INTRODUCTION TO FRACTOGRAPHY

These brief notes are intended as a brief introduction to the topic of Fractography. More extensive notes, list of references and case studies with examples of microstructures can be found at the web-site developed by Professor Neil James, University of Plymouth.
Go to:
http:www.tech.plym.ac.uk/sme/Interact.../Fractography/Fractography_Resource.htm

Fractography is the interpretation of features observed on fracture surfaces in order to establish the cause of failure. This may be due to stress overload, fatigue, creep, stress corrosion or some combination of mechanisms, depending on the conditions. Interpretation is not always straightforward, but if accurately assessed the information may be fed back into the design process in order to avoid similar failures in future. This may involve improvements to the material, the manufacturing and finishing process or adjustments to the design, applied stress or maintenance routines.

Fast fracture cracks in metals may propagate by several basic crack growth mechanisms, for example**:**
(i) Intergranular or along the grain boundaries**,** a brittle mode of failure leaving flat fracture facets.
(ii) Cleavage along crystallographic planes or other microstructural feature such as pearlite lamellae, also a brittle mode leaving flat facets.
(iii) Transgranular ductile fracture by **microvoid coalescence**. This produces a dimpled fracture surface with brittle inclusions often left in the bottom of the dimples since these have initiated the voids.

Stress corrosion failures may be characterised by intergranular cracking. Fatigue is often characterised by two zones, the first in which the crack grows in a sub-critical way and the second when the crack length exceeds the critical length for the applied stress and propagates rapidly. The first zone may be smoother and lighter in appearance due to rubbing of the mating surfaces as the fatigue oscillations open and shut the crack many times. There may also be conspicuous 'beach or clam-shell' markings radiating out from the origin of the crack visible to the naked eye (or macrostructural view), while at the microstructural level, minute ripples or 'striations' may be visible. It is clearly important to observe the failure at a variety of different magnifications in order to pick out the various clues. At the lowest level with the naked eye or with the aid of a magnifying glass (up to about X10), secondly using an optical microscope (up to about X1,000) and if fatigue striations are to be observed, using a scanning electron microscope (up to about X 30,000).

There are three golden rules when it comes to beginning a fractographic analysis:
(i) Approach the problem without any preconceived ideas. As stated above, interpretation is not always straightforward, and a fracture which at first glance may look like a fatigue failure could be very similar in appearance to a stress corrosion failure.

(ii) Visit the actual scene and talk to personnel involved. Gather as much information about the circumstances of the fracture and the conditions pertaining, such as ambient temperature, chemicals in contact etc. These may all have a bearing on the cause of fracture.
(ii) Protect the fracture surface. Attempting to re-mate the surfaces or allowing moisture to come into contact with the surface may destroy important evidence. It may be possible that during the moments after failure, the fracture surface will have been crashed into the mating surface or a nearby object, and this needs to be established also.

Factors that may cause failure include the following:
(i) **Design Inadequacies:** These may include: Failure to consider notches or stress concentrations properly; Incomplete knowledge of service conditions; lack of accurate stress analysis; selection of inadequate material; inappropriate finishing process; incorrect service scheduling, etc.
(ii) **Materials Processing or Fabrication Problems:** These may include metallurgical factors such as improper heat treatment; presence of casting or forging defects; quench cracks during welding or heat treatment; problems with coatings; non-metallic inclusions, etc. Fabrication problems may include misalignment; weld defects; poor machining; poor assembly etc.
(iii) **Environmental or service deterioration:** These may include overloads or other abuse; inadequate maintenance; incorrect repair procedure; corrosion; wear etc.