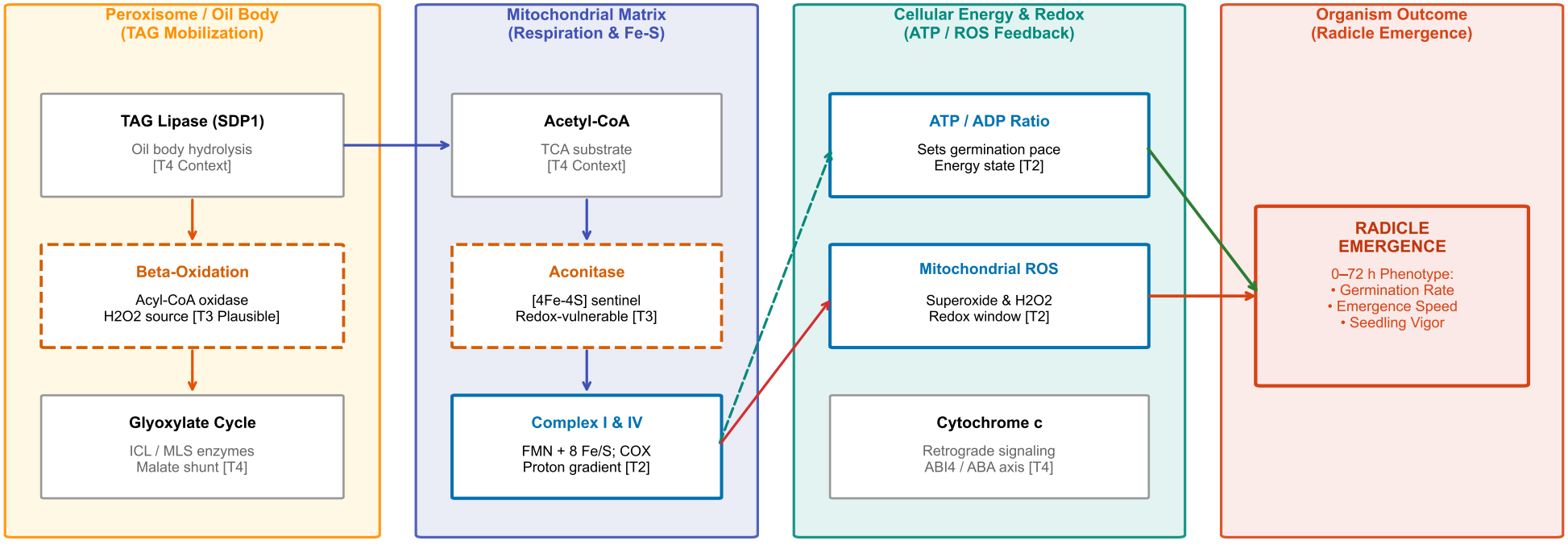
a

Seed Germination Before Photosynthesis (QBM-06): The 0–72 h Heterotrophic Energy Bottleneck



b

Evidentiary Tiers & Biophysical Timescale Constraints

T1: Demonstrated Field Effect
Solid black border (2.0 pt); applied field directly measured on biomolecule (e.g. CRY1/2 radical pair)

T2: Inferred from Complex
Solid blue border (1.5 pt); demonstrated for containing pathway (e.g. AOX buffering, Fv/Fm, Ferritin)

T3: Plausible Physical Route
Dashed vermillion border (1.5 pt); spin/quantum mechanism plausible but unmeasured in vivo (e.g. Complex III Qo)

T4: Contextual Scaffold
Hairline grey border (0.8 pt); structural/metabolic scaffold lacking magnetic claim

PHYSICAL TIMESCALE CRITERION FOR MAGNETIC RECEPTION

- Zeeman Precession (50 μT GMF): νL ≈ 1.4 MHz (τL ≈ 714 ns) — Decoupled to νL ≈ 28 Hz (τL ≈ 35.7 ms) in Lunar NNMF (1 nT)
- Radical-Pair Spin Coherence: τcoh ~ 1 μs [MATCHES GMF / Precession decoupled by 10^4× in NNMF]
- PSII Primary Charge Separation: ~200 ps [10^6× TOO FAST FOR DIRECT MF EFFECT]
- Complex III Qo Semiquinone-Rieske: Exchange coupling J ~ GHz >> GMF [Refutes runaway ROS leak]

c

Organellar Bioenergetics & Respiratory Buffering

Chloroplast Photosynthetic Electron Transport (QBM-02)

PSII (P680)
Open: 200 ps
Closed: 1O2 / 3Chl*
[T2 Inferred]

Cyt b6f Rieske
[2Fe-2S] cluster
Q-cycle H+ pump
[T3 Plausible]

PSI (P700)
P700•+ A1•- pair
FX/FA/FB Fe-S
[T2 Inferred]

Ferredoxin & FNR
NADPH formation
Cyclic flow (PGR5)
[T2 Inferred]

Mitochondrial Respiration & AOX Safety Valve (QBM-01)

Complex I & III
NADH oxidation; Fe-S
Major superoxide leak
[T2 Inferred]

ALTERNATIVE OXIDASE
(AOX Bypass)
Cyanide-resistant bypass
Bypasses CIII/IV; vents e-
Dampens ROS runaway [T2]

Complex IV (COX)
Heme a3 / CuB
High O2 affinity
[T4 Context]