FOUNDATIONS OF NEUROSCIENCE AND CRIMINAL LAW:

RECONSTRUCTING CULPABILITY, FREE WILL, AND JUSTICE IN THE AGE OF NEURAL EVIDENCE

Dr. Mohamed Kamal Arafa Elrakhawi
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DEDICATION

To the jurists who recognize that the architecture of justice must evolve alongside the architecture of the mind. To the neuroscientists, ethicists, and judicial scholars who understand that culpability cannot be anchored in metaphysical assumptions when empirical evidence reveals the biological substrates of decision-making. This work is dedicated to future generations who will inherit legal systems capable of balancing human dignity with scientific truth, and to every intellectual who believes that law must protect agency while acknowledging the neural realities of human behavior.

PREFACE

Traditional criminal law rests upon foundational assumptions of rational agency, conscious intent, and moral culpability. The doctrine of mens rea presumes that individuals possess free will, exercise deliberate choice, and can be justly blamed or praised for their actions. Contemporary neuroscience systematically challenges these assumptions. Functional neuroimaging, electrophysiological mapping, neurochemical profiling, and developmental cognitive research reveal that decision-making emerges from complex neural circuitry, genetically influenced architecture, environmental conditioning, and temporal brain states. When legal systems confront evidence that impulse control, moral reasoning, and volitional capacity are neurologically mediated, conventional culpability frameworks face structural deconstruction. This treatise does not seek to merely admit neural evidence within existing criminal doctrines. It proposes a foundational reconstruction of criminal liability itself. The objective is to articulate a coherent, theoretically grounded, and operationally viable architecture that recalibrates culpability thresholds, standardizes neural evidence admissibility, institutionalizes neuro-rehabilitative justice, and aligns penal philosophy with empirical reality. The methodology integrates comparative jurisprudential history, neuro-philosophical theory, evidentiary standardization, institutional design, and cross-border human rights harmonization. Each chapter advances from conceptual deconstruction to normative reconstruction, culminating in actionable legislative templates, judicial protocols, and implementation roadmaps. This work is structured for scholars, legislators, judges, and practitioners who recognize that the future of criminal justice depends not on preserving antiquated metaphysical assumptions, but on engineering resilient juridical structures capable of governing behavior in an age of neural evidence. The following pages present a unified framework that transforms neuro-law from speculative discourse into enforceable legal architecture.

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CHAPTER ONE: CONCEPTUAL, HISTORICAL, AND PHILOSOPHICAL FOUNDATIONS OF NEURO-LEGAL CULPABILITY

The application of neuroscience to criminal liability demands precise juridical delineation. Classical criminal theory anchors culpability in three interlocking concepts: voluntary action, conscious intent, and moral blameworthiness. When neural evidence demonstrates that volition operates through distributed cortical-subcortical networks, that impulse regulation depends on prefrontal maturation and neurotransmitter balance, and that moral reasoning emerges from developmental and environmental conditioning, traditional culpability models encounter empirical friction. Legal theory must first establish the boundary between metaphysical free will and functional agency. The concept of neuro-constrained volition introduces a tripartite analytical structure comprising neural capacity thresholds, environmental modulation factors, and temporal decision architecture. Neural capacity thresholds define the minimum cognitive and regulatory functioning required for legal culpability. Environmental modulation factors account for developmental deprivation, trauma exposure, and neurochemical disruption. Temporal decision architecture maps the sequence from stimulus perception to action execution across measurable neural timeframes.

To address the critique of total neural determinism, this framework establishes the principle of Functional Agency versus Metaphysical Determinism. The law does not punish the absence of metaphysical free will; rather, it regulates behavior by introducing legal consequences as environmental inputs that actively shape future neural decision-making circuits. Criminal liability is thus a forward-looking governance mechanism designed to calibrate behavioral predictability, not a backward-looking metaphysical judgment.

Historical jurisprudence provides profound precedents for managing biological constraints on responsibility. Roman law distinguished between dolus and culpa, recognizing that mental impairment could mitigate or eliminate culpability. Islamic jurisprudence established aql as a prerequisite for taklif, explicitly exempting individuals lacking cognitive maturity or neurological integrity from full criminal responsibility. Enlightenment philosophers debated determinism and moral agency, while modern legal theorists recognized that culpability operates as a social construct designed to regulate behavior rather than describe metaphysical reality. Modern neuro-philosophy further clarifies this boundary. Daniel Dennett articulated compatibilist free will, demonstrating that agency can exist within deterministic neural architecture. Stephen Morse emphasized that criminal law requires practical rationality rather than metaphysical freedom. Patricia Churchland established that moral reasoning emerges from evolved neural mechanisms rather than transcendent faculties. Together, these traditions demonstrate that legal systems have always calibrated culpability to biological and developmental realities. The proposed framework operates as a contemporary extension of this lineage, translating historical mitigation doctrines into neuro-evidentiary accountability architecture. Criminal liability is therefore not an absolute moral judgment but a calibrated governance mechanism, requiring proportional obligations aligned with neural capacity, developmental context, and behavioral predictability.

CHAPTER TWO: DECONSTRUCTION OF FREE WILL, MENS REA, AND THE NEUROSCIENCE OF DECISION-MAKING

The doctrine of free will in criminal law assumes that individuals could have acted otherwise under identical circumstances. Neuroscientific evidence reveals that decision-making operates through predictive coding, reward valuation networks, and inhibitory control circuits that function below conscious awareness. This empirical reality does not eliminate legal responsibility, but it requires recalibrating mens rea categories to align with measurable neural function. Intent, knowledge, recklessness, and negligence must be evaluated through functional capacity rather than metaphysical autonomy. The neuro-legal mens rea framework establishes three calibrated tiers: intact volitional architecture, partially impaired regulatory capacity, and severely compromised cognitive control. Intact volitional architecture corresponds to standard culpability thresholds where prefrontal inhibition, risk assessment, and moral reasoning operate within normative parameters. Partially impaired regulatory capacity applies when developmental trauma, neurochemical imbalance, or structural anomalies reduce impulse control without eliminating conscious awareness. Severely compromised cognitive control applies when neurological pathology, congenital impairment, or acute disruption eliminates the capacity for voluntary regulation.

Comparative criminal law demonstrates that effective neuro-legal integration requires statutory differentiation rather than judicial improvisation. The diminished capacity doctrine in common law jurisdictions recognizes reduced culpability for impaired mental functioning. Civil law insanity standards evaluate cognitive awareness and volitional control at the time of the offense. Islamic criminal jurisprudence distinguishes between full, partial, and absent aql, calibrating punishment

to cognitive integrity. These regimes collectively demonstrate that criminal justice succeeds when culpability aligns with measurable neural capacity, when sentencing incorporates rehabilitative potential, and when punitive models yield to evidence-based intervention. The proposed framework does not eliminate criminal responsibility. Rather, it offers a modular architecture that each jurisdiction can calibrate through its own statutory vocabulary while preserving the core mechanisms of capacity assessment, proportional culpability, and rehabilitative sentencing.

CHAPTER THREE: EVIDENTIARY STANDARDS, NEURAL DATA ADMISSIBILITY, AND JUDICIAL ADJUDICATION PROTOCOLS

The integration of neural evidence into criminal proceedings requires standardized evidentiary protocols, expert panel composition, and admissibility thresholds. Functional neuroimaging, electroencephalographic mapping, and neurochemical assays generate complex data that traditional courts struggle to interpret without specialized frameworks. Evidentiary standards require that neural data be admissible only when generated through validated methodologies, peer-reviewed protocols, and independent verification systems. Courts must recognize neural opacity limitations and apply capacity-weighting factors that prioritize functional assessment over speculative interpretation.

Admissibility protocols establish three evidentiary categories: structural imaging documenting anatomical anomalies, functional imaging demonstrating active neural patterns during decision-making tasks, and neurochemical profiling indicating regulatory disruption. Each category requires accreditation standards, chain-of-custody verification, and expert qualification thresholds. Judicial adjudication requires multidisciplinary panels comprising judicial officers, neuroscientists, cognitive psychologists, and legal ethicists. Panels must assess neural evidence in conjunction with behavioral history, environmental context, and developmental records to establish functional culpability. The burden of proof remains with the prosecution, but neural evidence may trigger capacity reassessment, sentencing modification, or rehabilitative diversion when threshold impairments are documented.

Furthermore, this framework explicitly recognizes Cognitive Liberty and the Privilege Against Compelled Neuro-Testing. Internal neural data constitutes the highest form of mental privacy. Defendants possess an absolute right to refuse compulsory neuroimaging, neurochemical extraction, or cognitive interrogation. Such data cannot be forcibly obtained by the prosecution, establishing a modern, inviolable equivalent to the right to silence and protecting the sanctity of the human mind from state intrusion.

Additionally, as artificial intelligence increasingly interprets complex neuroimaging data, the risk of algorithmic bias threatens procedural equity. Therefore, Algorithmic Auditing Standards for Neural Evidence are mandated. Any machine learning model used to assess neural capacity or predict recidivism must undergo mandatory, independent algorithmic auditing. These models must be transparent, open to peer review, and rigorously tested to ensure they are not trained

on historically biased datasets that could unfairly penalize specific demographic groups, thereby preserving the integrity of neuro-legal assessments.

Comparative evidentiary analysis reveals that successful integration occurs when scientific validation precedes judicial application. The Daubert standard in United States jurisprudence requires empirical reliability, peer review, and error rate documentation. European evidentiary frameworks mandate independent expert validation and transparent methodology disclosure. These precedents demonstrate that neural evidence must be functionally interpreted rather than deterministically applied. The proposed model establishes that neuro-evidence must be procedurally standardized, expertly contextualized, and judicially calibrated. Without evidentiary rigor, neural data risks speculative misuse. With standardized protocols, it becomes a precise instrument for culpability assessment.

CHAPTER FOUR: INSTITUTIONAL ARCHITECTURE, NEURO-REHABILITATION FRAMEWORKS, AND CROSS-BORDER HARMONIZATION

Theoretical coherence requires immediate operational viability. This chapter translates neuro-legal principles into actionable institutional architectures, legislative templates, and enforcement standards. Neuro-rehabilitation frameworks replace purely punitive models with evidence-based intervention architectures. The architecture operates through three structural components: capacity assessment protocols, therapeutic intervention pathways, and longitudinal monitoring systems. Capacity assessment protocols utilize standardized neurocognitive batteries, behavioral risk modeling, and developmental history analysis. Therapeutic intervention pathways integrate cognitive behavioral therapy, neurofeedback training, pharmacological regulation, and social reintegration programs. Longitudinal monitoring systems track recidivism risk, neural recovery markers, and community compliance through continuous clinical and judicial oversight.

The institutional architecture requires standardized operational protocols. Appointment procedures must ensure clinical expertise, judicial independence, and ethical oversight mandates. Funding mechanisms must guarantee financial autonomy through dedicated penal reform allocations, rehabilitation levies, and cross-jurisdictional compliance revenues. Enforcement authority must include treatment compliance monitoring, risk reassessment triggers, and direct judicial referral capabilities. Cross-border coordination requires international treaty frameworks that harmonize neuro-evidentiary standards, share rehabilitation outcomes, and enable cross-jurisdictional enforcement actions. Implementation roadways prioritize regulatory integration, judicial capacity building, and iterative institutional refinement. Legislative bodies must adopt enabling statutes that establish neuro-legal mandates, funding structures, and procedural authorities. Judicial systems must develop specialized criminal neuroscience tribunals equipped with clinical advisory panels and longitudinal compliance protocols. Academic institutions must establish neuro-law research centers that generate empirical outcome data, refine evidentiary standards, and train legal practitioners in computational neuro-jurisprudence. The operational architecture ensures that theoretical neuro-legal responsibility

translates into practical rehabilitation infrastructure, maintaining legal certainty while accommodating scientific evolution.

To prevent criminal justice from becoming a two-tiered system where only the affluent can afford advanced neuro-legal defenses, this framework mandates Safeguards Against the Neuro-Divide. The State must establish and fund an independent Public Neuro-Defense Fund. This mechanism guarantees that indigent defendants have equal access to accredited neurocognitive evaluations, expert testimony, and rehabilitative pathways. Procedural equity demands that neural evidence serves as a tool for universal justice, not a privilege of wealth.

CHAPTER FIVE: OPERATIONALIZATION, LEGISLATIVE DRAFTING, AND PROCEDURAL IMPLEMENTATION

The adjudication of neuro-informed criminal claims requires specialized evidentiary standards, causal methodologies, and remedial frameworks calibrated for neural complexity. Traditional courts struggle with culpability reassessment due to clinical ambiguity, interpretive variability, and cross-disciplinary coordination limitations. This chapter establishes judicial protocols that enable courts to adjudicate neuro-legal claims with precision, fairness, and enforceability. Evidentiary standards require the acceptance of validated neuroimaging reports, cognitive assessment documentation, and clinical verification records as admissible evidence when generated through standardized protocols, transparent methodologies, and independent verification systems. Courts must recognize neural interpretation limitations and apply capacity-weighting factors that prioritize functional assessment over deterministic claims.

Causal methodologies must transition from absolute intent attribution to probabilistic capacity analysis. Criminal behavior emerges through complex interactions between neural architecture, environmental conditioning, and situational triggers rather than isolated volitional choices. Judicial panels must utilize multidisciplinary expert testimony, clinical baseline comparisons, and longitudinal behavioral modeling to establish functional culpability. Remedial frameworks must prioritize capacity restoration mandates, therapeutic intervention orders, and neuro-rehabilitation funds over purely punitive incarceration. Capacity restoration mandates require clinical treatment programs tailored to documented neural impairments. Therapeutic intervention orders compel participation in cognitive regulation, impulse control, and social reintegration protocols. Neuro-rehabilitation funds capitalize through compliance penalties, treatment licensing fees, and cross-jurisdictional enforcement settlements, ensuring dedicated financing for evidence-based rehabilitation.

Judicial implementation requires specialized procedural pathways. Courts must establish dedicated neuro-legal litigation divisions staffed with judges trained in clinical neuroscience, cognitive psychology, and cross-disciplinary evidentiary standards. Expert tribunals must comprise multidisciplinary panels including judicial officers, clinical neuroscientists, cognitive statisticians, and rehabilitation specialists. Enforcement mechanisms must include compliance monitoring, penalty escalation for non-adherence, and cross-jurisdictional execution protocols.

The adjudicative architecture ensures that neuro-legal culpability is not merely declaratory but actively managed, preserving legal certainty while protecting human dignity.

APPENDIX A: MODEL CONSTITUTIONAL AND LEGISLATIVE PROVISIONS

SECTION ONE: CONSTITUTIONAL ENTRENCHMENT TEMPLATE

Article One: Neuro-Capacity and Culpability Recognition
The State recognizes that criminal culpability requires minimum neurocognitive capacity, volitional regulation, and conscious awareness. No individual shall be subjected to full criminal liability when verified neurological impairment substantially compromises decision-making architecture. This standard shall be non-derogable and subject to judicial enforcement.

Article Two: Right to Neuro-Evidentiary Assessment and Rehabilitation
Individuals possess an enforceable right to independent neurocognitive evaluation prior to sentencing, access to evidence-based rehabilitation programs, and judicial review of capacity-based liability determinations.

Article Three: Cognitive Liberty and Protection Against Compelled Testing
No individual shall be subjected to compulsory neuroimaging, neurochemical extraction, or cognitive interrogation without explicit, informed, and voluntary consent. Internal neural data is inviolable and protected under the privilege against self-incrimination.

Article Four: The Public Neuro-Defense Fund
The State shall establish and fund an independent Public Neuro-Defense Fund to guarantee equal access to neurocognitive evaluations and expert representation for indigent defendants, ensuring procedural equity and preventing a two-tiered justice system.

SECTION TWO: ENABLING STATUTE PROVISIONS

Section One: Establishment of the Neuro-Legal Assessment Authority
An independent regulatory and clinical authority shall be established to maintain standardized neurocognitive evaluation protocols, accreditation frameworks for expert testimony, and cross-jurisdictional rehabilitation coordination mandates. The Authority shall operate with financial autonomy, scientific advisory boards, and judicial referral capabilities.

Section Two: Calibrated Culpability and Sentencing Framework
Criminal liability shall be proportionally allocated based on documented neurocognitive capacity, developmental context, and behavioral risk assessment. Sentencing shall prioritize rehabilitation for partially impaired capacity, secure clinical treatment for severely compromised control, and standard accountability for intact volitional architecture.

Section Three: Neuro-Evidence Admissibility and Expert Panel Mandates

Neural imaging, electrophysiological mapping, and neurochemical profiling shall be admissible only when validated through peer-reviewed protocols, independent verification, and accredited expert qualification. Judicial proceedings involving neuro-evidence shall convene multidisciplinary panels comprising judicial officers, clinical neuroscientists, cognitive psychologists, and legal ethicists.

Section Four: Neuro-Rehabilitation Fund Capitalization
A dedicated rehabilitation fund shall be capitalized through penal compliance levies, treatment licensing fees, and cross-jurisdictional enforcement settlements. Disbursements shall be restricted to clinical intervention programs, capacity restoration research, and longitudinal recidivism monitoring. Annual audited reports shall be published and submitted to the legislature.

APPENDIX B: NEURO-LEGAL VALUATION MODEL, RISK ASSESSMENT FRAMEWORK, AND PROCEDURAL JUDICIAL GUIDE

SECTION ONE: NEURO-LEGAL CAPACITY VALUATION AND REHABILITATION FRAMEWORK

To ensure financial sustainability of neuro-rehabilitation programs and prevent punitive over-incarceration, mandatory treatment capitalization for capacity-impaired offenders shall be calculated using the standardized formula:

R = (C x I x S x T) divided by (1 + d) raised to the power of n

R represents the annual rehabilitation contribution required for capacity restoration programming.
C represents the documented neurocognitive impairment coefficient, scaled from 1.0 for mild regulatory disruption to 5.0 for severe volitional compromise.
I represents the intervention intensity multiplier based on clinical treatment complexity and duration requirements.
S represents the societal reintegration potential score derived from behavioral baseline and environmental stability metrics.
T represents the treatment compliance factor, which decreases with verified program adherence and clinical progress documentation.
d represents the social discount rate for rehabilitation investment, calibrated at 1.0 to 1.5 percent to prioritize long-term recidivism reduction over short-term fiscal optimization.
n represents the projected rehabilitation horizon in years based on clinical recovery timelines and developmental maturation cycles.

The hybrid financing architecture operates through three coordinated layers. The baseline rehabilitation pool is funded through tiered clinical licensing fees and proportional R contributions based on impairment severity. Smart contract treatment escrows automate the allocation of penal revenues into transparent, auditable accounts for clinical intervention and

longitudinal monitoring. A cross-border rehabilitation guarantee activates when domestic capacity is insufficient, leveraging bilateral neuro-legal treaties and international clinical arbitration standards.

SECTION TWO: PROCEDURAL JUDICIAL GUIDE FOR NEURO-LEGAL ADJUDICATION

Phase One: Filing, Jurisdiction and Capacity Preservation (Days One to Ten)
Claims are filed before specialized neuro-legal tribunals with jurisdiction based on offense location, defendant residence, or primary clinical assessment facility. Defense counsel submits verified neurocognitive evaluation requests, clinical history documentation, and preservation orders for neural data integrity. Courts issue immediate capacity assessment mandates. Data tampering triggers a rebuttable presumption of impairment documentation validity.

Phase Two: Expert Panel Formation and Clinical Verification (Days Eleven to Thirty-Five)
Multidisciplinary panels convene comprising judicial officers, clinical neuroscientists, cognitive psychologists, and legal ethicists. Panels assess neuroimaging validity, electrophysiological reliability, neurochemical consistency, and developmental context. Accredited independent clinicians extract and verify standardized capacity metrics. Absence of compliant evaluation shifts the evidentiary burden to the prosecution to demonstrate intact volitional architecture.

Phase Three: Culpability Calibration and Rehabilitation Activation (Days Thirty-Six to Sixty)
Courts may issue calibrated liability determinations, therapeutic intervention orders, or secure clinical placement mandates based on documented capacity thresholds. The Neuro-Rehabilitation Fund activates for verified treatment programs, capacity restoration research, and longitudinal monitoring infrastructure. Remaining accountability allocates proportionally among individual capacity, environmental conditioning, and institutional oversight based on functional impairment severity.

Phase Four: Cross-Border Execution and Compliance Monitoring (Days Sixty-One to Ninety)
Rehabilitation mandates enforce through mutual recognition protocols under international human rights frameworks and clinical arbitration standards. Compliance monitoring conducts via continuous clinical progress feeds and quarterly transparency reporting. Non-adherence triggers penalty escalation, treatment facility transfer, and cross-jurisdictional enforcement coordination.

Critical Judicial Directives:
Courts shall not require metaphysical free will as proof of criminal culpability. Functional neurocognitive capacity and volitional regulation are sufficient. Neural opacity shall not shield defendants from accountability. Transparent clinical evaluation is a statutory prerequisite for capacity determination. Rehabilitation mandates must utilize evidence-based protocols to prevent punitive exploitation and preserve human dignity.

SECTION THREE: LIVING SCIENCE PROTOCOL FOR NEURO-EVIDENTIARY STANDARDS

Neuroscience evolves at a pace that exceeds traditional legislative cycles. To ensure the enduring relevance of this framework, an independent Scientific-Judicial Review Commission shall be established with mandate to update Neuro-Evidentiary Acceptance Thresholds every twenty-four to thirty-six months. The Commission shall comprise equal representation from clinical neuroscientists, judicial officers, legal ethicists, and patient advocacy representatives. Updates shall address: validation standards for emerging neuroimaging modalities, recalibration of impairment coefficients based on longitudinal outcome data, integration of novel biomarkers for volitional capacity, and harmonization with international human rights instruments. Legislative bodies shall adopt enabling provisions that delegate technical standard-setting authority to the Commission while retaining substantive policy oversight. This mechanism ensures that the framework remains scientifically rigorous, legally certain, and ethically grounded without requiring frequent statutory amendment.

APPENDIX C: APPLICATION OF THE ELRAKHAWI FRAMEWORK TO LANDMARK CASES

To demonstrate the operational viability of this framework, we apply the Elrakhawi Calibrated Culpability Model to historical precedents.

Case Study One: Roper v. Simmons (Juvenile Capital Punishment). Under traditional frameworks, the debate centered on abstract notions of juvenile maturity. Under the Elrakhawi framework, the underdeveloped prefrontal cortex and incomplete myelination in adolescents constitute a documented partially impaired regulatory capacity. This mandates rehabilitative intervention rather than irreversible punitive measures, providing a concrete neuro-legal basis for the abolition of juvenile capital punishment.

Case Study Two: The Phineas Gage Paradigm and Acquired Brain Lesions. In cases where defendants commit crimes subsequent to the development of frontal lobe tumors or traumatic brain injuries, traditional law struggles with the sudden onset of impulsivity. The Elrakhawi model classifies this as severely compromised cognitive control due to acute neurological pathology. The framework mandates immediate clinical intervention and capacity restoration, shifting the judicial response from retributive incarceration to medically supervised rehabilitation, thereby aligning legal outcomes with biological reality.

CONCLUSION

The transition from metaphysical culpability models to neuro-informed criminal architecture requires foundational legal reconstruction rather than doctrinal adaptation. This treatise has demonstrated that traditional intent doctrines, absolute free will assumptions, and purely punitive frameworks are structurally inadequate for governing behavior in an age of neural evidence. The proposed framework integrates calibrated culpability assessment, standardized neuro-evidence admissibility, institutional rehabilitation architecture, and specialized judicial adjudication into a unified system capable of sustaining relevance across generations of scientific evolution. Historical jurisprudence and comparative criminal precedents provide foundational legitimacy, demonstrating that legal systems have always calibrated responsibility

to biological and developmental realities. Institutional design and evidentiary innovation ensure that neuro-legal culpability transitions from speculative discourse to enforceable justice architecture. Model statutes, clinical protocols, and operational frameworks provide immediate deployment pathways for legislators, courts, and rehabilitation authorities. Future research must prioritize empirical validation of neuro-evidentiary standards, international harmonization of capacity assessment protocols, and judicial interpretation frameworks for probabilistic culpability analysis. Legislators must transition from reactive penal patching to proactive neuro-legal engineering. Courts must develop evidentiary standards that accommodate neural complexity without abandoning legal certainty. Scholars must continue refining the intersection between clinical neuroscience and juridical structure. The evolution of behavioral science will not pause for legal deliberation. The responsibility of legal thought is to anticipate, structure, and govern rather than merely respond. This framework provides a coherent foundation for that endeavor, ensuring that criminal justice evolves alongside neural reality, and that human dignity remains anchored in enforceable legal architecture rather than metaphysical assumption.

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AUTHOR

Dr. Mohamed Kamal Arafa Elrakhawi

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