# Genomic Rescue:
# Restarting failed replication forks

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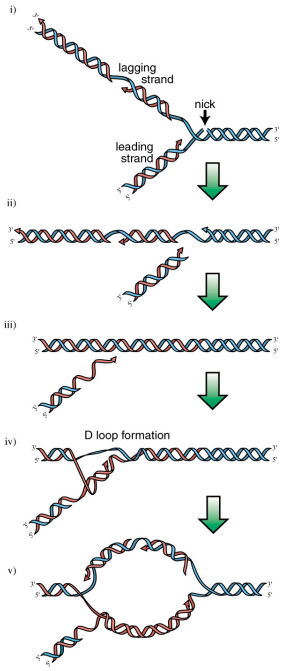
## Why Study *E. coli*?

fundamental metabolic processes generally conserved (at least philosophically) with those in higher organisms

easy to grow: fast and inexpensive
genome completely sequenced
powerful genetic tools

proteins generally well-characterized:
generally one function per protein, one protein per function
many crystallized




## PriA

Preferred substrate is a replication fork with a missing **lagging** strand.
Equivalent to a D-loop with an invaded 3'-OH single strand.
Loads the dnaB replicative helicase.

The loading of dnaB is necessary and sufficient for the construction of a new replication fork.

Molecular Cell, Vol 11, 817–826, March 2003
**PriA Mediates DNA Replication Pathway Choice at Recombination Intermediates**
Liewei Xu and Kenneth J. Marians

## RecA

- Binds single-stranded DNA and double-stranded DNA
- Searches for regions of homology
- Exchanges homologous strands

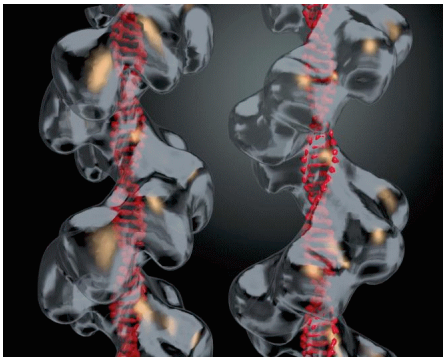
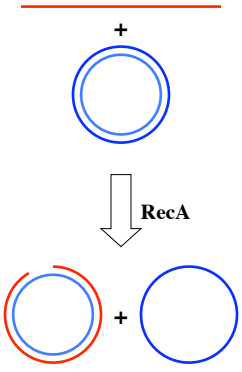
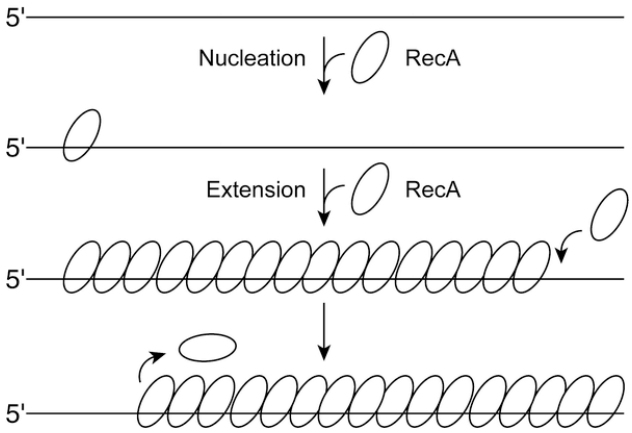


Image is from the cover of the March 26, 1993 issue of *Science*

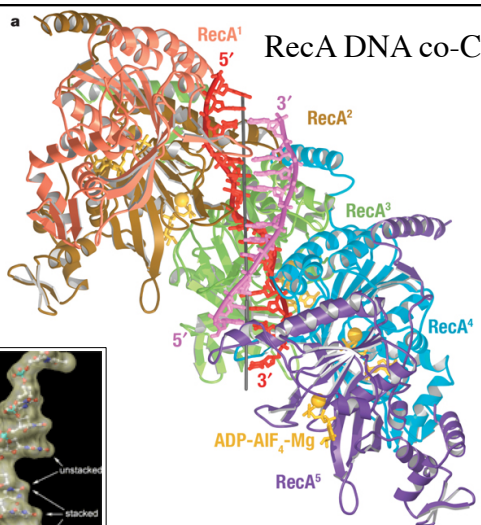


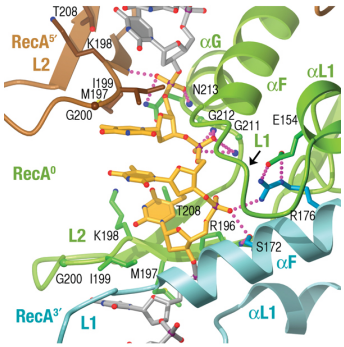
## RecA Nucleation and Extension

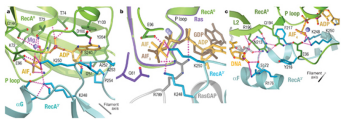


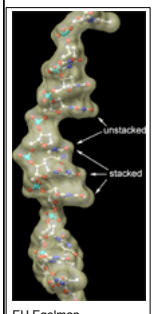

Cox JM, Tsodikov OV, Cox MM.
Organized unidirectional waves of ATP hydrolysis within a RecA filament.
PLoS Biol. 2005 Feb;3(2):e52.

## RecA DNA co-Crystal Structure

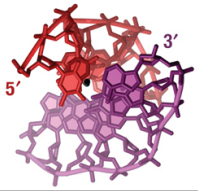




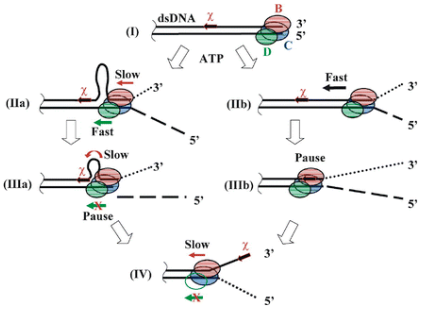

EH Egelman
**Implications of the RecA structure**
F1000 Biology Reports
2009, 1:7




Nature. 2008 May 22; 453(7194):489-4
**Mechanism of homologous recombination from the RecA-ssDNA/dsDNA structures.**
Chen Z, Yang H, Pavletich NP

# RecBCD

- Bind double-stranded DNA ends
- Degrade both stands until a X site (GCTGGTGG) is reached
- Switch to 5'-3' exonuclease generating a 3' single-stranded tail
- Load RecA on the single-stranded tail



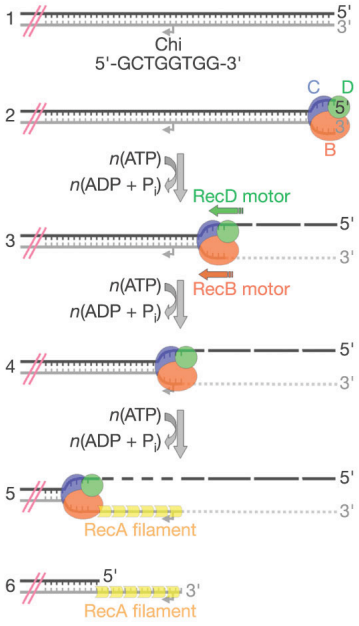

RecB: slow 3' to 5' helicase

RecD: fast 5' to 3' helicase
inhibits loading of RecA

RecBC: loads RecA on constitutively

Cell, Vol 114, 647–654, 5 September 2003
**A Molecular Throttle: The Recombination Hotspot χ Controls DNA Translocation by the RecBCD Helicase**
Maria Spies, Piero R. Bianco, Mark S. Dillingham, Naofumi Handa, Ronald J. Baskin, and Stephen C. Kowalczykowski

# RecBCD




Double-stranded DNA end

RecBCD binds

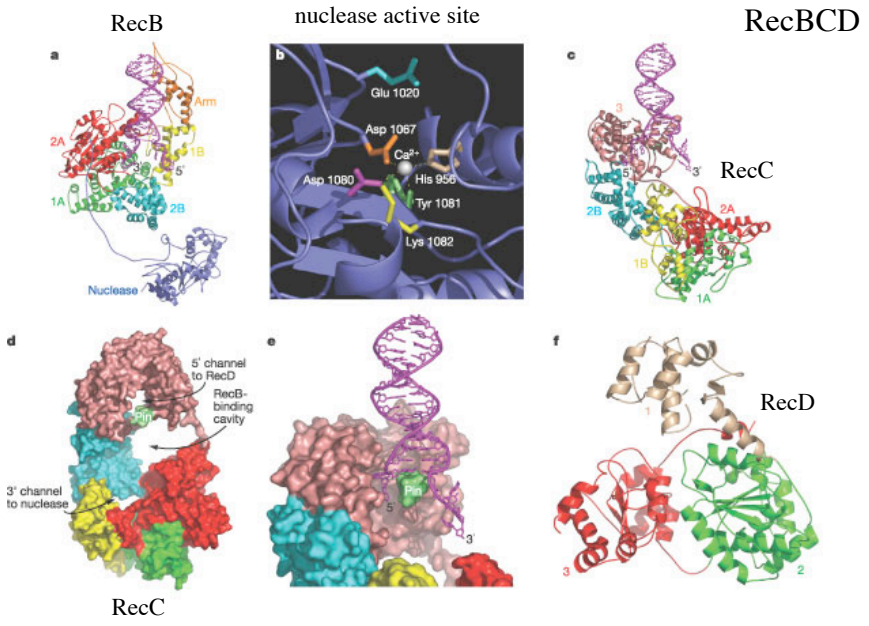
RecBCD translocates and separates DNA strands
Both strands are degraded

X site is recognized

Degradation of 3' strand stops
RecA is loaded

RecBCD dissociates

Nature. 2004 Nov 11;432(7014):187-93.
**Crystal structure of RecBCD enzyme reveals a machine for processing DNA breaks.**
Martin R. Singleton, Mark S. Dillingham, Martin Gaudier, Stephen C. Kowalczykowski and/\Dale B. Wigley




Nature. 2004 Nov 11;432(7014):187-93.
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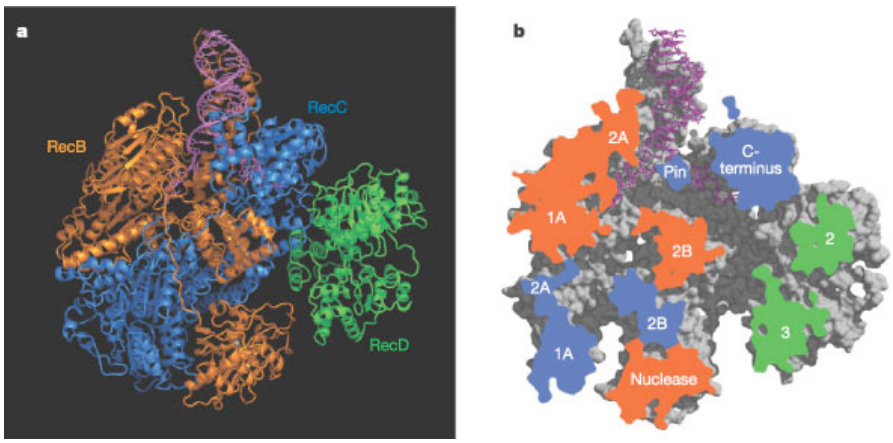
## RecBCD Cutaway Details

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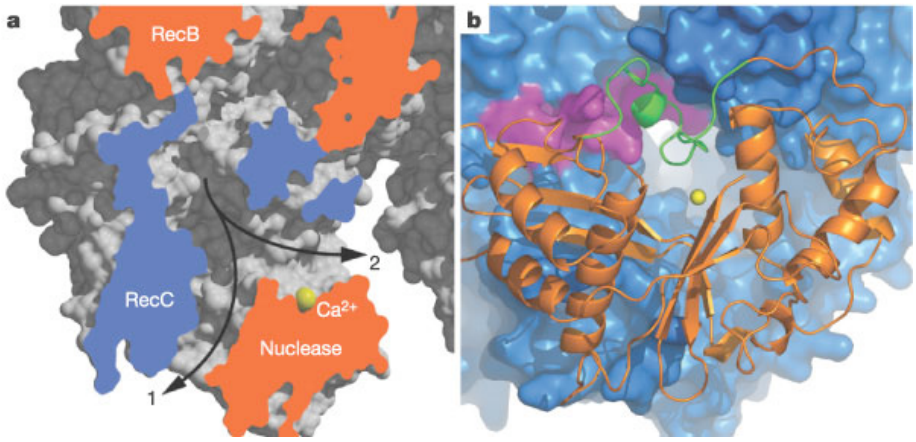


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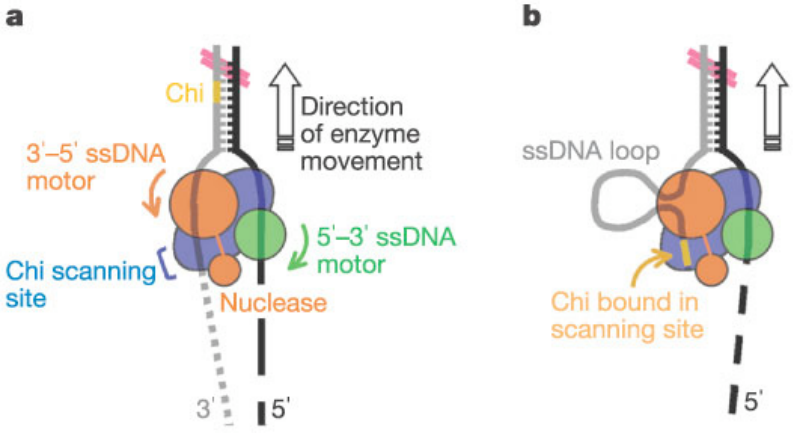
## RecBCD -- Activity Modulated by X Recognition

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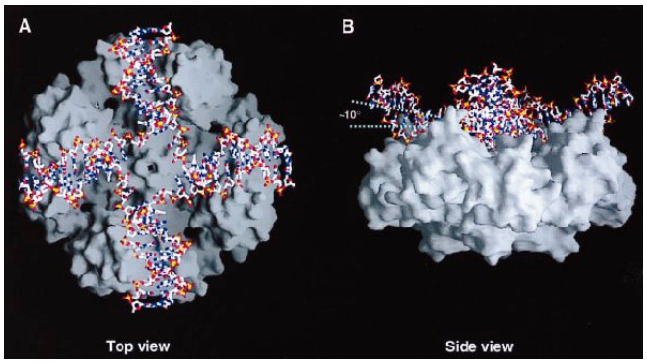
# RuvABC

RuvABC branch-migrates and then resolves Holliday junctions

RuvA binds a Holliday junction and maintains a square-planar open orientation

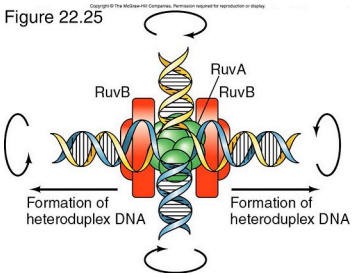


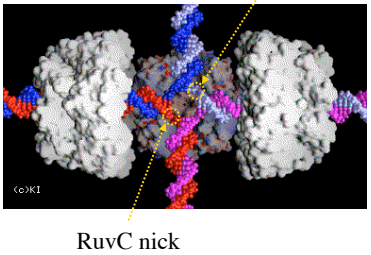

Mariko Ariyoshi, Tatsuya Nishino, Hiroshi Iwasaki, Hideo Shinagawa, and Kosuke Morikaw
**Crystal structure of the Holliday junction DNA in complex with a single RuvA tetramer**
PNAS 2000 97: 8257-8262

# RuvABC

RuvB is a helicase motor that causes the Holliday junction to branch migrate

RuvC is a Holliday junction resolvase that nicks DNA on opposite sides of the square-planar ring



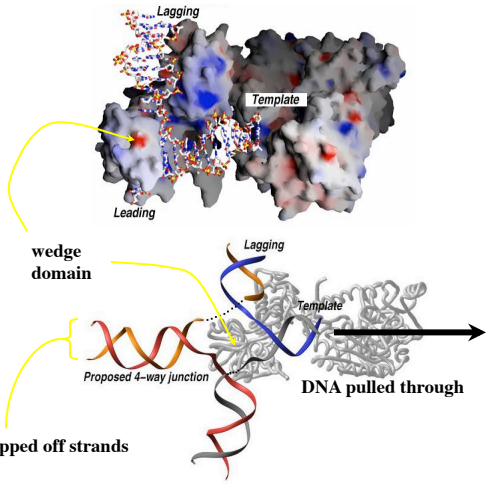

**Structure of the Recombination Protein RuvA and a model for its Binding to Holliday Junction**
J.B.Rafferty, S.E.Sedelnikova, D.Hargreaves, P.J.Artymiuk, P.J.Baker, G.J.Sharples, A.A.Mahdi, R.G.Lloyd and D.W.Rice
Science 274, (1996)

## RecG

Binds replication forks with a missing **leading** strand Equivalent to a D-loop with an invaded 5'-$PO_4$ single strand.

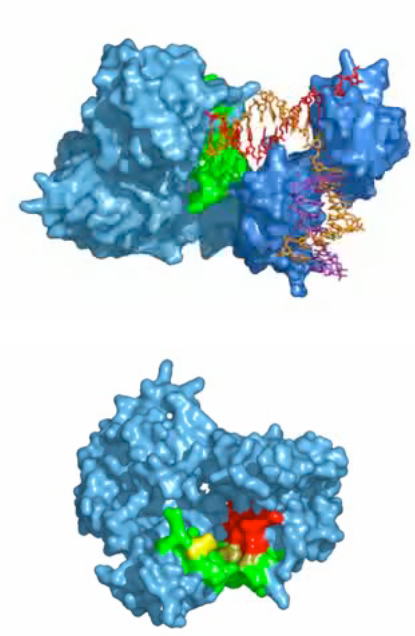
Translocates DNA through the protein using "wedge domain" to strip off any annealed strands

Stripped off strands can anneal to each other to form a Holliday junction




Cell, Vol 107, 79–89, 5 October 2001
**Structural Analysis of DNA Replication Fork Reversal by RecG**
Martin R. Singleton , Sarah Scaife, and Dale B. Wigley

## RecG movies



http://www.nottingham.ac.uk/life-env/contact/academics/lloyd/research.phtml