Wireless Radiation and Health:
The Past, The Present & The Future

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SCIENCE BLOGGER @ 'BRHP - BETWEEN A ROCK AND A HARD PLACE'

INTERNATIONAL LECTURER (FREELANCE)

Who I am… education and work

- Two doctorates in molecular biology (Krakow ‘83) and biochemistry/cell biology (Helsinki ‘90)
- Adjunct Professor of Biochemistry, University of Helsinki, Finland (‘92)
- 22 years (1992-2013) @ STUK – Radiation and Nuclear Safety Authority (Säteilyturvakeskus)
  - 2003-2007 as Head of Radiation Biology Laboratory
  - 2000-2013 as Research Professor
- Assistant Professor at Harvard Medical School, USA; 1997-1999
- Guangbiao Professor @ Zhejiang University, Hangzhou, China; 2006-2009
- Visiting Professor @ Swinburne Univ. Technology, Melbourne, Australia; 2012-2013

Who I am… expert experience

- 20 years of active research on EMFs and health
- Testified and advising
  - Polish Ministry of Digitization; 2016
  - Canadian Parliament's House of Commons' hearing; 2015
  - India's Minister of Health and Family Welfare; 2014
  - USA Senate Appropriations Committee hearing; 2009
  - Parliament of Finland
- Member of the 30-experts group that in 2011 International Agency for Research on Cancer (IARC) Working Group for classification of the carcinogenicity of cell phone radiation as *possibly carcinogenic (2B)*
- Advised e.g.: National Academies, USA; World Health Organization; Bundesamt für Strahlenshutz, Germany; International Commission on Non-Ionizing Radiation Protection (ICNIRP); Swiss National Foundation; The Netherlands Organization for Health Research and Development

Claims of *scientific consensus* on the issue of health hazard of wireless radiation are *false*

The scientific evidence is one but interpretations of it are many, some more extreme, some less extreme

"Uncertainty" by the WHO

THE DAILY PRINCETONIAN

March 31, 2015

The identification of scientific consensus is precisely where the debate about wireless radiation becomes so convoluted, Emilie van Deventer, head of the World Health Organization's International Electromagnetic Field Project, said. Established by the WHO nearly 20 years ago, the project aims to assess the health effects of low-level radiation, like the radiation emitted by the Wi-Fi base stations around campus.

Although the project has repeatedly concluded that wireless network routers and base stations have no measurable health effects, the volume of information on both sides of the argument has maintained the debate this long, vanDeventer said.

"The data is gray. It's not black and white," van Deventer said of research on these health effects. "There is no consensus, it's true. There's a big group and a little group, but it's still two groups. I can't tell you that there's one group that is completely correct."

"Uncertainty" by ICNIRP

- Mona Nilsson, Swedish Radiation Protection Foundation
  - "In conclusion [of your presentation] you say that it's very difficult to draw conclusions [about radiation and health] … Question is why should the Swedish people and the Swedish decision-makers trust you [ICNIRP] more than those 220 scientists [signing WHO & UN Appeal] who … have no difficulties to draw conclusion that this radiation is harmful?"
- Eric van Röngen, Chairman of the ICNIRP
  - "Well, that's difficult to say. Everybody can believe what they want. If those scientists think that there is enough evidence it's their responsibility to draw that conclusion. We [ICNIRP] draw different conclusions from that [evidence] and that', you know, it's up to people to decide which group they think is more reliable, in what they should believe."

Video available here: https://wp.me/pBbF9-X0

"There are things we know that we know.

There are known unknowns. That is to say there are things that we now know we don't know.

But there are also unknown unknowns. There are things we don't know we don't know."

Donald Rumsfeld, US Secretary of Defense, NATO Briefing, June 6, 2002 [http://www.nato.int/docu/speech/2002/s020606g.htm]

Policies concerning human health and EMF are based solely on "*what we know that we know*"

"*What we know that we do not know*" is dismissed as irrelevant (e.g. children and sick persons)

Anything that questions status quo and could lead to implementation of precautionary measures is considered as "*scaremongering*".

The Problem

- Rapidly developing wireless technology
- Human health hazard research lagging behind

- Deployment of technology based on assumed lack of health hazard
- Assumed lack of health hazard appears to be false
- Biomedical research conducted post-deployment shows health hazard
- Existence of health hazard is “selectively” accepted or denied

- The same scenario repeats = not learning from the past experiences

World Health Organization: Definition of Health

- "*Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*."

- According to the WHO, it is a health effect when people are stressed by the worry of radiation exposure

Cell phones were not tested for health hazard before marketing

- In early 1980s communications technology developed for US Department of Defense was put into commerce
- Food and Drug Administration (FDA) allowed cell phones to be sold without pre-market testing for human health hazard
- FDA rationale - the "low power exclusion"

- Loophole – any wireless gadget with low power emission can be freely deployed

Thirty years later…

In 2011, based on the post-deployment research, International Agency for Research on Cancer (IARC) classified cell phone radiation as a possible human carcinogen

The assumed lack of health hazard appears to be false

Limited biomedical research on wireless radiation & health

- The vast majority of electro-magnetic fields (EMF) research has been done on non-wireless communication frequencies
- EMF Portal * (www.emf-portal.org) listing as of November 28, 2017
  - Wireless communications epidemiological studies = **264**
  - Wireless communications experimental studies = **1144** (human, animal, in vitro)

* **EMF Portal**: Due to a lack of financial resources, we unfortunately have to suspend the import of any new radio-frequency and mobile phone-related articles as of now (November 27, 2017)

Limitations of biomedical research

- Very many studies useless for human health risk estimation
- Lack of studies examining responses of human physiology to exposure
- Lack of studies on chronic exposures, majority of studies examined only acute responses
- Very many studies of low scientific standard
- Very many studies too small to draw general conclusions

Evaluation of science problem: self-perpetuating 'Echo Chambers'

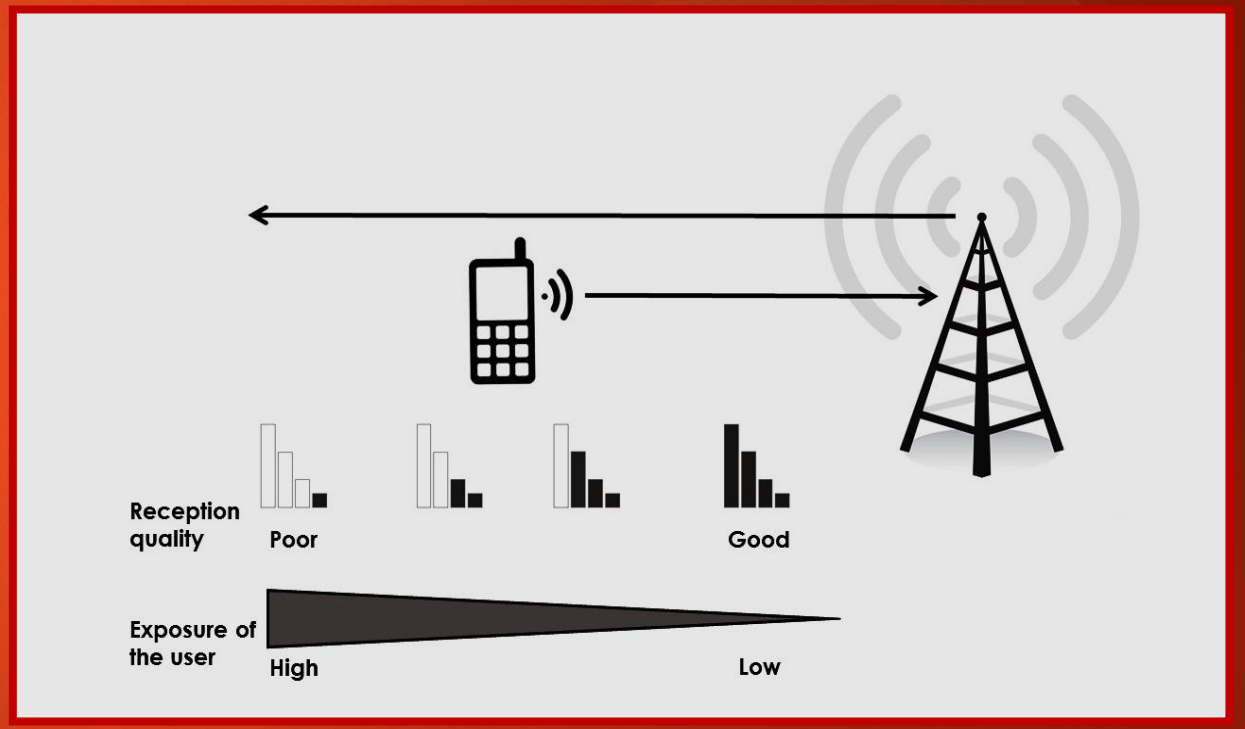
- **PROBLEM**: when all scientists on the evaluating team think the same = there will be no real scientific debate
- Scientists & Activists on the 'no-effects-team'
  - e.g. ICNIRP, SCENIHR, IEEE-ICES
- Scientists & Activists on the 'yes-effects-team'
  - e.g. BioInitiative, ICEMS, EHT, SSMAs
- **EXCEPTION**
  - 2011 International Agency for Research on Cancer (IARC) evaluation of the carcinogenicity of cell phone radiation
  - *Because of classification of cell phone radiation and glyphosate USA is considering defunding IARC – industry lobby…*

FOUR epidemiology case-control studies support brain cancer risk

- International Agency for Research on Cancer 2011 classification of cell phone radiation carcinogenicity was based on the results of **Interphone** and **Hardell** studies
- 2014 **CERENAT** study; 2017 **Canadian** Interphone re-analysis
- The **four** case-control epidemiological studies suggest the cell phone radiation increases risk of developing brain cancer in avid users
  - Regular user (!) – no problem at all but… definition: 1 call/week for 6 months
  - Avid user = ca. 30 minutes/day for 10+ years
  - **Interphone 40%; Hardell 170%, CERENAT 100%, Canada 100%** increase in glioma risk
- Interphone 2016 analysis of full data confirms location of cancer in the most exposed parts of brain

Epidemiology case-control studies have no radiation exposure data

- Surrogate for radiation exposure – minutes of using cell phone
- Such surrogate leads to underestimation of the effect
- Two persons talking for the same length of time may have entirely different radiation exposure because of the different proximity to cell tower
- **Persons with dramatically different radiation exposure are analyzed as if having the same exposure** because they have the same minutes of use



Epidemiology cohort and trend studies

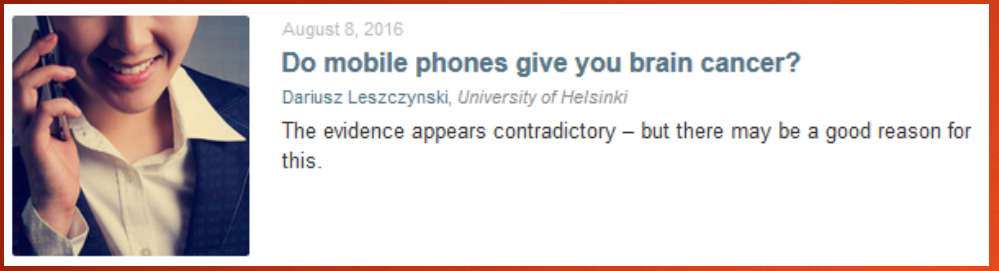
- Trend-data - Little et al. 2012: slow rise of brain cancer cases in USA
  - trend is similar to Interphone "prediction" but not Hardell "prediction"
- Danish Cohort update study 2011 – no effect
  - no exposure data; the length of phone subscription with service provider
  - Leszczynski's opinion **Scientific Peer Review in Crisis** in 'The Scientist Magazine'
- Million Women study 2014 - no effect
  - use of cell phone: 'never', 'less than once a day', 'every day'
- Chapman et al. 2016
  - Misleading claim of 29 years of use and **10 years latency of brain cancer (?!)**

Huge number of cell phone users but no dramatic increase in brain cancer

- Brain cancer is a rare disease
- Cancer latency is estimated to be several tens of years
- Length of use of cell phone and how avidly used
- Cancer statistics are too general – do not differentiate between types of brain cancer or age groups having it – might be misleading
- Cancer cause – cell phone radiation or something else?
- Cell phone radiation – just a co-factor in cancer development?

Leszczynski in: THE CONVERSATION

Academic rigor, journalistic flair



August 8, 2016

Do mobile phones give you brain cancer?

Dariusz Leszczynski, *University of Helsinki*

The evidence appears contradictory – but there may be a good reason for this.

- Case-control studies show increased risk of brain cancer not because mobile phone radiation causes it, but because it accelerates the development of brain cancers caused by other carcinogens or cancers occurring due to spontaneous mutations
- The incidence of brain cancer is low compared with the high rate of mobile phone use because the increases in cancer are solely due to co-carcinogenic effects of cell phone radiation
- Not all users are in danger of developing brain cancer, only those who are developing it as a result of other carcinogenic or genetic factors

Human studies

- The vast majority are “feelings” studies - subjects asked how they feel and do they feel when radiation is on/off
  - Subjective data influenced by experimental stress and preconceptions about EMF
- Lack of studies examining biochemical responses of human tissues (!)
  - Single skin proteomics study
  - Two studies examined glucose metabolism in the brain

Sensitivity to EMF

- EHS (electromagnetic hyper sensitivity) exists (common sense)
- Level of radiation exposure causing EHS – unknown
- Research to date insufficient to prove or to disprove EHS
- EHS studied by psychologists not physiologists – methods inadequate to prove physiological effects = "feelings" studies
  - Small sample sizes with unknown status of self-diagnosed EHS
  - Experimental stress affects subjective "feelings-type" responses of study subjects
  - Placebo and nocebo effects impact the "feelings-type" studies
- Lack of studies examining biochemical responses of human tissues (!)

Research on sensitivity to EMF needs new direction

- Time to step out-of-the-box of the self-diagnosed EHS
- Well established individual sensitivity phenomenon
  - e.g. ionizing radiation, ultraviolet radiation, ultrasound radiation, chemicals
- Genetic and epigenetic factors affect how person responds to stimulus
- Physiology-based research must replace the current psychology-based research
  - **e.g. high-throughput screening of responder genes and proteins**
- What part of the population possess traces making it individually sensitive to wireless radiation and to what radiation levels

Animal studies

- No classical toxicology possible - not possible to overdose cell phone radiation because of heating effect
- Life-time exposures to radiation at doses similar to those emitted by cell phones show no effect – results useless for human health risk estimation
- **Co-carcinogen studies show effects** (just few performed) – cell phone radiation might potentiate effects of carcinogenic chemicals or radiation
  - Published replication of Tillmann et al. 2010 confirmed by Lerchl et al. 2015
  - 2016 National Toxicology Program (!) study – cell phone radiation induces glioma and DNA damage in rats
- **Lack of co-carcinogen studies** (!)

Mechanism still unconfirmed
because of replication & robustness problems

- Plausible mechanisms: stress response, oxidative stress, calcium signaling
- Unrealistic exposures in laboratory studies cause replicability problem
- Schmid & Kuster study
  - Exposure of skin, blood, muscles may exceed 40 W/kg
  - Research done using 2 W/kg – underestimation of effects
- Exposures in laboratory studies had radiation levels significantly lower than exposures humans received in epidemiological studies
- Mechanistic studies need be repeated at higher radiation exposure levels

Conditions for invoking the Precautionary Principle

"…Whether or not to invoke the Precautionary Principle is a decision exercised where scientific information is insufficient, inconclusive, or uncertain and where there are indications that the possible effects on environment, or human, animal or plant health may be potentially dangerous and inconsistent with the chosen level of protection…"

Justification for invoking the Precautionary Principle

- ***Scientific information is insufficient, inconclusive, or uncertain***
  - IARC classification of cell phone radiation as possible carcinogen (Group 2B) means that the science is insufficient, inconclusive, and uncertain
- ***There are indications that the possible effects on human health may be potentially dangerous***
  - Epidemiological studies, Interphone, Hardell and CERENAT, show an increased risk of brain cancer in long-term avid users – potentially dangerous effect
- ***Inconsistent with the chosen level of protection***
  - Epidemiological studies, showing increased risk in long-term avid users, were generated in populations using regular cell phones, compliant with the current safety standards = current safety standards are insufficient to protect users

The impact of implementing the Precautionary Principle

- Consideration and implementation of the Precautionary Principle (PP) does not equal prevention of the use of wireless communication technology
- Strong opposition from telecom industry because implementation of PP may cause:
  - Technology providers can be made responsible to prove their product is safe – this may stimulate bio-med research
  - Requirement of making more efficient (less radiation emissions) technology
  - Limiting current rampant and uncontrolled deployment of wireless networks
- Implementation of PP will create new knowledge through research
- Implementation of PP will create new jobs in research and technology

Re-classification of carcinogenicity from possible (2B) to probable (2A)

Currently available scientific evidence from epidemiology and from animal studies is sufficient to re-classify the carcinogenicity of cell phone radiation from the possible carcinogen (Group 2B) to the probable carcinogen (Group 2A) in the scale of IARC (International Agency for Research on Cancer)

Evidence supporting re-classification of cell phone radiation as a probable carcinogen

- Epidemiological studies
  - Four case-control studies: Interphone, Hardell group, CERENAT, Canadians
  - Interphone study – tumor vs. radiation localization study
- Animal studies
  - Five co-carcinogenicity studies evaluated in 2011
  - Lerchl et al. co-carcinogen study in 2015
  - National Toxicology Program partial results in 2016
- Dosimetry
  - Re-evaluation of in vitro dosimetry by 2015 study of Schmid & Kuster showing discrepancy between real exposures and in vitro exposures

Gaps in research (examples)

- Epidemiology with realistic radiation exposure data
- Search for sensitive sub-population using biochemistry methods
- Finding out if DNA damage happens in people
- Examining whether human blood-brain barrier is affected
- Examining co-carcinogenic effects of cell phone radiation
- Effects of chronic exposures and delayed responses

Predicting the "unpredictable"(?)

With technologically improved hardware we forget to advise users that radiation exposures change

- **Laptops**, old, did not emit wireless radiation - keeping on the lap was **OK**
- **Laptops**, new, connect to internet, emit wireless radiation – keeping on the lap is **not OK**
- **Tablet**, connect to internet, emit wireless radiation – keeping close to the body is **not OK**
- **Cell phones**, non-smart,
  - emitted radiation when speaking/listening; on idle radiation emission was negligible
  - it was **OK** to keep in the pocket
- **Smart phones**
  - emit radiation when speaking/listening
  - when connected to internet - synchronizing apps
  - when using as base-station (tethering)
  - it is **not OK** to keep in pocket smart phone connected to internet

Where science and money collide… science is the looser…

- Network operators' revenue opportunity for wireless connectivity is likely to exceed $3 trillion ($3,000,000,000,000) by 2026, with the vast majority of revenue growth coming from new industrial applications powered by 5G (report from Ericsson)
- Meanwhile, the 5G-enabled health services segment alone will be worth $1.1 trillion by 2035 (report from Qualcomm)

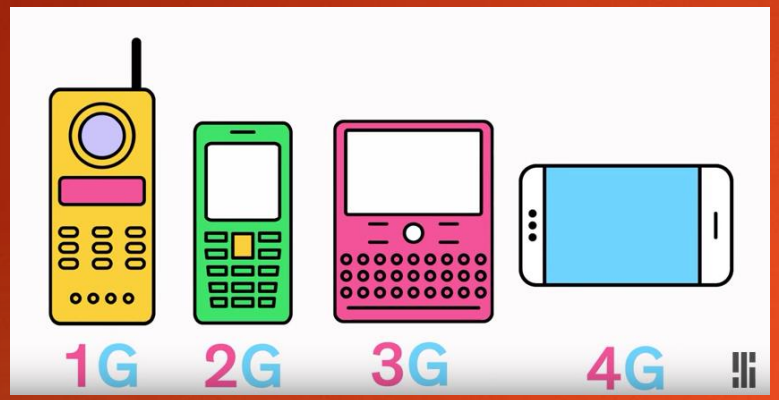
Source: https://www.edn.com/electronics-blogs/5g-waves/4459091/5G--It-s-the-use-cases--dummy

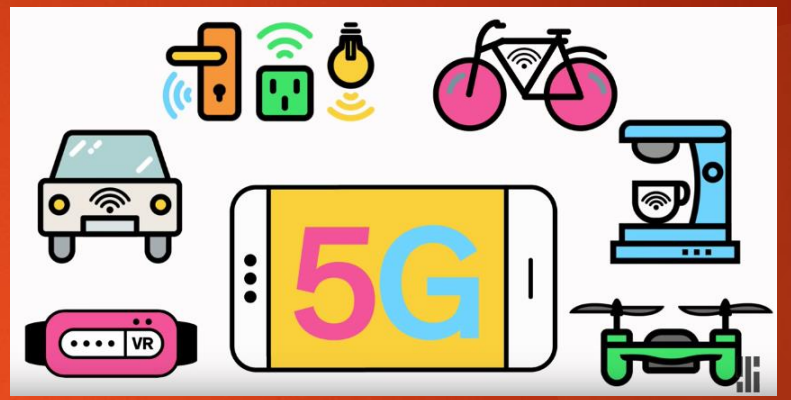
Predictable future with 5G

- Base stations networks will be first, followed by…
- Gadgets in pockets…
  - "No one is ready with components small enough for handsets; those will come later. Laptops are and tablets are likely to get 5G connectivity before 5G handsets appear."
- Users will be exposed additionally to new type of radiation – the millimeter-waves
- Current talk that users will not be exposed in close-range to millimeter-waves is incorrect

Source: https://www.edn.com/electronics-blogs/5g-waves/4458814/Movandi-optimizes-mmWave-5G-front-ends

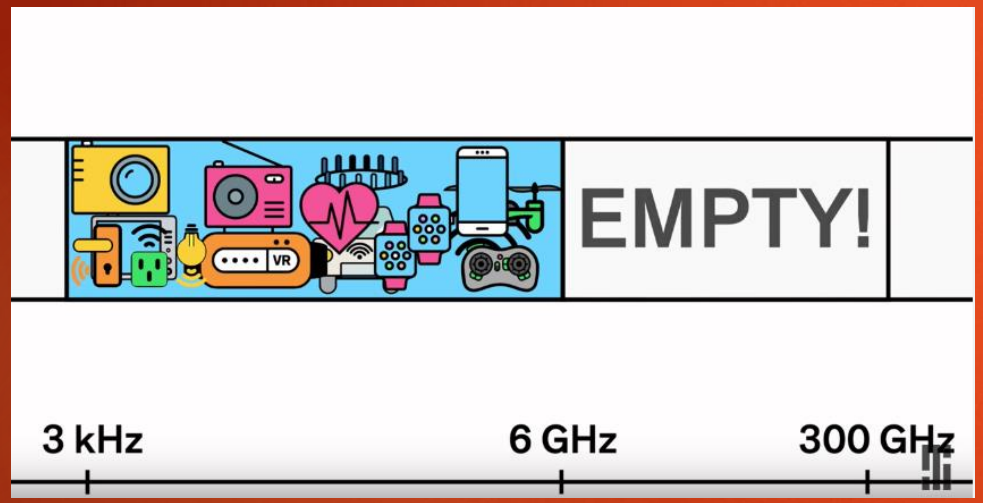
5G Technology

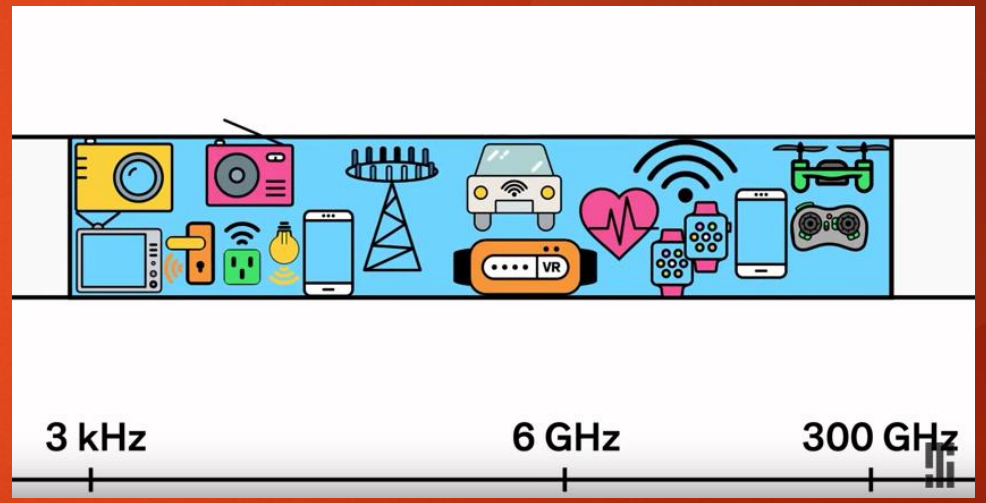




Source: IEEE Spectrum
http://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

5G Technology: radiation spectrum



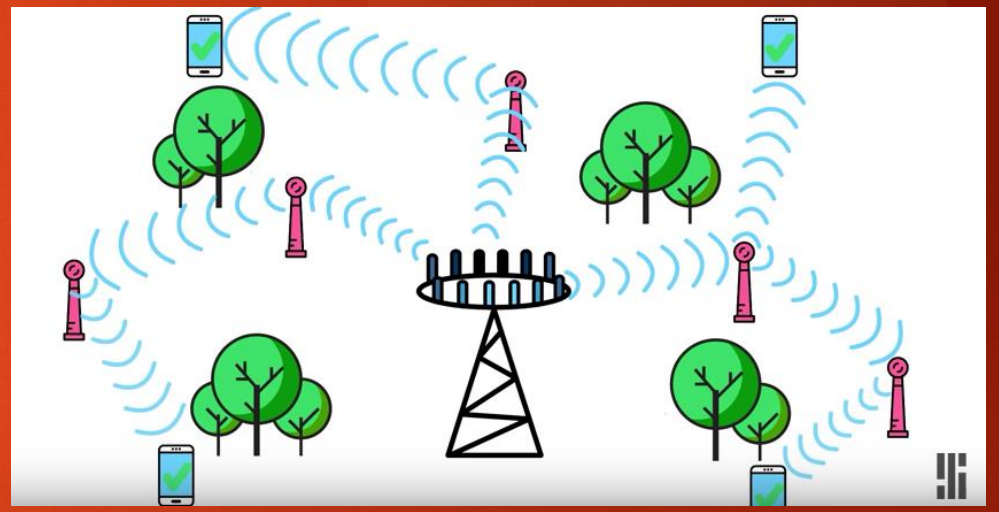


Source: IEEE Spectrum
http://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

5G Technology: obstacles for millimeter waves

Source: IEEE Spectrum
http://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

5G Technology:
need for small cells

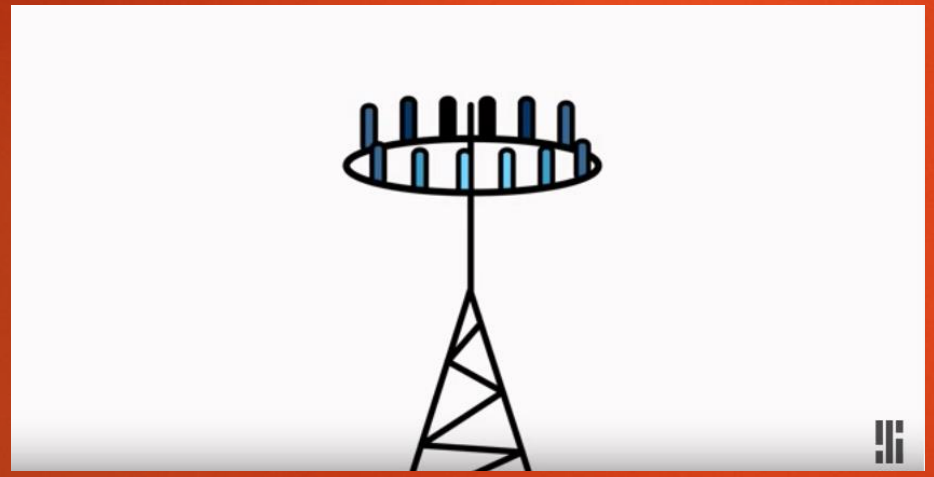


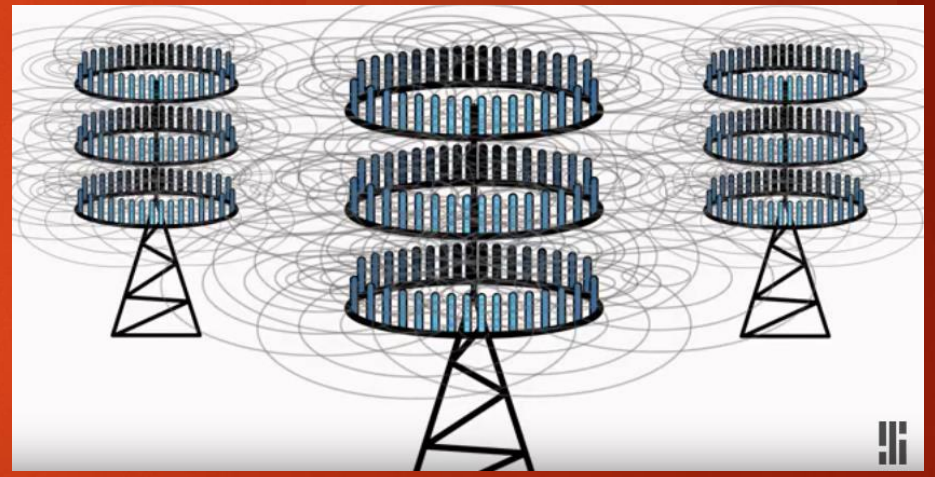
Source: IEEE Spectrum
http://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

5G Technology: massive base stations

Massive MIMO

Multiple Input Multiple Output





Source: IEEE Spectrum
http://spectrum.ieee.org/video/telecom/wireless/everything-you-need-to-know-about-5g

UNWIReD ReVOLUTION in Australia

Chris Althaus CEO Australian Mobile Telecommunications Association - AMTA

Very limited biomedical research on millimeter-waves & health

EMF Portal (www.emf-portal.org) listing as of November 28, 2017

- Epidemiological studies on mmWaves - **2**
- Experimental studies – **195** (human, animal, in vitro)
  - Majority of the studies is **useless** for human health hazard estimation

Industry review… inconsistency

claims technology to be safe but admits missing evidence for such claim…

- IEEE Microw Mag. 2015; 16: 65–84; **Safe for Generations to Come**. Ting Wu, Theodore S. Rappaport, Christopher M. Collins; New York University (NYU) WIRELESS
- In April 2014, the **Brooklyn 5G Summit**, sponsored by Nokia and the New York University (NYU) WIRELESS research center, drew global attention to mmWave communications and channel modeling
- Low-power – not causing thermal effects (?)
- "*…Compared with lower frequency bands,* ***relatively little careful research*** *has been conducted evaluating the potential of more* ***subtle long-term effects*** *than tissue damage due directly to heating at mmWave frequencies…*"

Skin… a few quotes…

- *"…Existing measured data of skin permittivity is rare in the mmWave band compared with frequencies below 20 GHz due to technical limitations, such as availability of vector network analyzers, in the mmWave frequency range…"*
- *"…Since most mmWave energy is absorbed near the surface of the human body, leading to localized temperature elevations near the skin surface, the study of mmWave heating of the skin is critical to protecting humans from mmWave overexposure…"*
- *"…At microwave frequencies, it is widely accepted that antennas placed in close proximity to lossy media, such as the human body, experience strong power absorption into the media, radiation pattern distortion, shift in resonance frequency, and change in the input impedance. In the mmWave band, the electromagnetic coupling between antennas and the human body as well as the possible perturbations of antenna characteristics due to the body require more study…"*

Eyes… a few quotes…

- *"…As with the eyes, however, more work is required to determine temperature increases from higher exposure levels that might be experienced in the near field from specific communication devices with high-gain antennas and to develop and demonstrate reliable mechanisms to ensure that no hazardous levels of energy are transmitted to the skin…"*
- *"…More work may be required to determine the possible effects from exposure above 10 mW/cm2 that might be experienced in the near field from specific communication devices with adaptive antennas as well as to ensure that mechanisms are in place to ensure that no hazardous levels of energy are transmitted into the eyes…"*

Déjà vu?

- Cell phones 1G – 4G
  - 1G technology emitting low power - no health hazard to envision in 1980's
  - Today – 3G & 4G – technology emitting low power – classified by WHO/IARC as a possible carcinogen
- Future 5G and Internet of Things (IoT)
  - Technology emitting low power – no heath hazard (?)
  - No research showing hazard because no research done (!)
  - The future research outcome – will health risks show up (?)

Conclusions 1/2

- 2011 IARC classification of cell phone radiation as a possible carcinogen is a sufficient reason for invoking Precautionary Principle
- Claims that the current safety standards protect all users are not supported by the scientific evidence
- Nearly complete lack of research on co-carcinogenicity
- Children should be especially protected by precautionary measures
- Schools should use only wired internet - a precautionary measure
- Users should be better informed about the current scientific uncertainty and advised to limit exposures whenever possible and feasible and strongly discouraged from keeping cell phones, laptops, tablets touching the body
- Real radiation exposure data should be used in epidemiological and human studies
- ALARA principle should be implemented for wireless radiation exposures

Conclusions 2/2
Between a Rock and a Hard Place:
technology deployment vs. health hazard

- Scientific evidence is limited, ambiguous, contradictory and with many gaps
- More research is needed but issue is trivialized and funding is denied
- Evaluation of evidence is scientifically biased = advice to decision-makers is biased
- Technology is very profitable & useful – "mesmerizing effect"; seeing only one side of the coin
- Technology deployment is based on biased evaluation of science
- Policy of "low power" used as an excuse for unrestricted deployment
- Precautionary Principle should be implemented – it's not a "scaremongering"
- Need for temporary moratorium on 5G & IoT deployment due to lack of health research
- Research on 5G-emitted millimeter-waves and health should be prioritized


Thank you
Cooktown, Qld, Australia