

Jan 04, 2026

Version 2

FLEX(+) Bacterial DNA Extraction Protocol for Nanopore Sequencing V.2

DOI

<https://dx.doi.org/10.17504/protocols.io.81wgbwbkogpk/v2>

Jack Boulé^{1,2}, Karan Desai^{1,2}, Robert Rebelo¹, Susan M Poutanen^{1,2}, Golnoush Akhtari¹

¹UHN/Mount Sinai Department of Microbiology, Toronto;

²UofT Department of Laboratory Medicine and Pathobiology

Mount Sinai Microbiology



Jack Boulé

Microbiology, Mount Sinai Hospital, Toronto

Create & collaborate more with a free account

Edit and publish protocols, collaborate in communities, share insights through comments, and track progress with run records.

Create free account

OPEN  ACCESS



DOI: <https://dx.doi.org/10.17504/protocols.io.81wgbwbkogpk/v2>

Protocol Citation: Jack Boulé, Karan Desai, Robert Rebelo, Susan M Poutanen, Golnoush Akhtari 2026. FLEX(+) Bacterial DNA Extraction Protocol for Nanopore Sequencing . **protocols.io**

<https://dx.doi.org/10.17504/protocols.io.81wgbwbkogpk/v2> Version created by **Jack Boulé**

Manuscript citation:

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

Protocol status: Working

Improved formatting version V3 now available

Created: January 04, 2026

Last Modified: January 04, 2026

Protocol Integer ID: 237041

Keywords: Nanopore, DNA Extraction, Extraction, Eluate, Long fragment, rapid extraction, fast, Sequencing, Illumina, dna extraction protocol for nanopore sequencing, nanopore sequencing, dna extraction protocol, nanopore, department of clinical microbiology, clinical microbiology, fragment genomic dna from gram, suitable for downstream molecular workflow, viridans group streptococci, enterococcus, read sequencing, positive bacteria, fragment genomic dna, downstream molecular workflow, hemolytic streptococcus, staphylococcus, bacterial dna extraction protocol for nanopore, bacterial dna extraction protocol, using oxford nanopore r10 chemistry, oxford nanopore r10 chemistry, oxford nanopore, dna extraction, addition to nanopore, bacterial dna, extracted dna, genome sequencing, fragment length for downstream molecular application, downstream molecular application, sequencing, specific extraction option, single extraction, bacteria, duplicate extraction step, dna, dna with sufficient purity, extraction, avoiding duplicate

Disclaimer

Please note: although this workflow may be broadly applicable to Gram-positive bacteria, it has been validated only for **MRSA, Group A, B, C, and G streptococci** (*Streptococcus pyogenes*, *Streptococcus agalactiae*, *Streptococcus dysgalactiae* subspp., and *Streptococcus anginosus* group isolates, respectively), *Streptococcus pneumoniae*, *Enterococcus faecalis*, and *Enterococcus faecium*.

Abstract

This protocol provides a **rapid, high-throughput, and cost-effective** method to extract **high-quality, long-fragment genomic DNA** from **Gram-positive bacteria** (e.g., *Staphylococcus*, *Enterococcus*, β -hemolytic *Streptococcus*, and viridans group streptococci). The workflow is optimized to produce DNA with **sufficient purity, concentration, and fragment length** for downstream molecular applications, with a primary focus on **whole-genome sequencing using Oxford Nanopore R10 chemistry** (including library preparation requirements).

In addition to Nanopore sequencing, the extracted DNA is suitable for common downstream workflows such as **qPCR** and other **library preparation** applications. The protocol can also be used for **Illumina short-read sequencing**; however, faster Illumina-specific extraction options may be available. In settings where **both Nanopore and Illumina sequencing** are performed in parallel, this protocol enables a **single extraction** to support both workflows, avoiding duplicate extraction steps.

This method has been **validated and implemented** by the **Department of Clinical Microbiology at Mount Sinai Hospital**, and is currently used routinely to support sequencing workflows.

Attachments



Flex(+) DNA Extracti...

147KB

Guidelines

Definitions and Abbreviations:

- **FLEX(+)**: Fast, Long-fragment, EXtraction for Gram + bacteria.
- **SPRI**: Solid-Phase Reversible Immobilization paramagnetic bead chemistry.
- **RT**: Room temperature (20–25 °C).



Materials

Reagents

- **TE buffer (pH 8.00, filtered):** 10 mM Tris, 1 mM EDTA
- **Sarkosyl (N-lauroylsarcosine; stock):** 10% (prepared in ddH₂O or TE buffer)
- **Lysozyme (stock):** 100 mg/mL (prepared in ddH₂O or TE buffer)
- **Proteinase K (stock):** 20 mg/mL (prepared in ddH₂O or TE buffer)
- **SPRI-Select paramagnetic beads:** Beckman Coulter
- **Molecular-grade water:** ddH₂O
- **Ethanol (fresh):** 80% (v/v) for bead washes

Consumables

- **0.5 mm glass bead tubes:** Qiagen PowerBead tubes with screw caps (or equivalent)
- **Inoculation loops:** sterile 1 µL loop (or 10 µL loop)

Collection vessels (choose one):

- 1.5 mL low-bind microcentrifuge tubes, **or**
- 0.8 mL “midi” or PCR 96-well plate
- **Pipette tips:** aerosol-resistant filter tips (20–1000 µL range)

Equipment

- **Vortex mixer:** compatible with a Qiagen PowerBead vortex adapter top
- Qiagen PowerBead vortex adapter top
- **Heating:** calibrated temperature blocks or water baths at **37 °C** and **56 °C**
- **Magnetic separation (choose one):**
- Thermo **DynaMag** rack (for 1.5 mL tubes), **or**
- Illumina-style **96-well magnetic rack** (for midi plates)
- **DNA quantification:** Qubit fluorometer (HS dsDNA assay) and NanoDrop (or equivalent spectrophotometer)
- **Fragment analysis (optional/as available):** TapeStation, Femto Pulse, or equivalent system



Troubleshooting

Problem

If concentration QC fails: Too low

Solution

Discard the eluate and rerun the protocol with more biomass than initial run.

Problem

If concentration QC fails: Too high

Solution

Simply dilute the final eluate with more ddH₂O until appropriate

Problem

If contamination QC fails:

Solution

Perform another SPRI Cleanup on the final eluate, but use 100 μ L of SPRI beads instead of original 225 μ L.

Problem

If fragment analyses QC fails: Too short

Solution

Discard eluate, repeat full FLEX protocol with 3 min of bead beating instead of 5 min.

Problem

If fragment analyses QC fails: Too long

Solution

Discard eluate, repeat full FLEX protocol with 8 min of bead beating instead of 5 min.

Safety warnings

⚠ Throughout the protocol, particularly the section that utilizes magnets, it is recommended that you review the actual mechanism behind DNA binding, and understand the chemistry of the SPRI select beads. This makes troubleshooting, as well as appropriate removal from the magnet, much more intuitive.

Warning: Sarkosyl (N-lauroylsarcosine) is an irritant and can be harmful if inhaled or if it contacts skin/eyes—handle it in a fume hood when possible, wear appropriate PPE (lab coat, nitrile gloves, eye protection), avoid generating aerosols, and clean spills immediately according to your institution's chemical safety procedures.



Before start

Specimen Collection

- **Specimen:** Single pure isolate from a confluent purity plate (18–24 h typical, organism-appropriate conditions).
- **Transport/Storage:** Room temperature (RT) bench-top during setup
- **Rejection criteria:** Mixed culture, plate age under 72 h (discretionary), or visible contamination.
- **Recommendations:**
 1. Confirm species ID using MALDI-TOF or other equivalent identification mechanism.
 2. Use an ethanol safe marker/pen when labelling tubes to prevent washing of labels



FLEX(+) Extraction Preparation

- 1 Label a **1:1 matched set** of **PowerBead tubes** and **LoBind tubes** for each isolate accession (use the same sample ID format across all tubes). Then label the **collection vessels** using the same IDs—either:
 - **1.5 mL Eppendorf tubes** (recommended for ≤ 48 samples), **or**
 - a **0.8 mL 96-well PCR plate** (recommended for > 48 samples).

- Note: Each requires a different magnet type; ensure you have the appropriate magnet.
- 2 Pre-equilibrate two temperature blocks or water baths to **37 °C** and **56 °C** (either format may be used based on personal preference/equipment availability).
- 3 Attach the **Qiagen Vortex Adapter top** to a **Vortex-Genie** (or equivalent vortex mixer).

Note: The adapter top holds **up to 24 samples**; use multiple adapter tops in parallel if processing more than 24 samples at once.

- 4 Calculate how much of each enzyme is required for given batch size (See Table 1).

- 5 Table 1:

	A	B	C	D
Reagent:		10% Sarkosyl Solution	Proteinase K 20mg/mL	Lysozyme (100mg/ml)
Volume/Sample:		8 μ L per sample	5 μ L per sample	4 μ L

- 6 Calculate the amount of each reagent required for a given batch size (See Table 2).

- 7 Table 2:

	A	B	C	D	E	F
Reagent		TE Buffer (10 mM Tris, 1 mM EDTA), pH 8.00)	SPRI Select Beads	Fresh 80%	Mol e	10 % Sa



	A	B	C	D	E	F
	en t:		(Beckman Coulter)	Ethan ol	c ul a r G r a d e W a t e r (d d H 2 O)	rk os yl So luti on
	Vo lu m e/ Sa m pl e:	300ul	225ul	1200u l	1 0 0 ul p e r s a m pl e	8μ L

- 8 Remove enzymes (Proteinase K and Lysozyme) from the freezer and allow them to thaw. Keep at 4 °C until ready for use.
- 9 Aliquot **300 μL** of TE Buffer into each 0.5mm Glass Powerbead Tube.
- 10 Inoculate each PowerBead tube with **isolated bacterial colonies** using either a **heaping 1 μL loop** or **half of a 10 μL loop**, while **minimizing agar carryover**.

Note: After inoculation, gently **spin/rotate the loop in the tube** to help disperse and homogenize the biomass before proceeding.

Enzymatic Lysis



- 11 Pipette **4 μ L** of Lysozyme (L100) (Using a P10) into each Powerbead tube, directly into the solution.
- 12 Slowly and **gently** pipette mix up and down 2-3 times.
- 13 Place Powerbead tube into a 37 °C dry incubator or a 37 °C water bath, maintaining the original layout of the tubes on their respective racks.
- 14 Incubate for **15 minutes**.
- 15 Remove from the incubator.

Mechanical Lysis

- 16 Insert Powerbead tubes into a Qiagen Vortex Adapter Top, with the cap side facing inward.
- 17 Place the top onto a Vortex Genie.
- 18 Set the vortex **speed to 9** (or the max speed on an equivalent Vortex), and allow the top to spin for **5 minutes**.

Note: If using an alternative Vortex, samples may spin faster than expected, causing over fragmentation of DNA, this can be corrected for by lowering the speed until fragment analysis returns optimal results)
- 19 Turn off the vortex and remove the adapter top.
- 20 Place the tubes back onto a rack, maintaining the original format.

Denaturation of Interfering Proteins

- 21 Pipette **5 μ L** of Proteinase K (20 mg/ml) (Using a P10) into each Powerbead tube, directly into solution.

- 22 Slowly and **gently** pipette mix up and down 2-3 times.
- 23 Place Powerbead tube into a 56 °C dry incubator or a 56 °C water bath, maintaining the original layout of the tubes on their respective racks.
- 24 Incubate for **15 min.**
- 25 Remove from incubator.

Removal of Contaminants/DNA Binding

- 26 Transfer **225 µL** of the solution from Powerbead tubes into either a 0.8 ml, 96 well MIDI/PCR Plate, or a 1.5 ml Eppendorf tube (see note in step 1)

Note: You may find that the powerbeads are sucked up into the pipette. This can be solved by tilting the tube sideways and drawing solution from the side beads are not sitting on.
- 27 Add **225 µL** of SPRI Select Beads into each well/tube.

Note: a 1:1 ratio of SPRI select beads to solution ensures you select for fragments of all sizes.
- 28 Mix by pipetting up and down 3-5 times.

- Homogeneity is critical for this step as too little mixing will prevent complete DNA binding.
- 29 Place onto appropriate magnet (96 well Illumina Magnet for MIDI plates, Thermo DYNAMag Magnet for Eppendorfs).
- 30 Leave on magnet until lysate appears clear (3-5 min), and a pellet has formed on the well/tube side wall.
- 31 With the plate/tube STILL on the magnet, carefully remove the supernatant with a P1000 set to 1000 µL. Avoid touching the pellet. If any pellet is sucked into the pipette, put it back into the well/tube, towards the magnet side, and leave for another 2 minutes before removal of supernatant.



It is highly recommended that you review the mechanism behind SPRI select beads to best understand and proactively troubleshoot proper lysate removal.

Ethanol Washes x 2

- 32 With the following steps, you must put on and take off the plate/tube from the magnet as stated. Failure to do so will result in the complete loss of eluate.
- 33 **Remove** the tube/plate from the magnet.
- 34 Pipette 600 μ L of 80% ethanol into each well/tube directly onto the pellet.
- 35 Resuspend the pellet in the ethanol by pipetting up and down until homogeneous.
Note: Some pellets may require scraping with the tip of the pipette to help them better homogenize.
- 36 Place tube/plate **back onto the magnet**.
- 37 Allow pellet to reform (2-3 min).
- 38 Remove supernatant with a P1000 set to 1000 μ L.
- 39 **Remove tube/plate** from magnet again.
- 40 Pipette 600 μ L of 80% ethanol into each well/tube directly onto the pellet.
- 41 This time, **do not** resuspend the pellet fully by mixing, simply allow the ethanol to sit on the pellet.
- 42 Place the tube/plate **back onto the magnet**.
- 43 Wait 2-3 min.



- 44 Remove and discard the supernatant with a P1000 set to 1000 μ L, carefully avoiding the pellet.
- 45 Allow pellet to air dry for **10 min**, monitoring and wicking away any residual pooling; do not over-dry to the point of visible cracking. That said, it is better to over-dry than under-dry, as any remaining ethanol will act as a contaminant in your final eluate.
- 46 Once dry, take the tube/plate **off the magnet**.

Final DNA Elution

- 47 Add **100 μ L** of Molecular Grade Water (ddH₂O) directly onto the pellet.

Note: if you are finding that your yield is too low using 100 μ L, you may decrease the volume accordingly.
- 48 Resuspend pellet **fully**, by mixing up and down with a pipette.
- 49 Place tube/plate **back onto the magnet**.
- 50 Wait 2-3 min for pellet to reform.
- 51 Transfer all 100 μ L of the supernatant into a labelled Lo-Bind Eppendorf tube, this is your final DNA solution, which can now be stored at -80 °C for up to 10 years.
- 52 You may now discard the tubes/plate with the pellet (DNA is now in the supernatant you just realiquoted)

Eluate Quality Control (Optional, but highly recommended)

- 53 Quantify DNA with a Qubit Fluorometer, using an eluate input of 4 μ L, and a High Sensitivity Reagent input of 196 μ L. (See Oxford Nanopore Technologies NO-MISS Protocol for acceptable eluate concentrations)
- 54 Check for contamination using a Nanodrop or equivalent device. (See Oxford Nanopore Technologies NO-MISS Protocol for acceptable 260/280 and 260/230 ratios)



- 55 Optionally: Check for high fragment length retention using a Bioanalyzer or Fragment Analyzer (See Oxford Nanopore Technologies NO-MISS Protocol for acceptable fragment lengths)
- 56 See Troubleshooting Guide for related fixes