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
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.
15. **Magnetic Resonance Fingerprinting (MRF)**
    Rapid, quantitative multiparametric tissue mapping for assessing dynamic physiological changes during brain activity.
16. **VASO (Cerebral Blood Volume fMRI)**
    Non-BOLD fMRI technique sensitive to cerebral blood volume changes for layer-specific functional imaging.

17. **Q-ball Imaging**
    High angular resolution diffusion imaging (HARDI) technique for resolving complex fiber crossings in white matter.
18. **Continuous Arterial Spin Labeling (CASL)**
    Non-invasive perfusion MRI method using continuous RF inversion of arterial water for quantitative CBF mapping.
19. **Pulsed Arterial Spin Labeling (PASL)**
    ASL variant using short RF pulses to label arterial blood, offering different trade-offs for perfusion imaging.

B. PET / Radiotracer Advances

20. **Fiber-Coupled PET Detectors (minimally invasive)**
    Enables localized in vivo PET from freely moving animals.
21. **Neuroimmune PET Ligands (TSPO, CSF1R etc.)**
    For studying microglial/astrocyte activation dynamically. (Not purely activity, but increasingly part of functional neuroimaging.)
22. **Total-Body PET Imaging**
    Enables whole-brain dynamic imaging with unprecedented temporal resolution and sensitivity.
23. **Positronium Lifetime Imaging**
    Emerging PET technique providing information about tissue microenvironment during neural activity.
24. **Synaptic Vesicle Glycoprotein 2A (SV2A) PET Imaging**
    Uses tracers like [^{11}C]UCB-J to quantify synaptic density in vivo.
25. **Mitochondrial Complex I PET Imaging**
    Employs [^{12}F]BCPP-EF to assess mitochondrial function and energy metabolism related to neural activity.
26. **CSF1R PET for Neuroinflammation**
    Tracers like [^{11}C]CPPC to image microglial activation during brain processes.
27. **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.
28. **μ-opioid Receptor PET ([^{11}C]carfentanil)**
    In vivo imaging of endogenous opioid release during various behavioral states.
29. **Dopamine D2/D3 Receptor Occupancy PET**
    Measures dynamic changes in dopamine transmission using radioligands like [^{11}C]raclopride.
30. **Cerebral Metabolic Rate of Oxygen (CMRO2) PET**
    Quantitative imaging of oxygen metabolism coupled to neural activity using ^{15}O-labeled tracers.
31. **Astrocyte-Specific PET Tracers (^{11}C-deuterium-L-deprenyl)**
    Targets monoamine oxidase B in astrocytes for glial activity mapping.

C. Electrophysiology & Implant Technologies

32. **Neuropixels Probes (latest gen)**
    Not just "multielectrode"; Neuropixels constitute a distinct class due to ultra-high channel count (1,000+), used in vivo widely.
33. **Silicon Probe Laminar Recordings**
    For cortical column laminar activity (V1, CA1).
34. **High-Density “ECoG Grids” (Neuropixels–ECoG hybrids)**
    New grids with thousands of micro-electrodes recordings across cortex.
35. **EMG-Assisted Brain–Body Coupled Recording**
    Used in behaving animals to integrate motor output with neural activity.
36. **Flexible Bioelectronic Neural Interfaces**
    Conformable electrode arrays that minimize tissue damage and enable stable long-term recordings.
37. **Transparent Graphene Microelectrode Arrays**
    Allow simultaneous electrical recording and optical imaging/optogenetics.
38. **Ultrasonic Neural Dust Motes**
    Wireless, millimeter-scale implants for chronic neural recording.
39. **Optetrode Recordings**
    Hybrid probes combining electrical electrodes with optical fibers for simultaneous recording and stimulation.
40. **CMOS-Integrated Neural Probes**
    On-chip amplified high-density probes for low-noise in vivo recordings.
41. **Sharp Electrode Intracellular Recordings**
    Historical method using fine glass micropipettes for high-impedance intracellular potential measurements.
42. **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.
43. **Autonomous Robotic In Vivo Patch-Clamp (AutoPatch / Robopatcher)**
    Automated robotics-enabled intracellular patch-clamp in awake or anesthetized
44. **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.
45. **Tetrode Recordings**
    Historical method using four-wire bundles for extracellular recording with improved single-unit isolation.
46. **Juxtacellular Recording and Labeling**
    Technique for extracellular recording followed by intracellular labeling of recorded neurons.

47. **Carbon Fiber Microelectrodes**
    Miniaturized electrodes for electrochemical detection of neurotransmitters with fast-scan cyclic voltammetry.
48. **Floating Microelectrode Arrays**
    Untethered microelectrodes that move with brain tissue for stable chronic recordings.

D. Optical / Imaging-Based Techniques

49. **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.
50. **Swept Confocally-Aligned Planar Excitation (SCAPE) Microscopy**
    High-speed volumetric neural imaging in freely moving animals.
51. **Structured-Light 3D Imaging of Cortical Hemodynamics**
    Used to map neural activity via intrinsic signals & hemodynamic changes.
52. **Mesoscopic Calcium Imaging (NOT miniscope)**
    Widefield mesoscopic Ca^{2+} imaging in vivo (distinct from fiber photometry).
53. **Adaptive Optics for In Vivo Neural Imaging**
    Corrects deep-tissue optical distortion; rapidly emerging technique.
54. **Oblique Plane Microscopy (OPM)**
    High-resolution, high-speed volumetric imaging for large-scale neural activity monitoring.
55. **Multifocal Two-Photon Microscopy**
    Simultaneous imaging of multiple planes for 3D functional imaging.
56. **Line-Scanning Temporal Focusing Microscopy**
    High-speed volumetric imaging with reduced out-of-focus excitation.
57. **Light Field Microscopy**
    Captures volumetric data in a single exposure for fast 3D neural activity imaging.
58. **Kilohertz Two-Photon Fluorescence Microscopy**
    Ultrafast scanning rates for capturing rapid neuronal dynamics in vivo.
59. **NIRE Cranial Window Method**
    Uses nanosheet-resin windows for large-scale, chronic high-resolution imaging in
60. **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.
61. **TIRF Microscopy In Vivo**
    Total internal reflection fluorescence microscopy adapted for superficial cortical imaging in live animals.
62. **Random Access Microscopy**
    Acousto-optic deflector-based rapid laser positioning for imaging distributed neurons.
63. **Reflectance Imaging**
    Measures intrinsic optical signals from cortical surface without exogenous labels.

64. **Second Harmonic Generation (SHG) Microscopy**
    Label-free imaging of membrane potential and structural proteins in live tissue.

E. Optical Indicators / Novel Sensors

65. **Genetically Encoded Dopamine Indicators (GRAB-DA, dLight1)**
    Used widely in in vivo with fiber photometry and two-photon microscopy.
66. **Genetically Encoded Glutamate Indicators (iGluSnFR)**
    High temporal resolution; used to study excitatory transmission.
67. **Genetically Encoded Acetylcholine Indicators (GACh)**
    Maps cholinergic dynamics in vivo.
68. **Genetically Encoded cAMP/PKA/Second-Messenger Sensors**
    (e.g., Pink Flamindo, G-Flamp) reflect intracellular signaling during neural activity.
69. **Genetically Encoded Serotonin Sensors (GRAB5-HT)**
    Monitor serotonergic transmission in behaving animals.
70. **Genetically Encoded Norepinephrine Sensors (GRAB-NE)**
    Track noradrenergic activity during behavior and cognitive tasks.
71. **Fluorescent False Neurotransmitters (FFNs)**
    Visualize neurotransmitter release and recycling in vivo.
72. **Genetically Encoded Chloride Indicators (Cl-Sensor)**
    Monitor chloride dynamics relevant for inhibitory transmission.
73. **Genetically Encoded ATP Indicators (iATPSnFR)**
    Track cellular energy status and metabolic activity in neurons.
74. **Genetically Encoded Lactate Sensors**
    Monitor lactate shuttling and metabolic coupling between neurons and glia.
75. **Genetically Encoded Redox Indicators (roGFP)**
    Detect oxidative stress and redox-state changes during neural activity.
76. **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.
77. **Genetically Encoded Potassium Indicators (GEPIs)**
    Fluorescent sensors for monitoring potassium dynamics in extracellular space.
78. **pHluorins (pH-sensitive GFPs)**
    pH-sensitive fluorescent proteins for tracking synaptic vesicle recycling.
79. **SypHy**
    Synaptophysin-pHluorin fusion protein for imaging synaptic vesicle exocytosis.
80. **GCamp Variants (GCamp6f, GCamp7f, GCamp8)**
    Successive generations of genetically encoded calcium indicators with improved kinetics and sensitivity.

F. Photoacoustic & Hybrid Techniques

81. **Voltage-Sensitive Photoacoustic Imaging**
    A new area combining voltage dyes with photoacoustics.
82. **Nanodiamond Magnetometry in Vivo**
    Nitrogen-vacancy (NV) diamond sensors used for in vivo magnetic-field measurements of neuronal activity.
83. **Multispectral Optoacoustic Tomography (MSOT)**
    Provides spectral unmixing of multiple chromophores for functional brain imaging.
84. **Photoacoustic Computed Tomography (PACT)**
    Deep-tissue functional imaging with optical contrast and ultrasound resolution.
85. **Functional Photoacoustic Microscopy (fPAM)**
    High-resolution imaging of hemodynamic responses to neural activity.
86. **Photoacoustic Lifetime Imaging Microscopy (PALM)**
    Measures oxygen consumption and metabolic rates in brain tissue.
87. **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.
88. **Photoacoustic Neurotransmitter Sensing**
    Molecular imaging of neurotransmitter release using photoacoustic contrast agents.
89. **Granger Causality Photoacoustic Imaging**
    Combines photoacoustic imaging with Granger causality analysis for functional connectivity mapping.

G. Neural Activity Through Blood Flow & Oxygenation

90. **Thermal Infrared Functional Imaging (ITIRI)**
    Detects activity-induced microvascular heating.
91. **Speckle-Modulated Optical Coherence Tomography (OCT)**
    OCT-based neuronal activity mapping (beyond standard laser speckle imaging).
92. **Doppler Optical Coherence Tomography (D-OCT)**
    For real-time blood-flow-linked neural-activity measurements.
93. **Visible Light Optical Coherence Tomography (vis-OCT)**
    Provides oximetry and flow measurements with higher resolution than NIR-OCT.
94. **Hyperspectral Imaging of Intrinsic Signals**
    Spectral unmixing of hemoglobin, cytochrome oxidase, and other chromophores.
95. **Time-Domain Near-Infrared Spectroscopy (TD-NIRS)**
    Offers depth-resolved hemodynamic monitoring with improved accuracy.
96. **Functional Diffuse Optical Tomography (fDOT)**
    3D reconstruction of brain activation through light scattering and absorption.
97. **In Vivo Electron Paramagnetic Resonance (EPR) Oximetry**
    Direct in vivo EPR/Electron Spin Resonance oximetry for quantitative tissue pO22 mapping and dynamic oxygen-consumption measurements coupled to neural activity.

98. **Laser Doppler Flowmetry**
    Continuous measurement of cerebral blood flow using laser Doppler shifts.
99. **Oxygen-15 Water PET ([^{15}O]H_2O PET)**
    Gold standard for quantitative cerebral blood flow measurement using positron emission tomography.
100. **Hydrogen Clearance CBF Measurement**
    Historical method using hydrogen electrodes to measure local cerebral blood flow.
101. **Autoradiographic CBF Measurement ([^{14}C]iodoantipyrine)**
    Ex vivo quantitative mapping of cerebral blood flow using radiotracers.

H. Behavioral + Neural Integrated Techniques

102. **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).
103. **Deep Label-Free Microscopy (DLFM)**
    Uses deep learning to extract neural activity from label-free imaging of scattering changes.
104. **Acoustic Recording of Neural-Related Behavior**
    Ultrasonic vocalization recording synchronized with neural activity measurements.
105. **Eye-Tracking Integrated Neural Recording**
    Combines pupil tracking with brain activity to study visual attention and processing.
106. **Pose Estimation with Neural-Activity Synchronization**
    Uses AI-based body tracking (e.g., DeepLabCut) linked to real-time neural signals.
107. **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.
108. **Whisker Tracking with Neural Recording**
    High-speed videography of whisker movements synchronized with neural data.
109. **Operant Conditioning Chambers with Neural Interfaces**
    Behavioral boxes integrated with neural recording/stimulation for learning studies.
110. **Sleep-Wake Monitoring with EEG/EMG**
    Polysomnography combined with neural activity measurements across sleep stages.

I. Interference / Modulation Techniques

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

112. **Temporal Interference Stimulation (TI Stimulation)**
Non-invasive deep-brain electromagnetic stimulation using intersecting high-frequency currents.
113. **Transcranial Random Noise Stimulation (RNS)**
Another electrical non-invasive modulation technique widely used.
114. **Photothermal Neuromodulation (non-genetic)**
Uses nanoparticles or infrared light to activate neurons.
115. **Infrared Neural Stimulation (INS)**
Pulsed IR light drives neural activity—distinct from optogenetics.
116. **Scanning Ultrasound Neuromodulation (SUN)**
Focused ultrasound for precise spatiotemporal neural control.
117. **Optoacoustic Neuromodulation**
Uses laser-generated ultrasound for deep-brain stimulation.
118. **Ion-CeMST (Ion Current–Controlled Microfluidic Stimulation)**
Microfluidic-based chemical stimulation with spatiotemporal precision.
119. **Transcranial Photobiomodulation (tPBM)**
Low-level near-infrared light to modulate brain metabolism and activity.
120. **Vagus Nerve Stimulation (VNS)**
Electrical stimulation of vagus nerve to indirectly influence brain circuits.
121. **Deep Transcranial Magnetic Stimulation (dTMS)**
Uses H-coil for deeper penetration than standard TMS.
122. **Closed-Loop Responsive Neurostimulation (RNS) for Research**
Implantable or external systems that detect electrophysiological biomarkers and
123. **Chemical-Genetic Actuation (PSAM/PSEM)**
Pharmacologically selective actuator modules for remote neural control.
124. **Cortical Cooling**
Focal cooling for reversible neural inactivation to study functional localization.
125. **Lidocaine Inactivation**
Local pharmacological blockade of neural activity for connectivity mapping.
126. **Muscimol Inactivation**
GABAA receptor agonist for reversible cortical silencing in behavioral studies.

J. Emerging & Frontier Approaches

127. **Bioluminescent Voltage Imaging (e.g., LOTUS-V)**
No excitation light; extremely low phototoxicity for in vivo activity imaging.
128. **Upconversion Nanoparticle-Based Neural Imaging**
Allows deeper brain optical readout using NIR-to-visible conversion.
129. **Magnetothermal Neural Recording & Readout**
Not just thermogenetic stimulation—actual readout emerging via nanomaterials.
130. **Molecular fMRI (m-fMRI)**
Probes coupling specific cellular signaling events to MRI contrast.
131. **Functional Ultrasound Localization Microscopy (ULM-fUS)**
Super-resolution vascular mapping during activity.

132. **"Neuromodulation via Magnetic Nanodiscs"**
A newer mechanogenetic-like frontier method.
133. **Quantum Diamond Microscopy**
Uses NV centers for magnetic imaging of neural activity at nanoscale.
134. **X-ray-Induced Acoustic Computed Tomography (XACT)**
Combines X-ray absorption with ultrasound detection for functional imaging.
135. **Magnetic Resonance Spectroscopic Imaging (MRSI)**
Spatially resolved spectroscopy for mapping neurotransmitter distributions.
136. **Neutron Stimulated Emission Computed Tomography (NSECT)**
Emerging nuclear technique for elemental mapping of neural tissue.
137. **Holographic Optogenetic Stimulation**
Uses holography for multi-site optical neural control and readout.
138. **Nanowire Intracellular Recordings**
Nanoscale wires for minimally invasive intracellular potential measurements.
139. **AI-Augmented Functional Connectivity Analysis**
Machine-learning-enhanced mapping of dynamic brain networks from imaging data.
140. **Cryogenic Electron Microscopy for In Vivo Snapshots**
Adapted for rapid freezing and imaging of activity states (though borderline in vivo).
141. **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.
142. **CLARITY with In Vivo Applications**
Tissue transformation for post-mortem structural mapping of functionally identified circuits.
143. **Expansion Microscopy In Vivo**
Physical tissue expansion for super-resolution imaging of activated circuits.
144. **Magnetic Resonance Phased Array Microscopy**
Ultra-high field MRI with phased array coils for microscopic resolution in live animals.
145. **X-ray Optogenetics**
Combining X-ray stimulation with optogenetic actuators for deep brain modulation.
146. **Neutron Scattering Tomography**
Emerging technique for mapping light element distributions in neural tissue.
147. **Diamond Quantum Sensing of Neural Magnetic Fields**
NV center magnetometry for direct detection of action potentials and synaptic currents.