

Wi-Fi in Schools: Are We Playing It Safe With Our Kids?

Dr. Cindy Russell
VP Community Health SCCMA

“Current FCC standards do not account for the unique vulnerability and use patterns specific to pregnant women and children. It is essential that any new standard for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded throughout their lifetimes.” American Academy of Pediatrics Letter to FCC August 29, 2013. (20)

Industry has been quite successful in creating magically useful wireless technologies such as cell phones, iPads, Wi-Fi and now wearable tech devices such as Google glasses and wrist health monitors we all love. Many of these handy gadgets have now reached the typical classroom across the globe. It has become apparent, however, that there are substantial downsides to being excessively connected to technology and as safety concerns mount governments such as France and Israel are backing away from the blind adoption of wireless technology in schools especially for young children.

These devices are cool and convenient however, there remain nagging questions of overuse and safety as the application of these devices has increased to the point we are literally exposed 24 hours a day to this radiation. Wireless microwaves come from many sources both at work and at home.

An increasing number of physicians, scientists and parents are concerned about long-term health effects from Wi-Fi in schools. (42)(43)(44)(49) As any parent knows computers now are as ubiquitous in schools as they are at work. From kindergarteners on up kids are required to learn computer skills in order to take core testing on-line. There is a push to enable students to have constant connection to the Internet 24/7 to take photos, email documents, and research a topic. In schools wired connections for computers have been rapidly eliminated in order to install wireless systems that connect students both indoors and outdoors on campus.

Europe and some schools in the U.S. are taking a different more precautionary approach and going back to the future with wired plug-in computers. (45) Studies have also cast doubt on some of the benefits of classroom computers and warned of the new age of “Digital Dementia” which has now crept into Korean youth due to the heavy use of electronic gadgets. (17)(48)

Professors in colleges and law schools are banning computers during lectures and finding students have less distraction and more learning. (38) (39)

Children are More Vulnerable thus Need More Protection

Children have several organ systems that are immature at birth and are thus much more sensitive to toxic exposures. The human brain, one of the top vital organs, is far from being a finished product in youth. Long-term structural maturation of the nervous system is required for successful development of cognitive, motor and sensory functions. Neuronal axons-long thin projections from the nerve cell- act as electronic transmission

lines. Axons in major pathways of the brain continue to develop throughout childhood and adolescence. Myelin is the insulation surrounding individual nerves protecting it from outside electrical charges. The process of myelination is much faster the first 2 years but continues into adulthood. (16) Children have thinner skulls (29), their immune systems are undeveloped, their cells are dividing more rapidly thus they are more vulnerable to EMF radiation and other carcinogens. They also have a longer cumulative exposure to all toxins including EMF radiation.

Current Wireless Safety Standards and Microwaving Potatoes

Wireless devices work on high frequency microwaves similar to the microwave you use to cook food with. It is with less power but substantial research (1)(2)(3)(4) demonstrates that even at low power within the current safety standards these microwaves can cause biologic harm to plants, animals, and cellular structures. Current Federal Communications Commission (FCC) standards are based only on heat generated by the device not on adverse biological effects seen in hundreds of studies and at much lower levels.

Our own CMA supports reassessment of EMF standards. The California Medical Association in 2014 passed Resolution 107-14 as follows:

“Resolved 1: That CMA supports efforts to reevaluate microwave safety exposure levels associated with wireless communication devices, including consideration of adverse non-thermal biologic and health effects from non-ionizing electromagnetic radiation used in wireless communications and be it further;

Resolved 2: That CMA support efforts to implement new safety limits for wireless devices to levels that do not cause human or environmental harm based on scientific research.”

In May 2011 The international Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B). (30)

Adverse effects of EMF are well documented below in peer reviewed published research (2) Direct affects on biological systems is added to epidemiologic studies linking EMF microwaves to cancer promotion, memory problems, sleep disorders and male infertility. (40)(41)(52)

- * DNA with single and double stranded breaks
- * Leakage of the blood brain barrier (2 hours of cell phone exposure causes 7+ days of albumin leakage)
- * Stress protein production in the body indicating injury
- * Sperm and ovarian damage
- * Neurologic harm with direct damage to brain cells
- * Lowering of melatonin levels
- * Immune dysfunction
- * Inflammation
- * Oxidative Stress

Plausible Mechanism Found for EMF Microwave Effects

Dr. Martin Pall, Professor Emeritus of Biochemistry Washington State University has studied how electromagnetic fields impact the cells of our bodies. His 2013 paper on this subject highlights a major biological mechanism of action of EMF microwave radiation on cell structure. This work, along with two-dozen prior studies, demonstrated that EMF microwave radiation affects cellular calcium channels and this could be inhibited with calcium channel blockers. He notes pacemaker cells in the heart have a very high density of VGCC's in them, therefore, may be particularly susceptible to EMF activation thus leading to tachycardia and arrhythmias. "A whole series of biological changes reportedly produced by microwave exposures can now be explained in terms of this new paradigm of EMF actions via Voltage Gated Calcium Channels (VGCC) activation." Dr. Pall. (14)(15)

EMF Affects on Wildlife: Birds, Bees and Tomato Plants

Bird researchers in Germany found that their migratory European Robins lost their sense of navigation when in the city. (5) This was found to be due to the EMF radiation interfering with the bird's special internal magnetic compass. They replicated the experiment over seven years before publishing the results in the prestigious journal Nature.

John Phillips and others have found that newts, sea turtles and migratory birds use a magnetic compass to navigate long distances and this can be interrupted by low levels of EMF. (6)(7) A review of effects on cell towers and wireless devices showed beehives could have rapid colony collapse with exposure to cell phone radiation. (8)

Plants have been shown to have stress response to EMF from wireless devices. (9)(10) (22) in tomatoes exposed for short duration the stress response seen by exposure to EMF was prevented by administration of calcium counteracting drugs. (11) Even simple high school science experiments document abnormal seed growth near Wi-Fi routers. (19) There appear to be adverse biological effects of this seemingly harmless radiation.

Human Electrosensitivity: Is it Real?

There is varied opinion about those who state they are sensitive to EMF. Scientific research has not given a definitive answer nevertheless many seem to suffer from vague and often disabling symptoms they feel in the presence of EMF. Exposure to EMF radiation in some people reportedly cause headaches, memory problems, fatigue, sleep disorders, depression. This is so significant for some people that they have to live in a very low EMF environment to feel normal. (25) Sweden recognizes electro-sensitivity as a functional impairment and estimates that about 3% of the population suffers from this. (23)(24) Dr. Magda Havas found in replicated studies that some EMF sensitive individuals heart rates increased with wireless devices turned on in double blind study. (12)(26) Researchers at Louisiana State University in 2011 studied a self reported EMF sensitive physician and found "In a double-blinded EMF provocation procedure specifically designed to minimize unintentional sensory cues, the subject developed temporal pain, headache, muscle twitching, and skipped heartbeats within 100 s after initiation of EMF exposure ($p < .05$)." They concluded, "EMF hypersensitivity can occur as a bona fide environmentally inducible neurological syndrome." (27)

Genius and Lipp reviewed the current literature on EHS in 2011 and point to several explanations for this multisystem phenomenon including toxicant induced loss of tolerance as many with EHS symptoms had high levels of PCB's possibly causing immune dysfunction. Scientific research also identifies an inflammatory response with cytokine production. Another aspect of research points to catecholamine and adrenal gland dysfunction. In addition heavy metal toxicity has also been proposed as contributing to EHS. (28)

The Austrian Medical Association feels Electrohypersensitivity is a real phenomenon and in 2012 published Guidelines for EMF and Electro- hypersensitivity. They state the primary method of treatment should consist in the prevention or reduction of EMF exposure, taking care to reduce or eliminate all sources of EMF if possible. (32)

Government Actions on Wi-Fi in Schools

While much of the U.S. is marching forward with Wi-Fi in schools Europe is changing direction as indicated by the policies listed below. (45) Internationally there is wide disagreement in standards. The U.S. and Canadian limits are 1000 microwatts/cm². China and Russia are 10 microwatts/cm². Belgium is 2.4 microwatts/cm² and Austria is 0.001 microwatts/cm². The Bioinitiative Report 2012 recommendation for "No Observable Effect" is 0.0003 microwatts/cm². Cosmic background EMF we evolved with is <0.0000000001 microwatts/cm². (2)

Council of Europe Parliament Assembly 2011 EMF Microwave Policy: "The potential dangers of electromagnetic fields and their effect on the environment"

The report notes "other non-ionizing frequencies, whether from extremely low frequencies, power lines or certain high frequency waves used in the fields of radar, telecommunications and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects and animals as well as the human body, even when exposed to levels that are below the official threshold values."

The Council calls for a number of measures to protect humans and the environment, especially from high-frequency electromagnetic fields. One of the recommendations is to "take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumours". (37)

"Certain high frequency waves used in the fields of radar, telecommunications and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects and animals as well as the human body, even when exposed to levels that are below the official threshold values."

In France A New National Law Bans WIFI in Nursery Schools

In January 2015 France passed a landmark law that calls for precaution with wireless devices for children and the general public. (34)(35) It calls for:

- 1) Wi-Fi banned in nursery schools.
- 2) Wi-Fi routers should be turned off in school when not in use.
- 3) Schools are informed when new tech equipment is installed.
- 4) Citizens will have access to environmental cell tower radiation measurements near homes.
- 5) There will be continued research conducted into health effects of wireless communications.
- 6) Information on reducing exposure to EMF radiation is mandatory in the contents of the cell phone package.
- 7) Wi-Fi hotspots are labeled.

Israeli Ministry Of Education Issue Guidelines to Limit Wi-Fi in Schools

On Aug 27, 2013 the Israeli Ministry of Education issued new guidelines regarding WiFi use in schools. (33) The guidelines will

- 1) Stop the installation of wireless networks in classrooms in kindergarten 2) Limit the use of Wi-Fi between first and third grades. In the first grade students will be limited to use Wi-Fi to study for one hour per day and no more than three days per week. Between the first and third grades students will be limited to use Wi-Fi up to two hours per day for no more than four days per week.
- 3) To limit unnecessary exposure teachers will be required to turn off mobile phones and Wi-Fi routers when they are not in use for educational purposes.
- 4) All Wi-Fi equipment be tested for compliance with safety limits before and after installation in an Israeli school.
- 5) Desktop computers and power supplies be kept at least 20 cm from students.

2012 The Russian Committee on Non-Ionizing Radiation Protection officially recommended that Wi-Fi not be used in schools.

2011 The Russian Committee on Non-Ionizing Radiation Protection (RNCNIRP) released their resolution entitled “Electromagnetic Fields From Mobile Phones: Health Effects on Children and Teenagers.” According to the opinion of the Russian National Committee on Non-Ionizing Radiation Protection, the following health hazards are likely to be faced by the children mobile phone users in the nearest future: disruption of memory, decline of attention, diminishing learning and cognitive abilities, increased irritability, sleep problems, increase in sensitivity to the stress, increased epileptic readiness. (36)

Expected (possible) remote health risks: brain tumors, tumors of acoustical and vestibular nerves (in the age of 25-30 years), Alzheimer’s disease, “got dementia”, depressive syndrome, and the other types of degeneration of the nervous structures of the brain (in the age of 50 to 60).

Playing it Safe For Our Kids

A healthy and safe learning environment is a cornerstone of education.

Current FCC standards are obsolete and inappropriate as they are based only on heat

effects not biological effects. They give us a false sense of security. **There may be higher EMF levels at school** than at home as routers are more powerful. **Cumulative Effects on DNA** or cell structures are not taken into consideration in any safety standard. Because of the **long-term exposure to EMF microwave radiation** this generation is experiencing, they will be at higher risk for potential health problems. We will not know what happens to our progeny's DNA until our grandchildren are born.

Considering there has been a more precautionary approach internationally to microwave radiation exposure, and the trend is toward less exposure in schools it makes sense to reevaluate our wireless schools. We buckle our seat belts and wear a helmet when we ride bikes even though we don't know if we will get in an accident. Although not all the issues of wireless microwaves are understood there is enough science to understand it acts as a toxicant or co-toxicant at even low levels that fall within current safety standards. We also know that **decades of research precedes meaningful regulation in the area of toxins thus the only reasonable approach is precautionary.**

In addition we need to be thoughtful about how much our kids should use computers and what this is doing not only to them but also to our society as a whole. (31)(48) We get starry eyed with every new wireless gadget however in "Alone Together" Sherry Turkle expertly addresses the rise in isolation, loneliness, lack of privacy and increasing pressure on students in this age of invasive technology. Her thorough and non-judgmental scientific investigation of the psychological effects of computers makes us aware that we need to take care that we do not replace real human connection and teaching with a "virtual reality" that will redirect us in an unhealthy direction.

As a physicians and parents we understand that decisions we make today may have far reaching consequences for the future wellbeing of our children. Let's play it safe for them right now.

Recommendations for schools

- 1) **Wired Internet connections** -Best Option- like we used to have are the safest and possibly cheapest option. All the benefits of the Internet without the risk.
- 2) **Wireless devices but with an on/off switch** -Better Option- in each room so teachers can use only when needed for educational purposes.
- 3) **Limit Wi-Fi /Computer use** -Better Option- especially in younger grades
- 4) **Cell phones stay off and in the backpacks during class** and on the campus during school hours.
- 5) **Have EMF and Electrical measurements done by one or more qualified, experienced consultants before and after any installation. Understand you may need to increase your knowledge of low and high frequency electromagnetic fields and EMF standards to accurately interpret the reports. The Bioinitiative Report is very useful compendium that has recommendations for safer levels.**
- 6) **Support efforts by governments to provide independent standardized transparent research to define safe limits in all the different wireless frequencies used commercially. This could lead to less EMF emissions and safer wireless devices.**

SAVE THE DATE!

SATURDAY AM, OCTOBER 10, 2015, Mountain View, California
SYMPOSIUM "Health Challenges In A Wireless Society: Cell phone and Wi-Fi Safety"

Full announcement in next newsletter.

References

- 1) "Overpowered" by Dr. Martin Blank, 2014 2) **Bioinitiative Report**. 2012 <http://www.bioinitiative.org/> 3) **EMF Portal**. <http://www.emf-portal.de/>
- 4) **Why Fi? : Is Wireless Communication Hazardous to Your Health?** <http://www.sccma-mcms.org/Portals/19/assets/docs/Why%20Fi.pdf>
- 5) **Electronics' noise disorients migratory birds.** <http://www.nature.com/news/electronics-noise-disorients-migratory-birds-1.15176>
- 6) **True Navigation: Sensory Bases of Gradient Maps.** Phillips, J. 2006 <http://www.pigeon.psy.tufts.edu/asc/Phillips/>
- 7) **A behavioral perspective on the biophysics of the light-dependent magnetic compass: a link between directional and spatial perception?** Phillips, J. *Journal of Experimental Biology*. June 17, 2010. <http://jeb.biologists.org/content/213/19/3247.full.pdf>
- Man-made electromagnetic radiation disrupts robins' internal magnetic compasses.** May 7, 2014
- 8) **Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – a review.** Sivani, S. *Biology and Medicine*. Dec 3, 2012 http://www.emrpolicy.org/regulation/united_states/Exhibit_19_EMRPI_Sivani_Bio_&Med_2012.pdf
- 9) Balmori, A. 2003. http://www.hese-project.org/de/emf/WissenschaftForschung/Balmori_Dr._Alfonso/showDoc.php?lang=de&header=Dr.%20Balmori&file=THE%20EFFECTS%20OF%20MICROWAVES%20N%20THE%20TREES%20AND%20OTHER%20PLANTS.html&back=../showAuthor.php?target=Balmori_Dr._Alfonso
- 10) **Effects of Electromagnetic Waves Emitted by Mobile Phones on Germination, Root Growth, and Root Tip Cell Mitotic Division.** *Pol J of Envir Studies*. Nov 2010. <http://www.pjoes.com/pdf/21.1/Pol.J.Envir.Stud.Vol.21.No.1.23-29.pdf>
- 12) **Provocation Study using heart rate variability shows microwaves radiation from 2.4 Ghz cordless phones.** *European Journal of Oncology*. January 16, 2011. <http://www.bemri.org/publications/dect/341-provocation-study-using-heart-rate-variability-shows-microwave-radiation-from-2-4ghz-cordless-phone.html?path=>
- 13) **Is newborn melatonin production influenced by magnetic fields produced by incubators?** <http://www.emf-portal.de/viewer.php?aid=20376&l=e>
- 14) **Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects.** Pall, ML. *J Cell Mol Med*. 2013 Aug;17(8):958-65. <http://www.ncbi.nlm.nih.gov/pubmed/23802593>
- 15) **Microwave Electromagnetic Fields Act by Activating Voltage-Gated Calcium Channels: Why the Current International Safety Standards Do Not Predict Biological Hazard.** Professor Dr. Martin L. Pall <http://apps.fcc.gov/ecfs/document/view?id=7521102473>

16) **Communication Studies UCLA.** <http://cogweb.ucla.edu/CogSci/Myelinate.html> 17) **“Digital Dementia” on the Rise. June 24, 2013** <http://koreajoongangdaily.joins.com/news/article/article.aspx?aid=2973527> 18) **International Precautionary Actions EMF.** <http://ehtrust.org/international-policy-actions-on-wireless/>

19) **Student Science Experiment Finds Plants won't Grow near Wi-Fi Router** <http://www.globalresearch.ca/student-science-experiment-finds-plants-wont-grow-near-wi-fi-router/5336877> 20) **American Academy of Pediatrics Letter to FCC and FDA regarding EMF Exposure Policies and Standards.** <http://www.wirelesswatchblog.org/wp-content/uploads/2011/06/FCC-13-84-09-03-2013-American-Academy-of-Pediatrics-7520941318-1.pdf>

21) **Transient DNA damage induced by high-frequency electromagnetic fields (GSM 1.8 GHz) in the human trophoblast HTR-8/SVneo cell line evaluated with the EFFECTS OF MICROWAVES ON THE TREES AND OTHER PLANTS**

11) **Intercellular Communication in Plants: Evidence for an EMF-Generated Signal that Evokes Local and Systemic Transcriptional Responses in Tomato.** 2013. http://link.springer.com/chapter/10.1007/978-3-642-36470-9_16

Early Hum Dev 2012; 88 (8): 707 – 710

alkaline comet assay. *Mutat Res.* 2010 Jan 5. <http://www.ncbi.nlm.nih.gov/pubmed/19822160> 22) **High frequency (900 MHz) low amplitude (5 V m⁻¹) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato.** Roux,D. *Planta.* 2008 Mar <http://www.ncbi.nlm.nih.gov/pubmed/18026987> 23) **Electrosensitivity in Sweden.** <http://www.emfacts.com/2009/02/1014-electrosensitivity-in-sweden-by-olle-johansson/> 24) **Towards Better Health: Switzerland TV Program on Electrohypersensitivity.** 2009. <http://mieuxprevenir.blogspot.com/2013/03/swiss-tv-program-from-2009-on.html> 25) **'Wi-fi refugees' shelter in West Virginia mountains.** 2011. <http://www.bbc.com/news/world-us-canada-14887428> 26) **Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings.** Havas,M. *Electromagn Biol Med.* 2013 Jun <http://www.ncbi.nlm.nih.gov/pubmed/23675629> 27) **Electromagnetic hypersensitivity: evidence for a novel neurological syndrome.** *Int J Neurosci.* 2011 Dec;121(12):670-6. <http://www.ncbi.nlm.nih.gov/pubmed/21793784> 28) **Review: Electromagnetic hypersensitivity: Fact or Fiction?** Genius, S, Lipp, C. *Science of Total Environment.* Sept 2011. http://www.academia.edu/4125616/Genius_EHS_paper

29) **Electromagnetic absorption in the human head and neck for mobile telephones at 835 and 1900 MHz.** Gandhi, O. *Microwave Theory and Techniques.* Vol 44,Oct, 1996. <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=539947> 30) **International Agency for Research on Cancer. IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans.** http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf 31) **Alone Together.** Sherry Turkle. 2012. <http://www.npr.org/2012/10/18/163098594/in-constant-digital-contact-we-feel-alone-together> 32) **Austrian Medical Association Guidelines- EMF and Electrohypersensitivity.** <http://freiburger-appell-2012.info/media/EMF%20Guideline%20OAK-AG%20%202012%2003%2003.pdf>

33) **Israeli Ministry Of Education issue guidelines to limit Wi-Fi in schools 2013**

<http://www.gsma.com/publicpolicy/israeli-ministry-of-education-issue-guidelines-to-limit-wi-fi-in-schools>

34) France: New National Law Bans WIFI in Nursery School!
<http://ehtrust.org/france-new-national-law-bans-wifi-nursery-school/>

35) French government bans advertising of mobiles to children. 2009
<http://www.independent.co.uk/life-style/gadgets-and-tech/news/french-government-bans-advertising-of-mobiles-to-children-1299673.html>

36) Electromagnetic Fields From Mobile Phones: Health Effects on children and Teenagers. April 2011.
http://www.magdahavas.com/wordpress/wp-content/uploads/2011/06/Russia_20110514-rncnirp_resolution.pdf

37) Parliament Assembly European Council EMF Microwave Policy 2011
<http://assembly.coe.int/Mainf.asp?link=/Documents/AdoptedText/ta11/ERES1815.htm>

38) Why a leading professor of new media just banned technology use in class. Sept 25, 2014. Washington Post. <http://www.washingtonpost.com/blogs/answer-sheet/wp/2014/09/25/why-a-leading-professor-of-new-media-just-banned-technology-use-in-class/>

39) Princeton/UCLA Study: Its Time to Ban Laptops in Law School Classrooms. Feb 5, 2015. http://taxprof.typepad.com/taxprof_blog/2015/02/princetonucla-study-.html

40) Brain Cancer- Mobile phone and cordless phone use and the risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009. Hardell. Pathophysiology. 2014 Oct 29.
<http://www.ncbi.nlm.nih.gov/pubmed/25466607>

41) Brain Cancer- Mobile phone use and brain tumours in the CERENAT case-control study. Coureau G. Occup Environ Med. 2014 Jul;
<http://www.ncbi.nlm.nih.gov/pubmed/24816517>

42) Wi-Fi In Schools. <http://wifiinschools.com/>

43) Wi-Fi in Australia. <http://www.wifi-in-schools-australia.org/>

44) Wi-Fi in UK. <http://wifiinschools.org.uk/>

45) International Precautionary Actions on EMF Radiation in Governments, Authorities and Schools. <http://ehtrust.org/international-policy-actions-on-wireless/>

46) “Disconnect: The Truth About Cell Phone Radiation, What Industry Has Done to Hide It and How to Protect Your Family” by Dr. Devra Davis.

47) “Zapped” by Anne Gittleman

48) “The Shallows: What the Internet Is Doing to Our Brains” by Nicholas Carr. 2011. “Finalist for the 2011 Pulitzer Prize in General Nonfiction: “Nicholas Carr has written a *Silent Spring* for the literary mind.”—Michael Agger, *Slate*”

48) “Your Child's Growing Mind: Brain Development and Learning From Birth to Adolescence.” Jane Healy.

49) Safe in School. <http://www.safeinschool.org/>

50) A Review of International Microwave Exposure Guidelines. 2011. <http://www.magdahavas.com/pick-of-the-week-25-review-of-international-microwave-exposure-guidelines-from-1957-to-1968/>

51) Microwave Oven Radiation <http://www.fda.gov/radiation-emittingproducts/resourcesforyourradiationemittingproducts/ucm252762.htm>

52) Tumor Progression by Exposure to Radiofrequency Electromagnetic Fields Below Exposure Limits for Humans. Lerchl, A Biochemical and Biophysical Research Communications. April 15, 2015.
<http://www.sciencedirect.com/science/article/pii/S0006291X15003988>