**
- **Cancer (other than brain), cell proliferation**
- **Cardiac, heart muscle, blood-pressure, vascular effects**
# Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

<table>
<thead>
<tr>
<th>SAR (Watts/Kilogram)</th>
<th>Reported Effect</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.43 W/Kg</td>
<td>Significant decrease in sperm mobility; drop in sperm concentration; and decrease in seminiferous tubules at 800 MHz, 8-hr/day, 12 weeks, with mobile phone radiation level on STANDBY ONLY (in rabbits)</td>
<td>Salama, 2008</td>
</tr>
<tr>
<td>0.5 W/Kg</td>
<td>900 MHz pulsed RF affects firing rate of neurons (Lymnea stagnalis) but continuous wave had no effect</td>
<td>Bolshakov, 1992</td>
</tr>
<tr>
<td>0.58 - 0.75 W/Kg</td>
<td>Decrease in brain tumors after chronic exposure to RFR at 836 MHz</td>
<td>Adey, 1999</td>
</tr>
<tr>
<td>0.6 - 0.9 W/Kg</td>
<td>Mouse embryos develop fragile cranial bones from in utero 900 MHz The authors say &quot;(O)ur results clearly show that even modest exposure (e.g., 6 min daily for 21 days&quot; is sufficient to interfere with the normal mouse developmental process&quot;</td>
<td>Fragopoulou, 2009</td>
</tr>
<tr>
<td>0.6 and 1.2 W/Kg</td>
<td>Increase in DNA single and double-strand DNA breaks in rat brain cells with exposure to 2450 MHz RFR</td>
<td>Lai &amp; Singh, 1996</td>
</tr>
<tr>
<td>0.795 W/Kg</td>
<td>GSM 900 MHz, 217 Hz significantly decreases ovarian development and size of ovaries, due to DNA damage and premature cell death of nurse cells and follicles in ovaries (that nourish egg cells)</td>
<td>Panagopoulous, 2012</td>
</tr>
<tr>
<td>0.87 W/Kg</td>
<td>Altered human mental performance after exposure to GSM cell phone radiation (900 MHz TDMA digital cell phone signal)</td>
<td>Hamblin, 2004</td>
</tr>
<tr>
<td>0.87 W/Kg</td>
<td>Change in human brainwaves; decrease in EEG potential and statistically significant change in alpha (8-13 Hz) and beta (13-22 Hz) brainwave activity in humans at 900 MHz; exposures 6/min per day for 21 days (chronic exposure)</td>
<td>D’Costa, 2003</td>
</tr>
<tr>
<td>0.9 W/Kg</td>
<td>Decreased sperm count and more sperm cell death (apoptosis) after 35 days exposure, 2-hr per day</td>
<td>Kesari, 2012</td>
</tr>
<tr>
<td>&lt; 1.0 W/Kg</td>
<td>Rats exposed to mobile phone radiation on STANDBY ONLY for 11-hr 45-min plus 15-min TRANSMIT mode; 2 times per day for 21 days showed decreased number of ovarian follicles in pups born to these pregnant rats. The authors conclude &quot;the decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries.&quot;</td>
<td>Gul, 2009</td>
</tr>
<tr>
<td>0.4 - 1.0 W/Kg</td>
<td>One 6-hr exposure to 1800 MHz cell phone radiation in human sperm cells caused a significant dose response and reduced sperm motility and viability; reactive oxygen species levels were significantly increased after exposure to 1.0 W/Kg; study confirms detrimental effects of RF/MW to human sperm. The authors conclude &quot;(T)hese findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring.&quot;</td>
<td>De Iulis, 2009</td>
</tr>
</tbody>
</table>

## Stress-related Effects

- Stress proteins, HSP, disrupted immune function
- Reproduction/fertility effects
- Oxidative damage/ROS/DNA damage/DNA repair failure
- Disrupted calcium metabolism

## Health effects

- Brain tumors and blood-brain barrier
- Sleep, neuron firing rate, EEG, memory, learning, behavior
- Cancer (other than brain), cell proliferation
- Cardiac, heart muscle, blood-pressure, vascular effects
<table>
<thead>
<tr>
<th>SAR (Watts/Kilogram)</th>
<th>Reported Biological Effects</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 W/Kg</td>
<td>Human semen degraded by exposure to cell phone frequency RF increased free-radical damage.</td>
<td>De Iuliis, 2009</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Motility, sperm count, sperm morphology, and viability reduced in active cell phone users (human males) in dose-dependent manner.</td>
<td>Agarwal, 2008</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>GSM cell phone use modulates brain wave oscillations and sleep EEG</td>
<td>Huber, 2002</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Cell phone RFR during waking hours affects brain wave activity. (EEG patterns) during subsequent sleep</td>
<td>Achermann, 2000</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Cell phone use causes nitric oxide (NO) nasal vasodilation (swelling inside nasal passage) on side of head phone use</td>
<td>Paredi, 2001</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Four-fold increase in eye cancer (uveal melanoma) in cell phone users</td>
<td>Stang, 2001</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Increase in headache, fatigue and heating behind ear in cell phone users</td>
<td>Sandstrom, 2001</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Significant increase in concentration difficulties using 1800 MHz cell phone compared to 900 MHz cell phone</td>
<td>Santini, 2001</td>
</tr>
<tr>
<td>1.0 W/Kg</td>
<td>Sleep patterns and brain wave activity are changed with 900 MHz cell phone radiation exposure during sleep</td>
<td>Borbely, 1999</td>
</tr>
<tr>
<td>1.4 W/Kg</td>
<td>GSM cell phone exposure induced heat shock protein HSP 70 by 360% (stress response) and phosphorylation of ELK-1 by 390%</td>
<td>Weisbrot, 2003</td>
</tr>
<tr>
<td>1.46 W/Kg</td>
<td>850 MHz cell phone radiation decreases sperm motility, viability is significantly decreased; increased oxidative damage (free-radicals) significantly decreased; increased oxidative damage (free-radicals)</td>
<td>Agarwal, 2009</td>
</tr>
<tr>
<td>1.48 W/Kg</td>
<td>A significant decrease in protein kinase C activity at 112 MHz with 2-hr per day for 35 days; hippocampus is site, consistent with reports that RFR negatively affects learning and memory functions</td>
<td>Paulraj, 2004</td>
</tr>
<tr>
<td>1.0 - 2.0 W/Kg</td>
<td>Significant elevation in micronuclei in peripheral blood cells at 2450 MHz (8 treatments of 2-hr each)</td>
<td>Trosic, 2002</td>
</tr>
<tr>
<td>1.5 W/Kg</td>
<td>GSM cell phone exposure affected gene expression levels in tumor suppressor p53-deficient embryonic stem cells; and significantly increased HSP 70 heat shock protein production</td>
<td>Czyz, 2004</td>
</tr>
</tbody>
</table>

- **Stress proteins, HSP, disrupted immune function**
- **Reproduction/fertility effects**
- **Oxidative damage/ROS/DNA damage/DNA repair failure**
- **Disrupted calcium metabolism**

<table>
<thead>
<tr>
<th>Biological Effects</th>
<th>Brain tumors and blood-brain barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sleep, neuron firing rate, EEG, memory, learning, behavior</td>
</tr>
<tr>
<td></td>
<td>Cancer (other than brain), cell proliferation</td>
</tr>
<tr>
<td></td>
<td>Cardiac, heart muscle, blood-pressure, vascular effects</td>
</tr>
</tbody>
</table>
Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure  
(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

<table>
<thead>
<tr>
<th>SAR (Watts/Kilogram)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 W/Kg</td>
<td>Whole-body exposure to RF cell phone radiation of 900-1800 MHz 1 cm from head of rats caused high incidence of sperm cell death; deformation of sperm cells; prominent clumping together of sperm cells into &quot;grass bundle shapes&quot; that are unable to separate/swim. Sperm cells unable to swim and fertilize in normal manner. Yan, 2007</td>
</tr>
<tr>
<td>2.0 W/Kg</td>
<td>GSM cell phone exposure of 1-hr activated heat shock protein HSP 27 (stress response) and P38 MAPK (mutagen-activated protein kinase) that authors say facilitates brain cancer and increased blood-brain barrier permeability, allowing toxins to cross BBB into brain Leszczynski, 2002</td>
</tr>
<tr>
<td>2 W/Kg</td>
<td>900 MHz cell phone exposure caused brain cell oxidative damage by increasing levels of NO, MDA, XO and ADA in brain cells; caused statistically significant increase in 'dark neurons' or damaged brain cells in cortex, hippocampus and basal ganglia with a 1-hr exposure for 7 consecutive days Ilhan, 2004</td>
</tr>
<tr>
<td>2.6 W/Kg</td>
<td>900 MHz cell phone exposure for 1-hr significantly altered protein expression levels in 38 proteins following irradiation; activates P38 MAP kinase stress signalling pathway and leads to changes in cell sie and shape (shrinking and rounding up) and to activation of HSP 27, a stress protein (heat shock protein) Leszczynski, 2004</td>
</tr>
<tr>
<td>2.0 - 3.0 W/Kg</td>
<td>RFR accelerated development of both skin and breast tumors Szmigielak, 1982</td>
</tr>
<tr>
<td>2 W/Kg</td>
<td>Pulse-modulated RFR and MF affect brain physiology (sleep study) Schmidt, 2012</td>
</tr>
</tbody>
</table>

**STANDARDS**

<table>
<thead>
<tr>
<th>SAR (Watts/Kilogram)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.08 W/Kg</td>
<td>IEEE Standard uncontrolled public environment (whole body) IEEE</td>
</tr>
<tr>
<td>0.4 W/Kg</td>
<td>IEEE Standard controlled occupational environment (whole body) IEEE</td>
</tr>
<tr>
<td>1.6 W/Kg</td>
<td>FCC (IEEE) SAR limit for 1 gram of tissue in a partial body exposure FCC, 1996</td>
</tr>
<tr>
<td>2 W/Kg</td>
<td>ICNIRP SAR limit for 10 grams of tissue ICNIRP, 1996</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress proteins, HSP, disrupted immune function</td>
<td>Brain tumors and blood-brain barrier</td>
</tr>
<tr>
<td>Reproduction/fertility effects</td>
<td>Sleep, neuron firing rate, EEG, memory, learning, behavior</td>
</tr>
<tr>
<td>Oxidative damage/ROS/DNA damage/DNA repair failure</td>
<td>Cancer (other than brain), cell proliferation</td>
</tr>
<tr>
<td>Disrupted calcium metabolism</td>
<td>Cardiac, heart muscle, blood-pressure, vascular effects</td>
</tr>
</tbody>
</table>