Thm (Alexander) $S^3$ is irreducible; that is, every smooth $S^2$ bounds a ball.

Def M is prime if $M = M_1 \# M_2 \Rightarrow M_1 = S^3 \text{ or } M_2 = S^3$

Thm A prime $M^3$ is irreducible or $M \cong S^1 \times S^2$

Thm (Kneser, Milnor) Unique factorization into primes for arbitrary $M^3$'s.

Def A 2-disk $(D, \partial D) \subset (M, \partial M)$ is essential if $\partial D$ does not bound a disk in $M$.

Thm (Bonahon) If $M$ is irreducible, then $\partial M$ is a submanifold that contains $\partial M$ and (up to isotopy) all essential boundary disks in $M$.

A Seifert Fiber Space (SFS): $M \cong \Sigma$ circles, locally like

\[ \text{glue with rotation} \]

The space of fibers of an SFS is a surface $F$.

JSJ For knot complements. Let $M_k$ be the knot complement of $K \subset S^3$. There are four possibilities:

1. $K = V$, $M_k = S^1 \times D^2 \cong \text{ess. } D^2$
2. $K = T^n$, $M_k$ is an SFS w/ $\rho^n$
3. Satellite knots have an essential $T^2$ in their complements.
   This is iff $M_k$ has an essential $T^2_k$ is a satellite.

4. Otherwise $M_k$ is hyperbolic.