The premature failure of engineering alloys in service is often associated with exposure to unintended environmental chemistry. High strength carbon steels and stainless steel will fail prematurely if exposed under tensile stress to absorbed atomic hydrogen. This is known as hydrogen embrittlement. Similarly, when aluminum alloys are exposed to liquid mercury, they are likely to crack prematurely if tensile stresses are present. This is an example of liquid metal embrittlement. Silicate glass cracks in the presence of water, a phenomenon known as static fatigue of glass. Plastics fail prematurely in the presence of organic solvents. Service environments that contain soluble chlorides may lead to premature transgranular cracking of austenitic stainless steels. Interestingly, the same environments will not cause such failure in ferritic stainless steels. Likewise, caustic solutions are known to promote the premature failure of carbon steels and austenitic stainless steels.

All of the above phenomena are described as environmentally-induced embrittlement or environmentally-induced cracking, EIC. These phenomena have been known for a very long time. Materials engineers are fully able to make materials selection decisions for the construction of engineering systems that see service in virtually any environment. What is also not known with certainty at this stage is the mechanism by which these examples of environmentally-induced embrittlement occur. There are multiple schools of thought regarding the mechanisms of each phenomenon mentioned above. As such, it is not uncommon to find such phenomena described broadly as stress corrosion cracking even though it is clear that corrosion is not a general prerequisite to such phenomena. It should be noted that in many cases of EIC, the alloy is virtually corrosion-free over most of its surface, including the fracture surface. As such, chemical or electrochemical dissolution has minimal if any effect on the fracture process.

There has been an enormous amount of effort directed toward identifying the mechanism or mechanisms of environmentally-induced cracking, but there is wide disagreement and debate on this subject. Most involve in some fashion either the adsorption of specific embrittling species and subsequent lowering of the surface energy for fracture or localized anodic electrochemical processes such as dissolution or film formation. Our goal in this presentation is to assess the current state of knowledge of EIC in terms of the above phenomena, to identify what is known in a mechanistic sense and what remains to be understood in terms of the path forward toward a more complete mechanistic understanding.