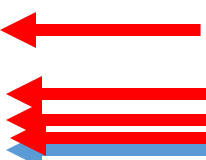




# 5G: A summary of the research

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# Millimetre waves: Radar & other technologies

Designation	Frequency range	Historical Uses	
<a href="#">L band</a>	1 to 2 GHz	Air traffic control	 Current 4G deployment
<a href="#">S band</a>	2 to 4 GHz	Long-range weather, marine radar	
<a href="#">C band</a>	4 to 8 GHz	Satellite transponders, weather	
<a href="#">X band</a>	8 to 12 GHz	Marine, surveillance, weather	
<a href="#">Ku band</a>	12 to 18 GHz	Satellite transponders, hi-res	 Current 5G deployment
<a href="#">K band</a>	18 to 26.5 GHz	Police radar guns, cloud detection	
<a href="#">Ka band</a>	26.5 to 40 GHz	Traffic camera triggers	 Future
<a href="#">Q band</a>	33 to 50 GHz	Automotive radars, Radioastronomy	
<a href="#">U band</a>	40 to 60 GHz	(overlapping bands)	
<a href="#">V band</a>	50 to 75 GHz	(overlapping bands)	
<a href="#">W band</a>	75 to 110 GHz	Autonomous vehicle sensors, hi-res	
<a href="#">F band</a>	90 to 140 GHz	Active denial systems	
<a href="#">D band</a>	110 to 170 GHz		

# Summary of radar and other early work on mm wave exposures

- Survey of Naval personnel (Robinette et al. Am J Epi 112:39, 1980).
  - ‘in a group of men, many of whom may have received **substantial exposures, any health effects** which may have occurred were **insufficient to be clearly perceptible...**’
- Eye hazards
  - ‘As of now, **we do not know of a case** in which microwave radiation has been the **proven cause of human cataract.**’ (Carpenter et al. 1974: Thresholds for opacity measured for experimental animals  $\sim 1 \text{ kW/m}^2$ )
  - ‘Since that time, **no clear-cut evidence** has emerged on this subject’. (Lipman et al. 1988)
  - Hollows, Lancet 1981, 1984: exposure assessment issues (Hocking).

# More recent reviews of 5G frequency bioeffects

- Aachen University EMF-Portal (<https://www.emf-portal.org>)
  - Lists over **500 refs using 'millimetre wave'**, but some dosimetric rather than bioeffects papers
- Three recent reviews
  - Russell, CL (2018) Environmental Research 165: 484-495
  - Di Ciaula, A (2018) Int J Hyg Env Health 221: 367-375
    - Both advocate caution, but **neither constitute 'systematic reviews'** (i.e scoring for quality, exposure calibration, double blinding etc.)
  - Alexeev & Ziskin (2018) Ch 6 in Greenebaum & Barnes: Biological & Medical Aspects of Electromagnetic Fields. 4<sup>th</sup> Ed CRC Press
- ARPANSA review: 251 studies: **89 below the RPS3** limits

# Skin depth for mm-waves

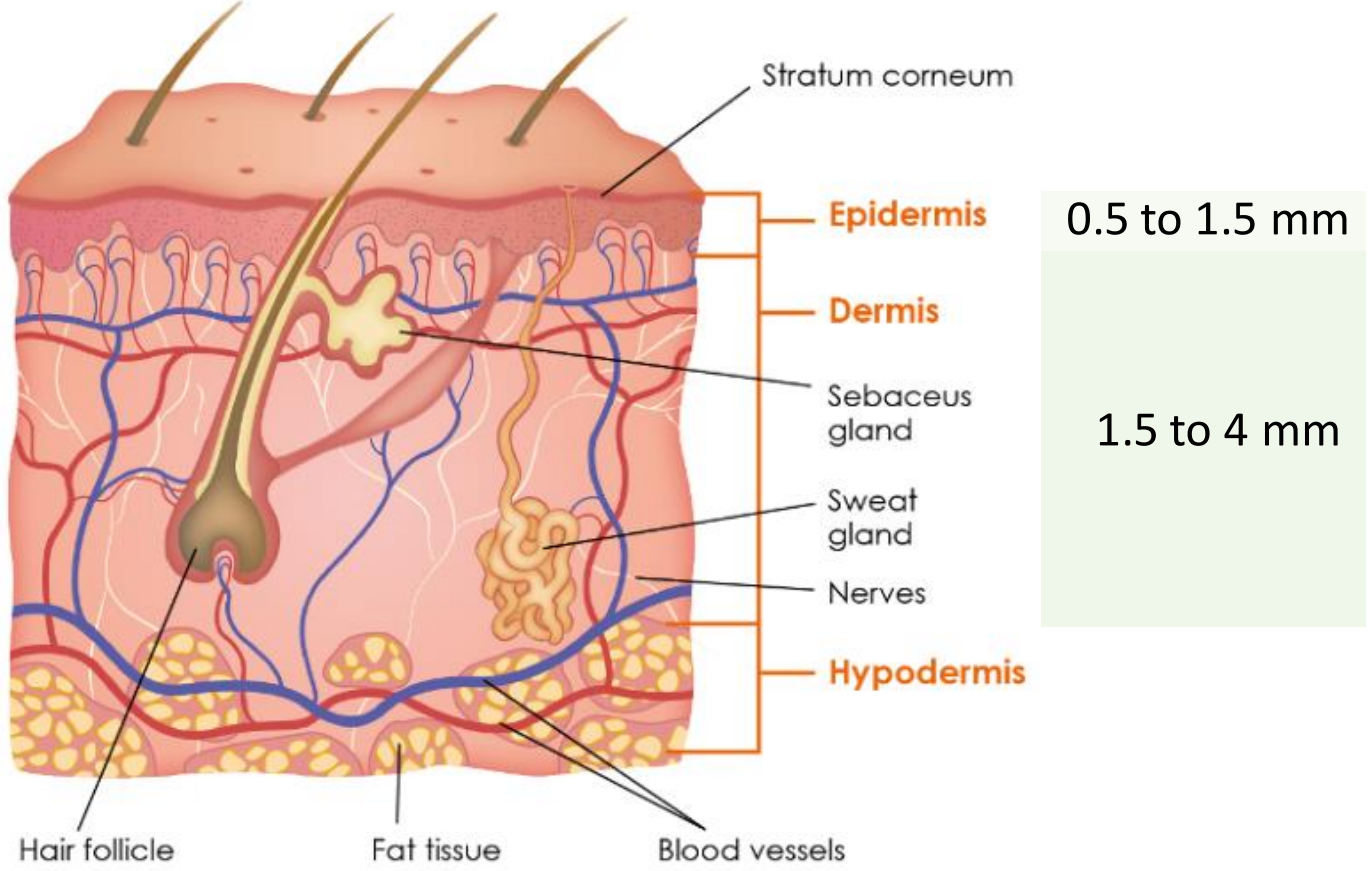
(distance for intensity to fall by 67%)

30 GHz      100 GHz

↓              ↓

1 mm      0.3 mm

Penetration depth



# Animal studies: US (NTP); Italy (Ramazzini); Japan/S Korea (ongoing)

- Both report ↑ cardiac neurinomas in ♂ rats (GSMA) but not ♀ or mice
- SAR values in US & Italy **quite different**
  - Exploratory or hypothesis driven?
  - Problem of **multiple comparisons**
    - Over 300: ordinarily should only look at  $P < 0.05/300$
  - Reported US **SAR values had quite a range** – up to 5 x mean
    - Issue of tails acting as antennas: tail-licking as a means of thermoregulation
- DNA breaks paper (Smith-Roe et al. Env Mol Mut 2019)
  - ↑ DNA damage in frontal cortex of ♂ mice; leukocytes of ♀ mice (CDMA only), & hippocampus of ♂ rats (CDMA only).

# Need for more 'in-depth' reviews

- Most assessments of health intervention efficacy now use 'systematic review' rather than 'narrative review'
  - E.g. Cochrane Collaboration 'risk-of-bias' tool & 'quality' metrics
- Not all studies are of the same quality.....
  - Vijayalaxmi 2019: 225 genotox studies: highest 'quality' scores associated with highest % of 'no effect' outcomes, and vice-versa
- Need to step back a bit...
  - Handset numbers from 0 to 6 bn in nearly 50 years: no evidence of catastrophic rise in serious illness
  - In reviews, reported SAR values for 'no effect' > 'effect'
  - Mobile telephony delivers immense benefits – e.g. mHealth in rural and remote areas