Figure Captions

Figure 1.) Examples of lamination morphologies formed principally by abiotic physiochemical processes. **A.** Parallel laminations formed through seawater evapoconcentration and precipitation, Castille Fm., Texas, USA. **B.** Cross laminations formed by aqueous fluid flow, in Baraboo Quartzite, Devil's Lake State Park, Wisconsin, USA. **C.** Concretion exhibiting concentric Liesegang banding. **D.** Deformed laminations caused by pedogenesis and the displacive growth of calcite concretions (arrows). **E.** Stylolote formed by pressure solution, Columbus Limestone, Kelleys Island, Ohio, USA. **F.** Convolute (irregular) laminations formed by soft-sediment deformation, Navajo Sandstone, Capitol Reef National Park, Utah, USA. **G.** Irregular layers produced by metamorphism in the Joshimath Formation, Indian Himalayas; note the presence of red metamorphic garnets (arrows). Image credits: (A, B, E, F, G) J. St. John, Ohio State University at Newark; (C, D) S. Potter-McIntyre.

Figure 2.) Laminations interpreted as microbial mat remains. **A.** Outcrop image of microbial mat laminations (dark layers) interbedded with medium- to coarse grained sandstone of the 3.22 Ga Moodies Group, South Africa (Small scale bar in image is 3 cm). **B.** Thin section photomicrograph of carbonaceous laminae overlaying medium- to coarse-grained sand. Abundant trapped grains suggest that cementation and early silicification predated significant burial and that subsequent compaction was minor. **C.** Thin section photomicrograph of microbial mat layers that appear as dark bands among quartz-rich sandstone from the 2.9 Ga Pongola Supergroup, South Africa. Oriented grains are visible inside the mat layers (arrow a); trapped grain aggregates are visible in the lower mat layer (arrow b); scale bar is 0.2 mm. **D–I** modern- to Archean-aged microbial mat laminae exhibiting irregular, wavy laminae along with trapped grains, reproduced from Noffke et al., 2013. Scale bars in these images represents 250 µm. **D.** Modern microbial mat laminations, El Bibane, Tunisia. **E.** 380 Ma Gres et Schistes de la Cluse de l'Orb, Montagne Noire, France. **F.** 650 Ma Nama Group, Namibia. **G.** 2.9 Ga Mozaan Group, South Africa. **H.** 3.2 Ga Moodies Fm., South Africa **I.** *ca.*3.48 Ga Dresser Fm., Western Australia. Image credits: (A–B) M. Homann; (C–I) N. Noffke.

Figure 3.) Laminations exhibiting tufted morphology consistent with microbial mat remains. **A.** Profile of gas-filled tuft in an active microbial mat (Homann et al., 2015). **B–E.** Tufted laminations from 3.22 Ga Moodies Group, Barberton greenstone belt, South Africa, interpreted as microbial mat remains (B–D: Homann et al., 2015; E: Homann 2018). Arrow in B indicates chert-filled interior cavity, interpreted as a gas-filled void consistent with trapped gas bubbles in A (Homann et al., 2015). Tufts are partially chert-filled and laterally linked by draping laminations (arrow in D). **F.** Carbonaceous micro-tufted fabrics (arrows) interpreted as microbial mats preserved in the 3.47 Ga Middle Marker horizon of the Barberton greenstone belt, South Africa (Hickman-Lewis 2018). **G–H.** Micro-tufted laminated fabrics interpreted as microbial mat remains from the 3.48 Ga Dresser Fm., Pilbara, Western Australia (Noffke et al., 2013).

Figure 4.) Lamination morphologies indicative of microbial mat cohesion. **A.** Modern rolled up microbial mat, El Bibane, Tunisia (Noffke et al., 2013). **B.** Roll-up structure with strongly folded dark carbonaceous laminations interpreted as microbial mat remains from the ~2.6 Ga Carawine Dolomite, Hamersley basin, Western Australia (Simonson and Carney, 1999). **C.** Carbonaceous laminations exhibiting delamination and folding (black arrows), Carawine Dolomite (Simonson and Carney, 1999). **D.** Roll-up structure formed among thick carbonaceous laminae in the 3.46 Ga Apex Chert, Pilbara, Western Australia (Hickman-Lewis et al., 2016). **E.** Carbonaceous folded laminations in the 2.52 Gamohaan Fm., South Africa (McLoughlin et al., 2023). **F.** Roll-up structure from the 3.42 Ga Buck Reef Chert, South Africa (Tice and Lowe, 2006). **G.** Storm layer composed of microbial mat fragments with bent mat laminae (yellow arrows) and roll-up structure (red arrow) from the Neoproterozoic Hyco Formation, North Carolina, USA.

Figure 5.) Stromatolite lamination architectural types and associated examples, reproduced from Grey, K and Awramik, S.M. 2020, Handbook for the Study and Description of Microbialites (Geological Survey of Western Australia, Bulletin 147, licensed under Creative Commons Attribution 4.0 International Licence). **A.** Banded lamination type; example is from Paleoproterozoic-aged Peedawarra Flats, Mount Phillips, Western Australia (polished face, sample ID: GSWA F9908–46036; photo by K. Grey). **B.** Filmy lamination type; example is from Paleoproterozoic-aged Nabberu Basin, Western Australia (thick section, sample ID: GSWA F12365–46333; photo by S.M. Awramik and K. Grey). **C.** Striated lamination type; example is from Paleoproterozoic-aged Turee Creek, Western Australia (thick section, sample ID: GSWA F53603–84727; photo by S.M. Awramik and K. Grey). **D.** Streaky lamination type; example is Mesoproterozoic-aged from Pingandy Creek, Mount Egerton, Western Australia (thick section, sample ID: GSWA F9932–46009; photo by M. Ang). **E.** Tussocky lamination type (outlined); example is Paleoproterozoic-aged from near Lake Wells Homestead, Throssell, Western Australia (thick section, sample ID: GSWA F52286–193359; photo by K. Grey). **F.** Pillared lamination type (outlined); example is Paleoproterozoic-aged from Thurraguddy Bore, Throssell, Western

Australia (thick section, sample ID: GSWA F12356–42896; photo by S.M. Awramik and K. Grey). **G.** Vermiform ("worm like") lamination type (arrows); example is Neoproterozoic-aged from the Gibson Desert, Westwood, Western Australia (split core; core ID: GSWA Empress 1A, 1077.4 m depth; photo by K. Grey). **H.** Alveolar lamination type (arrows); example from Holocene-aged Carnarvon Basin, Hamelin Pool, Shark Bay, Yaringa, Western Australia (cut face, UC Santa Barbara collection; photo by S.M. Awramik).

Figure 6.) Schematic representation of the relationship between criteria, "arguments", and false positive/negative potential within the Life Detection Knowledge Base (LDKB). Knowledge sourced from peer-reviewed publications is represented in the LDKB in the form of user-created "arguments" that are organized according to whether they (i) relate to biological or abiotic sources of a given PB, (ii) concern prevalence or signal strength, and (iii) argue for high versus low prevalence or signal strength. Arguments can be formulated in environment- or context-dependent terms.