



Apr 30, 2019

Working

Budding yeast ChEC

Gabe Zentner¹

¹Department of Biology, Indiana University, Bloomington, IN 47405

[dx.doi.org/10.17504/protocols.io.2gjjgbun](https://doi.org/10.17504/protocols.io.2gjjgbun)



Gabe Zentner
Indiana University



ABSTRACT

Genome-wide mapping of protein-DNA interactions is critical for understanding gene regulation, chromatin remodeling, and other chromatin-resident processes. Formaldehyde crosslinking followed by chromatin immunoprecipitation and high-throughput sequencing (X-ChIP-seq) has been used to gain many valuable insights into genome biology. However, X-ChIP-seq has notable limitations linked to crosslinking and sonication. Native ChIP avoids these drawbacks by omitting crosslinking, but often results in poor recovery of chromatin-bound proteins. In addition, all ChIP-based methods are subject to antibody quality considerations. Enzymatic methods for mapping protein-DNA interactions, which involve fusion of a protein of interest to a DNA-modifying enzyme, have also been used to map protein-DNA interactions. We recently combined one such method, chromatin endogenous cleavage (ChEC), with high-throughput sequencing as ChEC-seq. ChEC-seq relies on fusion of a chromatin-associated protein of interest to micrococcal nuclease (MNase) to generate targeted DNA cleavage in the presence of calcium in living cells. ChEC-seq is not based on immunoprecipitation and so circumvents potential concerns with crosslinking, sonication, chromatin solubilization, and antibody quality while providing high resolution mapping with minimal background signal. We envision that ChEC-seq will be a powerful counterpart to ChIP, providing an independent means by which to both validate ChIP-seq findings and discover new insights into genomic regulation.

EXTERNAL LINK

<https://www.jove.com/video/55836/genome-wide-mapping-protein-dna-interactions-with-chec-seq>

THIS PROTOCOL ACCOMPANIES THE FOLLOWING PUBLICATION

Grünberg S, Zentner GE. Genome-wide Mapping of Protein-DNA Interactions with ChEC-seq in *Saccharomyces cerevisiae*. J Vis Exp 124:e55836.

GUIDELINES

This is a condensed, bench-friendly version of the detailed protocol in the linked JoVE article.

MATERIALS

NAME ▾	CATALOG # ▾	VENDOR ▾	CAS NUMBER ▾	RRID ▾
EGTA	View	Sigma Aldrich		
RNase A	R4642-10MG	Sigma-aldrich		
Spermidine	85558	Sigma Aldrich		
Buffered Phenol Chloroform Isoamyl alcohol (P:C:I) ((25:24:1, saturated with 10 mM Tris, pH 8.0 and 1 mM EDTA	Sigma P2069	Sigma		
Proteinase K	E00491	Thermo Fisher Scientific		
Sodium Dodecyl Sulfate (SDS)	BP166-500	Fisher Scientific		
Roche Complete Protease Inhibitor EDTA-Free tablets	5056489001	Sigma Aldrich		
Agencourt Ampure XP	A63AA0	Beckman Coulter		
Potassium Chloride	P9541	Sigma Aldrich		
Calcium Chloride	C4904	Sigma Aldrich		
EDTA	AM9261	Invitrogen - Thermo Fisher		

NAME ▾	CATALOG # ▾	VENDOR ▾	CAS NUMBER ▾	RRID ▾
Digitonin	300410	Millipore Sigma		
Linear acrylamide	AM9520	ThermoFisher		
Spermine	AC132750010	Fisher Scientific		

MATERIALS TEXT

Protease inhibitors should not contain EDTA so as not to interfere with MNase cutting.

SPRI beads can also be made in-house using the protocol found here: https://ethanomics.files.wordpress.com/2012/08/serapure_v2-2.pdf

BEFORE STARTING

Prepare and store the following stock solutions prior to beginning. In addition to these solutions, you will need 1 M CaCl₂, 10% SDS, and 75% ethanol.

2% digitonin

Add 20 mg high-purity digitonin to 1 mL DMSO. Vortex for ~30 sec to dissolve and store 100 µL aliquots at -20°C.

Buffer A (100 mL)

1.5 mL 1 M Tris, pH 7.5 (15 mM final)

8 mL 1 M KCl (80 mM final)

50 µL 0.2 M EGTA (0.1 mM final)

H₂O to 100 mL

Prior to use, add:

Protease inhibitors to 1X

1 µL 200 mM spermine/1 mL buffer A (0.2 mM final)

0.5 µL 1 M spermidine/1 mL buffer A (0.5 mM final)

Make 4 mL complete buffer A/sample

2X Stop buffer (100 mL)

8 mL 5 M NaCl (400 mM final)

4 mL 0.5 M EDTA (20 mM EDTA)

2 mL 0.2 M EGTA (4 mM EGTA)

For each strain, prepare 6 microfuge tubes for collecting time points. To each tube, add 90 µL 2X stop buffer and 10 µL 10% SDS

Yeast culture and harvest

- 1 The day before the experiment, inoculate 3 mL YPD or SC medium with a single colony. Grow overnight at 30°C.
- 2 In the morning, dilute the overnight culture to OD₆₀₀ = 0.2-0.3 in 50 mL YPD or SC medium in a 300 mL flask. Grow 50 mL culture at 30°C until OD₆₀₀ = 0.5-0.7.
- 3 Harvest cells in a 50 mL conical tube at 1,500 x g for 1 min.
- 4 Wash cells 3 x 1 mL Buffer A. Transfer cells to a 1.5 mL tube with the first wash and spin as above between washes.

ChEC

- 5 Permeabilize cells. Resuspend pellet in 600 μ L Buffer A + 0.1% digitonin (add 30 μ L 2% digitonin in DMSO to 570 μ L Buffer A) and incubate at 30°C for 5 min. Remove 100 μ L as zero timepoint prior to step 6.
- 6 Add 1.1 μ L 1 M CaCl₂ (~2 mM final), mix, and incubate at 30°C.
- 7 At each desired time point, remove a 100 μ L aliquot of the digestion to a tube containing 90 μ L stop solution and 10 μ L 10% SDS and vortex to mix.



ChEC experiments with factors that rapidly cleave DNA at 30°C may be performed at lower temperatures to slow MNase cleavage kinetics.

DNA extraction

- 8 Add 2 μ L 20 mg/mL proteinase K. Digest protein at 55°C for 20 min.
- 9 Extract nucleic acids. Add 200 μ L phenol/chloroform/isoamyl alcohol, mix well, and spin at max. speed for 5 min in a microfuge. Transfer aqueous phases to new tubes, add 2 μ L (10 μ g) linear acrylamide and 500 μ L 100% ethanol, mix, and precipitate at -80°C for \geq 30 min.
- 10 Spin at max speed and 4°C for 10 min.
- 11 Wash pellets with 1 mL 75% ethanol and aspirate ethanol.
- 12 Briefly air-dry pellets and resuspend in 29 μ L Qiagen EB or comparable buffer + 1 μ L 10 mg/mL RNase A and incubate at 37°C for 10 min.
- 13 Run 5 μ L RNase-treated DNA on a 1.5% agarose gel to check DNA fragmentation if desired.

Size selection

- 14 Dilute RNase-treated DNA to 200 μ L with Qiagen EB or comparable buffer.
- 15 Add 160 μ L Ampure beads (0.8:1 beads:sample ratio) and pipet up and down 10X to mix. Incubate at room temperature for 5 min.
- 16 Collect beads on magnetic rack for 2 min.
- 17 Remove the supernatant (~400 μ L) to a new tube containing 16 μ L 5 M NaCl (~200 mM final).

- 18 Extract DNA from the unbound fraction. Add 400 μ L phenol/chloroform/isoamyl alcohol, mix well, and spin at max. speed for 5 min in a microfuge.
- 19 Transfer aqueous phases to new tubes, add 2 μ L (10 μ g) linear acrylamide and 1 mL 100% ethanol, mix, and precipitate at -80C for \geq 30 min.
- 20 Spin at max speed and 4°C for 10 min.
- 21 Wash pellets with 1 mL 75% ethanol and remove ethanol with vacuum.
- 22 Briefly air-dry pellets and resuspend in 25 μ L Qiagen EB or comparable buffer. Recovered DNA can be quantified by Qubit and the size distribution analyzed via TapeStation using a high-sensitivity tape. Sequencing libraries can be prepared using any standard ChIP-seq-style method.



This is an open access protocol distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited