A. Magnetic / MRI-Related (Non-Invasive)

1. **Functional Connectivity MRI (fcMRI)**
   Not the same as BOLD; uses correlation structure across voxels. (Probably implicit, but useful to explicitly list.)

2. **Resting-State fMRI (rs-fMRI)**
   Now its own category of technique with unique analytical methodology.

3. **Magnetic Particle Imaging (MPI)**
   A new imaging modality using superparamagnetic nanoparticles for high temporal resolution neurovascular imaging.

4. **Susceptibility-Weighted Imaging (SWI)**
   Useful for venous blood mapping and hemodynamic activity in vivo.

5. **Quantitative Susceptibility Mapping (QSM)**
   Reconstructs iron content and hemodynamic changes related to function.

6. **Functional MRS (fMRS)**
   Measures neurotransmitter fluctuations (Glu, GABA) in vivo in real time.

7. **Magnetic Resonance Elastography (MRE)**
   Measures brain tissue stiffness changes associated with neural activity and neurovascular coupling.

8. **Chemical Exchange Saturation Transfer (CEST) fMRI**
   Detects metabolites and neurotransmitters via exchangeable protons, providing molecular functional imaging.

9. **Microvascular Volumetric Pulsatility Mapping**
   Combines VASO and ASL at ultra-high field to map pulsatile flow in cerebral microvessels linked to activity.

10. **Neurite Orientation Dispersion and Density Imaging (NODDI)**
    Multicompartment diffusion MRI model to estimate neuronal microstructure and density in vivo.

11. **Neuromelanin-Sensitive MRI**
    Detects neuromelanin in substantia nigra and locus coeruleus as a proxy for catecholaminergic neuron function.

12. **Free-Water Diffusion Imaging**
    Removes extracellular free water contributions from diffusion signals to assess

neuroinflammation and tissue changes.

13. **Optically Pumped Magnetometer MEG (OPM-MEG)**
    Room-temperature, scalp-proximate optically pumped magnetometer arrays for high-sensitivity, flexible MEG recordings in naturalistic and mobile settings.

14. **Hyperpolarized 13C Metabolic MRI**
    Real-time metabolic flux imaging using hyperpolarized 13C tracers to measure rapid changes in brain energy metabolism linked to neural activity.

B. PET / Radiotracer Advances

15. **Fiber-Coupled PET Detectors (minimally invasive)**
    Enables localized in vivo PET from freely moving animals.

16. **Neuroimmune PET Ligands (TSPO, CSF1R etc.)**
    For studying microglial/astrocyte activation dynamically. (Not purely activity, but increasingly part of functional neuroimaging.)

17. **Total-Body PET Imaging**
    Enables whole-brain dynamic imaging with unprecedented temporal resolution and sensitivity.

18. **Positronium Lifetime Imaging**
    Emerging PET technique providing information about tissue microenvironment during neural activity.

19. **Synaptic Vesicle Glycoprotein 2A (SV2A) PET Imaging**
    Uses tracers like [^{11}C]UCB-J to quantify synaptic density in vivo.

20. **Mitochondrial Complex I PET Imaging**
    Employs [^{18}F]BCPP-EF to assess mitochondrial function and energy metabolism related to neural activity.

21. **CSF1R PET for Neuroinflammation**
    Tracers like [^{11}C]CPPC to image microglial activation during brain processes.

22. **Positron Emission Metabolic Tracing with Short-Lived Isotopes (rapid kinetic PET)**
    High-temporal-resolution PET protocols using short-lived radiotracers and fast kinetic modeling to track sub-minute metabolic changes associated with neural events.

C. Electrophysiology & Implant Technologies

23. **Neuropixels Probes (latest gen)**
    Not just "multielectrode"; Neuropixels constitute a distinct class due to ultra-high channel count (1,000+), used in vivo widely.

24. **Silicon Probe Laminar Recordings**
    For cortical column laminar activity (V1, CA1).

25. **High-Density “ECoG Grids” (Neuropixels–ECoG hybrids)**
    New grids with thousands of micro-electrodes recordings across cortex.

26. **EMG-Assisted Brain–Body Coupled Recording**
    Used in behaving animals to integrate motor output with neural activity.

27. **Flexible Bioelectronic Neural Interfaces**
    Conformable electrode arrays that minimize tissue damage and enable stable long-term recordings.

28. **Transparent Graphene Microelectrode Arrays**
    Allow simultaneous electrical recording and optical imaging/optogenetics.

29. **Ultrasonic Neural Dust Motes**
    Wireless, millimeter-scale implants for chronic neural recording.

30. **Optetrode Recordings**
    Hybrid probes combining electrical electrodes with optical fibers for simultaneous recording and stimulation.

31. **CMOS-Integrated Neural Probes**
    On-chip amplified high-density probes for low-noise in vivo recordings.

32. **Sharp Electrode Intracellular Recordings**
    Historical method using fine glass micropipettes for high-impedance intracellular potential measurements.

33. **Wireless High-Density Neural Probes (wireless Neuropixels variants)**
    Fully wireless, implantable high-channel-count probe systems enabling untethered large-scale neural recordings in freely moving animals.

34. **Autonomous Robotic In Vivo Patch-Clamp (AutoPatch / Robopatcher)**
    Automated robotics-enabled intracellular patch-clamp in awake or anesthetized

animals for systematic single-cell membrane-potential measurements in vivo.

35. **Graphene Field-Effect Transistor Neurochemical Sensors (gFETs)**
    Implantable gFET biosensors for direct, high-sensitivity, real-time detection of neurotransmitters and neuromodulators in vivo with electrical readout.

D. Optical / Imaging-Based Techniques

36. **Light-Sheet Fluorescence Microscopy (LSFM) In Vivo**
    Now used in small transparent animals (zebrafish, larval models). Technically in vivo and provides whole-brain fast activity imaging.

37. **Swept Confocally-Aligned Planar Excitation (SCAPE) Microscopy**
    High-speed volumetric neural imaging in freely moving animals.

38. **Structured-Light 3D Imaging of Cortical Hemodynamics**
    Used to map neural activity via intrinsic signals & hemodynamic changes.

39. **Mesoscopic Calcium Imaging (NOT miniscope)**
    Widefield mesoscopic Ca^{2+} imaging in vivo (distinct from fiber photometry).

40. **Adaptive Optics for In Vivo Neural Imaging**
    Corrects deep-tissue optical distortion; rapidly emerging technique.

41. **Oblique Plane Microscopy (OPM)**
    High-resolution, high-speed volumetric imaging for large-scale neural activity monitoring.

42. **Multifocal Two-Photon Microscopy**
    Simultaneous imaging of multiple planes for 3D functional imaging.

43. **Line-Scanning Temporal Focusing Microscopy**
    High-speed volumetric imaging with reduced out-of-focus excitation.

44. **Light Field Microscopy**
    Captures volumetric data in a single exposure for fast 3D neural activity imaging.

45. **Kilohertz Two-Photon Fluorescence Microscopy**
    Ultrafast scanning rates for capturing rapid neuronal dynamics in vivo.

46. **NIRE Cranial Window Method**
    Uses nanosheet-resin windows for large-scale, chronic high-resolution imaging in

awake subjects.

47. **Volumetric Fluorescence Lifetime Imaging Microscopy (FLIM) for In Vivo Metabolic Readouts**
    High-speed volumetric FLIM approaches enabling in vivo mapping of metabolic state (NADH, FAD) and oxygen-consumption dynamics across populations of cells.

E. Optical Indicators / Novel Sensors

48. **Genetically Encoded Dopamine Indicators (GRAB-DA, dLight1)**
    Used widely in vivo with fiber photometry and two-photon microscopy.

49. **Genetically Encoded Glutamate Indicators (iGluSnFR)**
    High temporal resolution; used to study excitatory transmission.

50. **Genetically Encoded Acetylcholine Indicators (GACh)**
    Maps cholinergic dynamics in vivo.

51. **Genetically Encoded cAMP/PKA/Second-Messenger Sensors**
    (e.g., Pink Flamindo, G-Flamp) reflect intracellular signaling during neural activity.

52. **Genetically Encoded Serotonin Sensors (GRAB5-HT)**
    Monitor serotonergic transmission in behaving animals.

53. **Genetically Encoded Norepinephrine Sensors (GRAB-NE)**
    Track noradrenergic activity during behavior and cognitive tasks.

54. **Fluorescent False Neurotransmitters (FFNs)**
    Visualize neurotransmitter release and recycling in vivo.

55. **Genetically Encoded Chloride Indicators (Cl-Sensor)**
    Monitor chloride dynamics relevant for inhibitory transmission.

56. **Genetically Encoded ATP Indicators (iATPSnFR)**
    Track cellular energy status and metabolic activity in neurons.

57. **Genetically Encoded Lactate Sensors**
    Monitor lactate shuttling and metabolic coupling between neurons and glia.

58. **Genetically Encoded Redox Indicators (roGFP)**
    Detect oxidative stress and redox-state changes during neural activity.

59. **Genetically Encoded Nitric Oxide Sensors (geNOps and related probes)**
    Fluorescent genetically encoded reporters for nitric oxide dynamics to monitor NO signaling in vivo during neural activity.

F. Photoacoustic & Hybrid Techniques

60. **Voltage-Sensitive Photoacoustic Imaging**
    A new area combining voltage dyes with photoacoustics.

61. **Nanodiamond Magnetometry in Vivo**
    Nitrogen-vacancy (NV) diamond sensors used for in vivo magnetic-field measurements of neuronal activity.

62. **Multispectral Optoacoustic Tomography (MSOT)**
    Provides spectral unmixing of multiple chromophores for functional brain imaging.

63. **Photoacoustic Computed Tomography (PACT)**
    Deep-tissue functional imaging with optical contrast and ultrasound resolution.

64. **Functional Photoacoustic Microscopy (fPAM)**
    High-resolution imaging of hemodynamic responses to neural activity.

65. **Photoacoustic Lifetime Imaging Microscopy (PALM)**
    Measures oxygen consumption and metabolic rates in brain tissue.

66. **Microbubble-Enhanced Functional Ultrasound (Contrast-Enhanced fUS)**
    Use of intravascular microbubble contrast agents to boost sensitivity and spatial resolution of functional ultrasound hemodynamic measurements linked to neural activity.

G. Neural Activity Through Blood Flow & Oxygenation

67. **Thermal Infrared Functional Imaging (fTIRI)**
    Detects activity-induced microvascular heating.

68. **Speckle-Modulated Optical Coherence Tomography (OCT)**
    OCT-based neuronal activity mapping (beyond standard laser speckle imaging).

69. **Doppler Optical Coherence Tomography (D-OCT)**
    For real-time blood-flow-linked neural-activity measurements.

70. **Visible Light Optical Coherence Tomography (vis-OCT)**
    Provides oximetry and flow measurements with higher resolution than NIR-OCT.

71. **Hyperspectral Imaging of Intrinsic Signals**
    Spectral unmixing of hemoglobin, cytochrome oxidase, and other chromophores.

72. **Time-Domain Near-Infrared Spectroscopy (TD-NIRS)**
    Offers depth-resolved hemodynamic monitoring with improved accuracy.

73. **Functional Diffuse Optical Tomography (fDOT)**
    3D reconstruction of brain activation through light scattering and absorption.

74. **In Vivo Electron Paramagnetic Resonance (EPR) Oximetry**
    Direct in vivo EPR/Electron Spin Resonance oximetry for quantitative tissue pO_2 mapping and dynamic oxygen-consumption measurements coupled to neural activity.

H. Behavioral + Neural Integrated Techniques

75. **Neuromorphic Cameras Linked With Neural Imaging**
    High-speed event-driven sensors capturing animal behavior synchronized with brain activity (not a brain technique per se, but part of modern in vivo pipelines).

76. **Deep Label-Free Microscopy (DLFM)**
    Uses deep learning to extract neural activity from label-free imaging of scattering changes.

77. **Acoustic Recording of Neural-Related Behavior**
    Ultrasonic vocalization recording synchronized with neural activity measurements.

78. **Eye-Tracking Integrated Neural Recording**
    Combines pupil tracking with brain activity to study visual attention and processing.

79. **Pose Estimation with Neural-Activity Synchronization**
    Uses AI-based body tracking (e.g., DeepLabCut) linked to real-time neural signals.

80. **Real-Time Closed-Loop Neural Decoding & Stimulation Systems**
Integrated pipelines that decode ongoing neural activity in real time and deliver contingent stimulation (optogenetic, electrical, ultrasonic) to probe causality during behavior.

I. Interference / Modulation Techniques

81. **Focused Ultrasound Blood–Brain Barrier Opening (FUS-BBBO)**
Used in vivo to modulate circuits or allow entry of neuromodulators.

82. **Temporal Interference Stimulation (TI Stimulation)**
Non-invasive deep-brain electromagnetic stimulation using intersecting high-frequency currents.

83. **Transcranial Random Noise Stimulation (tRNS)**
Another electrical non-invasive modulation technique widely used.

84. **Photothermal Neuromodulation (non-genetic)**
Uses nanoparticles or infrared light to activate neurons.

85. **Infrared Neural Stimulation (INS)**
Pulsed IR light drives neural activity—distinct from optogenetics.

86. **Scanning Ultrasound Neuromodulation (SUN)**
Focused ultrasound for precise spatiotemporal neural control.

87. **Optoacoustic Neuromodulation**
Uses laser-generated ultrasound for deep-brain stimulation.

88. **Ion-CeMST (Ion Current–Controlled Microfluidic Stimulation)**
Microfluidic-based chemical stimulation with spatiotemporal precision.

89. **Transcranial Photobiomodulation (tPBM)**
Low-level near-infrared light to modulate brain metabolism and activity.

90. **Vagus Nerve Stimulation (VNS)**
Electrical stimulation of vagus nerve to indirectly influence brain circuits.

91. **Deep Transcranial Magnetic Stimulation (dTMS)**
Uses H-coil for deeper penetration than standard TMS.

92. **Closed-Loop Responsive Neurostimulation (RNS) for Research**
Implantable or external systems that detect electrophysiological biomarkers and

apply targeted stimulation in milliseconds for causal interventions during experiments.

J. Emerging & Frontier Approaches

93. **Bioluminescent Voltage Imaging (e.g., LOTUS-V)**
    No excitation light; extremely low phototoxicity for in vivo activity imaging.

94. **Upconversion Nanoparticle-Based Neural Imaging**
    Allows deeper brain optical readout using NIR-to-visible conversion.

95. **Magnetothermal Neural Recording & Readout**
    Not just thermogenetic stimulation—actual readout emerging via nanomaterials.

96. **Molecular fMRI (m-fMRI)**
    Probes coupling specific cellular signaling events to MRI contrast.

97. **Functional Ultrasound Localization Microscopy (ULM-fUS)**
    Super-resolution vascular mapping during activity.

98. **“Neuromodulation via Magnetic Nanodiscs”**
    A newer mechanogenetic-like frontier method.

99. **Quantum Diamond Microscopy**
    Uses NV centers for magnetic imaging of neural activity at nanoscale.

100. **X-ray–Induced Acoustic Computed Tomography (XACT)**
    Combines X-ray absorption with ultrasound detection for functional imaging.

101. **Magnetic Resonance Spectroscopic Imaging (MRSI)**
    Spatially resolved spectroscopy for mapping neurotransmitter distributions.

102. **Neutron Stimulated Emission Computed Tomography (NSECT)**
    Emerging nuclear technique for elemental mapping of neural tissue.

103. **Holographic Optogenetic Stimulation**
    Uses holography for multi-site optical neural control and readout.

104. **Nanowire Intracellular Recordings**
    Nanoscale wires for minimally invasive intracellular potential measurements.

105. **AI-Augmented Functional Connectivity Analysis**
Machine-learning-enhanced mapping of dynamic brain networks from imaging data.

106. **Cryogenic Electron Microscopy for In Vivo Snapshots**
Adapted for rapid freezing and imaging of activity states (though borderline in vivo).

107. **In Vivo Quantum Diamond Scalp Magnetometry (NV-MEG)**
Scalp-mounted or near-scalp arrays of diamond NV sensors for high-spatial-resolution magnetic field mapping of population neural currents, bridging nanoscale NV sensing advances with whole-head MEG-style recordings.