# The Biological Fidelity Act

*A precautionary framework for biologically informed RF spectrum governance, indoor light-first connectivity, and protection of long-dwell developmental environments*

Policy concept paper

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This paper proposes a Biological Fidelity Act: a federal framework that treats chronic RF exposure in long-dwell indoor environments as a developmental-systems problem, not only a short-term heating problem.

Its strongest form is precautionary and research-driven. It does not assume that science has already mapped every biologically active modulation pattern that should be prohibited. Instead, it creates the legal and technical machinery to identify biologically active modulation, tighten indoor defaults, and accelerate wired and optical alternatives such as IEEE 802.11bb light communications.

## Executive Summary

Current RF exposure policy was built primarily around avoidance of acute tissue heating. That framework does not square neatly with the questions now driving public concern: chronic exposure, prenatal vulnerability, reproductive endpoints, modulation and pulsation, long-dwell indoor exposure, and the adequacy of standards developed before modern always-on wireless ecosystems.

A serious Biological Fidelity Act should therefore be framed as a precautionary modernization statute. Its purpose would be to preserve the reliability - or fidelity - of developmental and physiological signaling environments where people spend long periods of time, especially before conception, during pregnancy, in infancy, and in childhood. The Act would not need to prove every contested human endpoint in advance. It would instead respond to a converging evidence base: animal carcinogenicity findings, experimental-animal reproductive and pregnancy findings, mechanistic hypotheses focused on temporal structure and ion-channel disruption, and a regulatory record showing that current agencies have not fully resolved these questions.

The immediate policy implication is not that Congress already knows the exact low-frequency modulation envelopes that must be outlawed everywhere. The more defensible move is to establish a federal program to identify and classify biologically active modulation; amend Section 704 so localities are no longer barred from considering health evidence; require stricter defaults in long-dwell indoor environments; and accelerate wired and light-based communications for indoor use where standards-based optical alternatives already exist.

## 1. Why a Biological Fidelity Act is needed

The phrase biological fidelity is useful because it shifts the policy discussion away from a false binary. The question is not simply whether RF exposure does or does not produce immediate symptomatic injury at environmental levels. The deeper question is whether the developmental environment that supports reliable signaling, repair, differentiation, endocrine timing, reproduction, and neurodevelopment is being altered in ways that conventional thermal limits were never designed to detect.

The statutory mismatch is visible on its face. Federal law still blocks state and local governments from regulating personal wireless facilities on the basis of the environmental effects of radiofrequency emissions when the facilities comply with FCC rules. At the same time, the D.C. Circuit held in 2021 that the FCC had failed to provide a reasoned explanation for its refusal to address evidence concerning non-cancer effects, children, long-term exposure, modulation or pulsation, and environmental harms. A modernization statute should begin by acknowledging that this is not a closed scientific file.

A second mismatch is technological. Indoor connectivity no longer has to mean saturating homes, schools, hospitals, offices, dormitories, and care facilities with the same RF-first architecture used for wide-area mobile service. IEEE 802.11bb now provides a standards-based path for light communications, and standards literature already points to indoor, medical, classroom, industrial, and secure-room use cases. That makes a light-first indoor transition a credible policy objective rather than a science-fiction placeholder.

- What is strongest now: long-latency animal cancer data, experimental-animal reproductive and pregnancy reviews, and the legal record created by the 2021 D.C. Circuit remand of the FCC.
- What is plausible but not settled: the claim that low-frequency envelopes, pulsation, or modulation geometry are central drivers of bioactivity in modern wireless signals.
- What is not yet proven: sweeping population-scale claims about cognition, empathy, violence, or civilizational decline from everyday RF exposure.

### Working definitions

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| **Biological fidelity** | The reliability with which living systems perform developmental and physiological signaling in the presence of environmental electromagnetic conditions. |
| **Long-dwell indoor environment** | A residence, bedroom, school, daycare, office, hospital, eldercare facility, dormitory, or similar setting in which occupants commonly spend sustained repeated periods, typically greater than an eight-hour workday or overnight. |
| **Biologically active modulation** | A temporal, spectral, pulsed, or envelope feature of an electromagnetic signal that a competent federal review determines to be plausibly associated with adverse biological effects or to warrant precautionary restriction in sensitive settings. |
| **Light-first connectivity** | An indoor communications design priority that prefers optical or wired links for routine high-bandwidth local use, reserving RF as supplemental rather than dominant infrastructure where practical. |

*Table 1. Working terms for a biologically informed wireless policy framework.*

## 2. What the evidence does and does not support

A credible Act has to be built on an evidence ladder rather than a slogan. Table 2 separates what is already strong enough to justify policy attention from what remains mechanistically plausible but not settled.

| Claim class | Current status | Policy consequence |
|---|---|---|
| **Strong enough for action** | Animal evidence supports concern for carcinogenicity in male rats, with systematic reviews finding high certainty for glioma and malignant heart schwannoma in experimental animals; animal reviews also support concern for male fertility and some pregnancy endpoints. | Thermal-only assumptions are not sufficient as a sole basis for long-dwell indoor policy. |
| **Legally unresolved** | The 2021 D.C. Circuit remand held that the FCC did not adequately explain its treatment of non-cancer effects, children, long-term exposure, modulation, and environmental harms. | Congress has a strong basis to demand a revised evidence review and statutory reform. |
| **Plausible but not settled** | Mechanistic literature proposes that pulsing, variability, and low-frequency envelopes may contribute materially to bioactivity through ion-channel disruption and oxidative stress. | Create a federal classification program for biologically active modulation rather than pretending the problem is solved or fully mapped. |
| **Not yet demonstrated in humans at population scale** | Current human evidence on cognition, cancer, and many reproductive outcomes is mixed, limited, or very | Do not build the Act on sweeping claims that outrun the evidence; build it on precaution, better |

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| | uncertain. | measurement, and sensitive-setting protection. |

*Table 2. Evidence ladder for the Biological Fidelity Act.*

The recent benchmark-risk analysis by Melnick and Moskowitz sharpens the urgency argument. Using benchmark-dose methods and traditional uncertainty factors, the authors estimated health-protective whole-body SAR values in the milliwatt-per-kilogram range and concluded that current public whole-body limits are substantially higher than exposure levels associated with conservative cancer-risk and male-fertility protection targets. That paper is not itself a binding regulatory standard, but it is precisely the sort of risk-analysis exercise that current agencies have largely declined to perform.

Mechanism is the most contested part of the story. Dimitris Panagopoulos and colleagues argue that the biologically important feature of modern wireless communication signals is not simply carrier frequency but the combination of coherence, pulsation, and low-frequency variability embedded in the signal structure. That remains a disputed interpretation, but it directly motivates the Act's most original element: spectrum governance should begin characterizing temporal envelope structure and biologically relevant low-frequency components, not only average power and heating.

## 3. Core architecture of the Act

The Biological Fidelity Act should be designed as a modernization statute with both immediate and staged components. Immediate provisions would reform the legal framework, improve indoor defaults, and direct federal procurement. Staged provisions would fund targeted research and standards development so that future restrictions on specific modulation patterns are evidence-based and enforceable.

The Act should not promise more certainty than science can presently deliver. It should instead operationalize a rule of prudence: where a plausible, unresolved developmental hazard exists and less intrusive alternatives are available, long-dwell indoor environments should move toward the lower-burden alternative while the government develops better biological criteria.

### Proposed titles

| Provision | Operational effect |
|---|---|
| **Title I - Findings and definitions** | Codify congressional findings on developmental vulnerability, statutory uncertainty, and the need to evaluate modulation, pulsation, and chronic exposure in addition to heating. |
| **Title II - Federal Biological Fidelity Program** | Direct HHS, NIEHS/NTP, FCC, NIST, DOE, and EPA to create a coordinated research and standards program on biologically active modulation and long-dwell exposure assessment. |
| **Title III - Indoor long-dwell standards** | Require stricter default exposure design criteria in residences, schools, child-centered facilities, hospitals, eldercare, dormitories, and similar settings. |
| **Title IV - Light-first and wired-first transition** | Establish procurement preferences and grant programs for optical and wired indoor networks; require Li-Fi compatibility for new federal long-dwell buildings and major renovations where practical. |
| **Title V - Section 704 amendment** | Amend 47 U.S.C. section 332(c)(7)(B)(iv) so localities may consider health and environmental evidence, especially near sensitive receptors. |

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| **Title VI - Transparency and labeling** | Require disclosure of temporal signal characteristics, duty cycle behavior, and indoor operating modes for covered equipment and infrastructure. |

*Table 3. Proposed structure of the Biological Fidelity Act.*

# 4. Specific policy tools

## 4.1 Biologically Active Modulation designation

The most important technical innovation in the Act is a formal designation for biologically active modulation. Congress would direct the relevant agencies to characterize not only carrier frequency and average exposure, but also pulse structure, temporal envelope, low-frequency content, duty-cycle dynamics, beam-forming behavior, and other signal features that may plausibly interact with biological systems.

This designation should be evidence-weighted, tiered, and revisable. A signal feature could be placed into a watch list, a sensitive-setting restriction list, or a prohibited indoor-use list depending on the quality and consistency of the evidence. That structure is far more defensible than pretending that one already knows the final banned frequency bins.

## 4.2 Indoor long-dwell defaults

For long-dwell indoor environments, the Act should impose stricter defaults immediately, even before the final biologically active modulation map is complete. Examples include lower-power default operating modes, time-of-day exposure reduction, wired backhaul requirements, occupancy-aware duty-cycle reduction, RF-free sleeping areas in federal facilities, and exposure-minimizing design rules for bedrooms, neonatal units, fertility clinics, and classrooms.

The Act should also require exposure assessment for real indoor use rather than best-case laboratory abstractions. Long-dwell buildings should be evaluated with realistic occupancy patterns and cumulative source loads, including routers, repeaters, personal devices, and building systems.

## 4.3 Light-first and wired-first procurement

Because IEEE 802.11bb now exists as a light-communications amendment to the Wi-Fi family, a federal indoor transition strategy can be concrete. The Act should require all new federal long-dwell buildings and major renovations to assess wired and light-based options first, and to include optical-communications compatibility where technically and economically practical.

This does not mean replacing all RF instantly. It means reversing the design hierarchy: indoor high-bandwidth local traffic should default toward wired or optical pathways, with RF serving mobility and fallback functions. For schools, hospitals, secure spaces, and homes, that is a technologically credible direction of travel.

## 4.4 Flicker and lighting co-design

A light-first policy must not substitute one poorly characterized exposure regime for another. Li-Fi deployment should therefore be paired with explicit low-temporal-light-modulation and flicker criteria in procurement standards. In practice, the Act should direct DOE, NIST, and the standards community to co-specify communications performance and lighting quality so that optical networking is health-protective in both electromagnetic and visual-neurological terms.

### 4.5 Reform of Section 704

Section 704 should be amended so that compliance with FCC emissions rules no longer preempts state and local consideration of health and environmental effects. At minimum, local governments should regain the authority to apply heightened scrutiny around homes, schools, daycares, hospitals, and other sensitive receptors and to require exposure-minimizing alternatives where feasible.

This is not an anti-technology position. It is a restoration of ordinary public-health governance where the federal scientific record is acknowledged to be incomplete.

## 5. Research and standards agenda

The Act will only be as strong as the program it creates. Congress should direct a five-year interagency program with published milestones, open protocols, and adversarial peer review. The purpose is not to fund generic repetition of the old exposure debate. It is to identify which signal features matter biologically, in which tissues, during which windows, and at what cumulative doses.

Priority research areas should include the following:

- Spectral-temporal dosimetry that captures pulse structure, low-frequency envelope content, variability, duty cycle, and realistic indoor occupancy patterns.
- Preconception-pregnancy-child cohort studies with actual exposure measurement rather than self-reported device use alone.
- Correctly designed multigenerational animal models, with paternal-line studies extending to F2 and maternal-line studies to F3 for true transgenerational inference.
- Biomarker panels covering oxidative stress, calcium signaling, sperm small RNAs, DNA methylation, mitochondrial function, placental endpoints, endocrine markers, and neurodevelopmental phenotypes.
- Comparative intervention trials in sensitive settings that test whether wired and optical substitutions measurably reduce biological burden or symptom patterns.
- Standards research linking Li-Fi system design to low-flicker, low-modulation-risk lighting practice.

## 6. Model legislative principles

**Findings.** Congress finds that current federal radiofrequency exposure policy was developed primarily around prevention of acute thermal effects and does not fully address unresolved questions concerning chronic exposure, developmental vulnerability, reproductive toxicity, modulation or pulsation, and long-dwell indoor exposure.

**Purpose.** The purpose of this Act is to preserve biologically compatible developmental and physiological environments through precautionary modernization of wireless policy, improved exposure characterization, and accelerated deployment of wired and light-based indoor communications alternatives.

**Rule of construction.** Nothing in this Act shall be construed to prohibit wireless communications. Rather, this Act establishes a biological-fidelity framework for identifying and reducing avoidable signal features

and deployment patterns that may create unnecessary risk in sensitive settings.

## 7. Conclusion

The strongest version of the Biological Fidelity Act is neither a blanket rejection of wireless technology nor a rhetorical claim that all modern social problems have already been traced to RF exposure. Its strength lies elsewhere. It recognizes that the present regulatory system was built for a narrower hazard model than the one now at issue, that the animal and mechanistic record is substantial enough to justify precaution, that the courts have already exposed unresolved gaps in the agency rationale, and that less intrusive indoor alternatives are increasingly available.

A biologically serious society would not wait to map every last mechanism before improving the environments in which children are conceived, carried, born, sleep, learn, and recover. It would reform the law, build the measurement tools, constrain the riskiest uncertainties first, and move indoor connectivity toward wired and optical systems wherever practical. That is the policy value of a Biological Fidelity Act.

## Selected References


Aldad TS, Gan G, Gao XB, Taylor HS. Fetal radiofrequency radiation exposure from 800-1900 MHz-rated cellular telephones affects neurodevelopment and behavior in mice. Scientific Reports. 2012;2:312.

Cordelli E, Arno L, Benassi B, et al. Effects of radiofrequency electromagnetic field (RF-EMF) exposure on pregnancy and birth outcomes: a systematic review of experimental studies on non-human mammals. Environment International. 2023;180:108178.

Cordelli E, Arno L, Benassi B, et al. Effects of radiofrequency electromagnetic field (RF-EMF) exposure on male fertility: a systematic review of experimental studies on non-human mammals and human sperm in vitro. Environment International. 2024;185:108509.

Karipidis K, Baaken D, Loney T, et al. The effect of exposure to radiofrequency fields on cancer risk in the general and working population: a systematic review of human observational studies - Part I: most researched outcomes. Environment International. 2024;191:108983.

Melnick RL, Moskowitz JM, and ICBE-EMF. Exposure limits to radiofrequency EMF do not account for cancer risk or reproductive toxicity assessed from data in experimental animals. Environmental Health. Published March 14, 2026.

Mevissen M, Ducray A, Ward JM, et al. Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review. Environment International. 2025;199:109482.

National Toxicology Program. NTP Technical Report 595: Toxicology and carcinogenesis studies in Hsd:Sprague Dawley SD rats exposed to whole-body radio frequency radiation used by cell phones. 2018.

Falcioni L, Bua L, Tibaldi E, et al. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to a 1.8 GHz GSM base station signal. Environmental Research. 2018;165:496-503.

Panagopoulos DJ. A comprehensive mechanism of biological and health effects of anthropogenic extremely low frequency and wireless communication electromagnetic fields. Frontiers in Public Health. 2025;13:1585441.

Environmental Health Trust v. Federal Communications Commission, No. 20-1025 (D.C. Cir. Aug. 13, 2021).

47 U.S.C. section 332(c)(7)(B)(iv).

Radiation Control for Health and Safety Act of 1968, Pub. L. 90-602; codified in 21 U.S.C. sections 360hh-360ss.

IEEE Standards Association. IEEE 802.11bb-2023, Amendment 7: Light Communications. Approved June 2023.