

Gingeras Lab RNA-Seq Library Production Document

ENCODE Transcriptome

Sample Description: A549 2 Cyto_TAP

RNA ID: 088C

Library ID: LID47042

Protocol ID: A Tail Small RNA

Cold Spring Harbor Laboratory

Genome Center

500 Sunnyside Blvd

Woodbury, NY 11797

LAB MEMBERS

Wet lab: Kim Persaud, Meagan Fastuca, Carrie A. Davis, Jorg Drenkow, Lei Hoon See, Huaian Wang.

Computational Lab: Alex Dobin, Sonali Jha, Wei Lin, Felix Schlesinger, Chris Zaleski.

PI: Tom Gingeras

STRATEGY: This document contains information about small RNA libraries generated as part of the ENCODE Consortia. It describes the Small RNA Isolation and cloning methods used to generate stranded libraries that capture the 5' ends of RNAs <200 nucleotides in length. The libraries can then be sequenced on the Illumina platform. The 3' ends are A-tailed followed by ligating on a RNA linker to the 5' ends and RT-PCR.

CELL CULTURE: Cells are grown according to the ENCODE growth protocol and standards. Each bioreplicate was grown and isolated independently.

RNA ISOLATION:

Kits: RNeasy Mini kit (QIAGEN cat: 74106)
miRNeasy Mini kit (QIAGEN cat#:217004)
RNeasy MinElute cleanup kit (QIAGEN cat#:74204)

Separate Cytosol and Nuclear From the Whole Cells

1. Regular harvest and count cells and centrifuge for 10 min at 1900 rpm 4°C.
2. Completely aspirate supernatant.
3. Resuspend all pellets in 10-30 mL of cold PBS by pipetting up and down.
4. Centrifuge for 5 min at 2000 rpm 4°C.
5. Carefully aspirate the supernatant.

Number of Cells	RLN Buffer (4°C) (mL)
5X10 ⁶ - 5X10 ⁷	0.5
5X10 ⁷ - 1X10 ⁸	1.0
5X10 ⁷ - 2.5X10 ⁸	2.0
2.5X10 ⁶ - 5X10 ⁸	4.0

6. Add the appropriate amount of cold Buffer RLN to lyse plasma membrane. For the pelleted cells loosen them by pipetting up and down. Incubate on ice for 5 min.
7. Centrifuge lysate at 4°C for 10 min at 3200 rpm. Transfer the supernatant (the cytosol) to an RNase free centrifuge tube and keep the nuclear pellet.

For the nuclear pellet, put 1 mL RLN buffer and try to resuspend the pellet. Centrifuge at 4°C for 5 min at 3200 rpm. Carefully discard the supernatant, add 800 µL RLT (+BME 1:100, 1 mL RLT buffer add 100 µL BME). Homogenize the sample using a syringe and 18 gauge needle. Pass the sample through the needle until it becomes smooth and there are no thick globs. It is important that the sample is homogenized completely. Freeze the lysate in -80°C.

****To purify small RNA fraction proceed to Small RNA Purification.****

****To purify large RNA fraction proceed to Total RNA (Containing Large RNA) Purification.**** (Large RNAs were sequenced using RNA-Seq as well as CAGE).

Isolate Small RNA from Cytosol

- C8. Add 7X volumes of QIAzol Lysis Reagent to the supernatant (cytosol) and vortex to mix well.
- C9. Place the tube(s) containing the homogenate on the benchtop at room temperature (15-25°C) for 5 min.
- C10. Add 20% volumes of chloroform to the homogenate and cap it securely. Shake the tube vigorously for 15 s.
- C11. Place the tube containing the homogenate on the benchtop at room temperature for 2-3 min.
- C12. Centrifuge the homogenate for 15 min at 12,000 x g at 4°C.
- C13. Transfer the upper, colorless, aqueous phase containing the RNA to a new RNase free Falcon tube.
- C14. Add an equal volume of 70% ethanol and mix thoroughly by vortexing. Do not centrifuge.
- C15. Pipet 700 µL of the sample including any precipitate that may have formed into an RNeasy Mini spin

column placed in a 2 mL collection tube. Close the lid gently and centrifuge at $\geq 8000 \times g$ ($\geq 10,000$ rpm) for 30 s at room temperature. Repeat this step until the whole sample has been pipetted into the spin column and discard the flow-through each time.

C16. Pipet the flow-through (which contains miRNA) into a 2 mL RNase free tube. The spin column contains the large RNA.

****To purify small RNA fraction proceed to Small RNA Purification.****

Small RNA Purification

S1. Add 0.65 volumes of 100% ethanol to the flow-through from step C16 and mix thoroughly by vortexing. Do not centrifuge.

S2. Pipet 700 μ L of the sample into an RNeasy MinElute spin column placed in a 2 mL collection tube. Close the lid gently and centrifuge at $\geq 8000 \times g$ ($\geq 10,000$ rpm) for 30 s at room temperature. Discard the flow through. Repeat this step until the whole sample has been pipetted into the spin column and discard the flow-through each time.

S3. Add 700 μ L Buffer RWT to the RNeasy MinElute spin column. Close the lid gently and centrifuge for 30 s at $\geq 8000 \times g$ ($\geq 10,000$ rpm) to wash the column. Discard the flow through.

S4. Pipet 500 μ L Buffer RPE into the RNeasy MinElute spin column. Close the lid gently and centrifuge for 30 s at $\geq 8000 \times g$ ($\geq 10,000$ rpm). Discard the flow-through.

S5. Add 500 μ L of 80% ethanol to the RNeasy MinElute spin column. Close the lid gently and centrifuge for 2 min at $\geq 8000 \times g$ ($\geq 10,000$ rpm) to dry the spin column membrane. Discard the flow-through and the collection tube.

S6. Place the RNeasy MinElute spin column into a new 2 mL collection tube, making sure that the column does not come in contact with the flow through. Open the lid and centrifuge for 5 min at $\geq 8000 \times g$ ($\geq 10,000$ rpm).

S7. Place the RNeasy MinElute spin column into a 1.5 mL collection tube and pipet 20 μ L RNase free water onto the spin column membrane. Close the lid gently and wait 1 min. Then centrifuge for 1 min at $\geq 8000 \times g$ ($\geq 10,000$ rpm) to elute the small RNA fraction. Repeat with a second volume of 20 μ L RNase free water.

S8. Proceed to ethanol precipitation.

Ethanol Precipitation (same for Total, Small and Large RNA)

1. Add 2.5 volumes of 100% ethanol and 1/10 volumes of NaOAc PH 5.5 to the eluted RNA.
2. Freeze in -80°C for at least 30 min.
3. Centrifuge for 35 min at max speed at 4°C .
4. Pipette and discard the supernatant making sure not to touch the pellet of RNA.
5. Wash with 1 mL of 70% ethanol and centrifuge at max speed for 5 min.
6. Pipette and discard the supernatant.
7. Open the cap and speed vacuum at low heat for 3-5 min making sure that the pellet is dry.
8. Resuspend the pellet with RNase-free water.

DNase Digest (same for Total, Small and Large RNA)

Reagents	100 μ L Sample (100 μ g RNA max)	50 μ L Sample (50 μ g RNA max)
Total RNA (100 μ g max)	78 μ L	39 μ L
10X One-phor-all Buffer	10 μ L	5 μ L
10 U/ μ L DNase/RNase Free	8 μ L	4 μ L

20 U/ μ L RNasin/anti-RNase	4 μ L	2 μ L
Total Volume	100 μ L	50 μ L

1. Add all reagents to resuspended RNA and pipette to mix well.
2. Place in a 37°C waterbath for 30 min.
3. Proceed to RNA Cleanup, which is different for Small and Total or Large RNA.

Small RNA Cleanup

1. Make sure there is a max of 45 μ g RNA in the 100 μ L RNA sample.
2. Add 350 μ L Buffer RLT to the 100 μ L sample of RNA. Vortex to mix well.
3. Add 675 μ L of 100% ethanol to the reaction and mix by inverting.
4. Transfer 700 μ L of sample into an RNeasy MinElute column in a 2 mL collection tube. Close the lid gently and centrifuge for 30 s at 8000 x g ($\geq 10,000$ rpm). Discard the flow through. Repeat this step with the remaining sample.
5. Add 700 μ L Buffer RWT to the RNeasy MinElute spin column. Close the lid gently and centrifuge for 30 s at ≥ 8000 x g ($\geq 10,000$ rpm) to wash the column. Discard the flow through.
6. Pipet 500 μ L Buffer RPE into the RNeasy MinElute spin column. Close the lid gently and centrifuge for 30 s at ≥ 8000 x g ($\geq 10,000$ rpm). Discard the flow-through.
7. Add 500 μ L of 80% ethanol to the RNeasy MinElute spin column. Close the lid gently and centrifuge for 2 min at ≥ 8000 x g ($\geq 10,000$ rpm) to dry the spin column membrane. Discard the flow-through and the collection tube.
8. Place the RNeasy MinElute spin column into a new 2 mL collection tube, making sure that the column does not come in contact with the flow through. Open the lid and centrifuge for 5 min at ≥ 8000 x g ($\geq 10,000$ rpm).
9. Place the RNeasy MinElute spin column into a 1.5 mL collection tube and pipet 20 μ L RNase free water onto the spin column membrane. Close the lid gently and wait 1 min. Then centrifuge for 1 min at ≥ 8000 x g ($\geq 10,000$ rpm).
10. Repeat step 9 with a second volume of 20 μ L RNase free water.
11. Proceed to ethanol precipitation.

RIBOMINUS TREATMENT: In addition to the probes supplied with the Ribominus kit we also spike-in our own LNA probes against the 5S and 5.8S rRNA.

5S-LNAprobe-1 tt+Ccc+Agg+Cgg+Tct+Ccc+At
 5S-LNAprobe-2 tc+Agg+Gtg+Gta+Tgg+Ccg+Tag
 5.8S-LNAprobe-1 ct+Tca+Tcg+Acg+Cac+Gag+Cc
 5.8S-LNAprobe-2 cg+Ctc+Aga+Cag+Gcg+Tagc

Hybridization Step

Instructions are provided below to perform hybridization for 1–10 μ g of your total RNA sample with the RiboMinus™ Eukaryote Probe. To process >10 μ g total RNA sample, divide your sample into two samples, each containing <10 μ g total RNA.

1. Set a water bath or heat block to 70–75°C.
2. To a sterile, RNase-free 1.5 mL microcentrifuge tube, add the following:
 Total RNA (1–10 μ g): <10 μ L
 RiboMinus™ Probe (15 pmol/L): 8 μ L
 Custom probes (5S, 5.8S 100 μ M each) : 1.5 μ L

Hybridization Buffer: 100 μ L

3. Incubate the tube at 70–75°C for 5 min to denature RNA.
4. Allow the sample to cool to 37°C slowly over a period of 30 min by placing the tube in a 37°C water bath (a heat block works as well). To promote sequence-specific hybridization, it is important to allow slow cooling. **Do not** cool samples quickly by placing tubes in cold water.
5. While the sample is cooling down, proceed to **Preparing Beads**.

*An earlier version of this protocol says to use RNA in less than 20 μ L, add 10 μ L of probe and 300 μ L hybridization buffer, this larger volume means you need to precipitate the ribominused RNA in a 2 mL tube at the end. Either way works. It doesn't change anything else except the supernatant volumes and the precipitation tube size.

Preparing Beads

1. Resuspend RiboMinus™ Magnetic Beads in its bottle by thorough vortexing.
2. Pipet 750 μ L of the bead suspension into a sterile, RNase-free, 1.5 mL microcentrifuge tube.
3. Place the tube with the bead suspension on a magnetic separator for 1 min. The beads settle to the tube side that faces the magnet. Gently aspirate and discard the supernatant.
4. Add 750 μ L sterile, DEPC Water to the beads and resuspend beads by pipetting
5. Place tube on a magnetic separator for 1 min. Aspirate and discard the supernatant.
6. Repeat Steps 4–5 once.
7. Resuspend beads in 750 μ L Hybridization Buffer and transfer 250 μ L beads to a new tube and maintain the tube at 37°C for use at a later step.
8. Place the tube with 500 μ L beads on a magnetic separator for 1 min. Aspirate and discard the supernatant.
9. Resuspend beads in 200 μ L Hybridization Buffer and keep the beads at 37°C until use.

Removing rRNA

1. After the incubation at 37°C for 30 min of the hybridized sample (above), briefly centrifuge the tube to collect the sample to the bottom of the tube.
2. Transfer the sample (~120 μ L - this will be ~330 μ L with the older protocol) to the prepared RiboMinus™ Magnetic beads from Step 9 (**Preparing Beads**, above). Mix well by pipetting up and down
3. Incubate the tube at 37°C for 15 min. During incubation, gently mix the contents occasionally. Briefly centrifuge the tube to collect the sample to the bottom of the tube.
4. Place the tube on a magnetic separator for 1 min to pellet the rRNA-probe complex. **Do not discard the supernatant. The supernatant contains RiboMinus™ RNA.**
5. Place the tube with 250 μ L beads from Step 7 (**Preparing Beads**, above) on a magnetic separator for 1 min. Aspirate and discard the supernatant.
6. To this tube of beads, add ~320 μ L (~500 μ L with older protocol) supernatant containing RiboMinus™ RNA from Step 4, above. Mix well by pipetting up and down or low speed vortexing.
7. Incubate the tube at 37°C for 15 min. During incubation, gently mix the contents occasionally. Briefly centrifuge the tube to collect the sample to the bottom of the tube.
8. Place the tube on a magnetic separator for 1 min to pellet the rRNA-probe complex. **Do not discard the supernatant as the supernatant contains RiboMinus™ RNA.**
9. Transfer the supernatant (~ 320 μ L - ~500 μ L with older protocol) containing **RiboMinus™ RNA** to a small filter column and spin at max speed for 2 min to remove any remaining magnetic particles.
10. Transfer flow through (ribominus RNA) to a new tube (1.5 mL for small volume, 2 mL for large volume)
11. Ethanol precipitate as before but add μ L glycoblu to facilitate the precipitation.
12. After drying the pellet, resuspend in 22.25 μ L H₂O. Keep 1 μ L for running a small RNA Bioanalyzer chip.

LIBRARY PROTOCOL:

The following primers and RNA Linker are needed to perform this procedure:

5'SBS3_Adapter (This is the RNA ligated onto the 5' end): "r" = ribose, RNA base

5'- rArCrArCrUrCrUrUrCrCrCrUrArCrArCrGrArCrGrCrUrCrUrUrCrCrGrArUrCrUrNrNrNrNrCrG

A-Tail RT Primer (This is the primer used in the RT reaction):

5'-TCTCGGCATTCTGCTGAACCGCTCTTCCGATCTTTTTTTTTTTVN

PE 5' PCR (PCR Primer):

5'-AATGATACGGCGACCACCGAGATCTACACTCTTTCCCTACACGACGCTCTTCCGATC
PE 3' PCR (PCR Primer):
5'-CAAGCAGAAGACGGCATACGAGATCGGTCTCGGCATTCTGCTGAACCGCTCTTC

Tobacco Acid Pyrophosphatase Reaction (TAP, Epicentre T19250)

1. Denature RNA at 85°C for 2 min or 65°C for 10 min. Cool on ice for 1 min.
2. Set up the reaction by adding :

a. RNA	21.25 µL
b. 10X TAP reaction buffer	2.5 µL
c. Suprase.In (Ambion 20U/uL)	1 µL
d. TAP (10 U/µL)	0.25 µL
3. Incubate at 37°C for 1hr.
4. Proceed to phenol chloroform extraction.
5. Proceed to ethanol precipitation.
6. After drying the pellet, resuspend in 28 µL H₂O.

Phenol Chloroform Extraction

1. Add 1 volume phenol-chloroform 5:1 (pH 4.5) and vortex for 10 s.
2. Spin at 13000rpm 4°C for 20 min.
3. Transfer the upper phase to a new tube.
4. Add 1 volume chloroform and vortex for 10 s.
5. Spin at 13000rpm 4°C for 15 min.
6. Transfer the upper phase to a new tube.

A-tailing (PolyA kit, Ambion AM1350)

1. Denature RNA at 85°C for 2 min or 65°C for 10 min. Cool on ice for 1 min.
2. Set up the reaction by adding :

a. 5X PolyA buffer	10 µL
b. 25 mM MnCl ₂	5 µL
c. BSA 1mg/mL	2.5 µL
d. 100mM ATP (Roche)	1 µL
e. Suprase.In	1 µL
f. E_PAP Poly A polymerase	2.5 µL
g. RNA	28 µL
3. Incubate at 37°C for 20 min.
4. Proceed to phenol-chloroform extraction.
5. Proceed to ethanol precipitation.
6. After drying the pellet, resuspend in 11 µL H₂O. Keep 1 µL for running a small RNA Bioanalyzer chip.

Ligation

We recently reduced the amount 5'SBS3 adapter by 100 fold. We found that this reduced the amount of linker-linker formed and facilitated its subsequent removal.

1. Denature RNA at 85°C for 2 min or 65°C for 10 min. Cool on ice for 1 min.
2. Set up the reaction by adding :

a. Suprase.In	0.5 µL
b. 10X T4 ligase buffer	1.5 µL
c. BSA	0.25 µL
d. 5'SBS 3 adapter (1 µM)	1 µL

- e. T4 RNA ligase (Ambion 5U/ μL) 0.75 μL
- f. RNA 11 μL

3. Incubate at 4 °C overnight.
4. Proceed to small RNA cleanup using the RNeasy MinElute column.
5. Proceed to ethanol precipitation.
6. After drying the pellet, resuspend in 16.5 μL H₂O.

First Strand cDNA Synthesis

1. To 16.5 μL RNA, add 2 μL A-Tail RT primer.
2. Incubate at 65 °C for 5 min. Leave on ice for 5 min.
3. Then add the following :
 - a. 10mM dNTPs 1.5 μL
 - b. 5X first strand cDNA buffer 6 μL
 - c. 0.1M DTT 1.5 μL
 - d. Anti-RNase 1 μL
 - e. Superscript RT III 1.5 μL

PCR

1. Set up the reaction by adding :
 - a. First strand cDNA 5 μL
 - b. PE 5' PCR primer 100 μM 0.5 μL
 - c. PE 3' PCR primer 100 μM 0.5 μL
 - d. 2X Phusion mix (NEB F-531L) 50 μL
 - e. H₂O 44 μL
2. Program the thermal cycler as follows:

1. 94°C 2 min.
2. 94°C 15 s.
3. 54 °C 30 s. 5'
4. 72 °C 20 s.
5. Go back to step 2 and repeat 4 more times.
6. 94°C 15 s.
7. 60 °C 30 s.
8. 72 °C 20 s.
9. Go back to step 6 and repeat 12 more times.
10. 4 °C forever

3. After PCR, clean up the reaction by putting through a Minelute column as follows:
 - a. Add 5 volumes of PB buffer to the reaction.
 - b. To bind DNA, apply the sample to a Minelute column. Spin at 13000rpm for 1 min. Discard the flow-through.
 - c. Wash with 750 μL PE buffer. Spin at 13000rpm for 1 min. Discard the flow-through.
 - d. Spin at 13000rpm for 1 min to dry the column.
 - e. Add 10 μL EB buffer. Spin at 13000rpm for 1 min to elute DNA.
 - f. Repeat the elution one more time.
 - g. Use 1 μL of the elute for running on a High sensitivity DNA Bioanalyzer chip.

Gel extraction

1. Run the rest of the sample in a 2% agarose gel.
2. Excise the DNA from >128bp to 350bp.
3. Weigh the gel slice and add 3 volumes of QG buffer.
4. Incubate at 50°C for 10 min or until the gel slice has completely dissolved.
5. After the gel slice has dissolved completely, check that the color of the mixture is yellow. **Note** : If the color of the mixture is orange or violet, add 10 µL of 3M NaOAc pH 5.0 and mix. The color of the mixture will turn to yellow.
6. Add 1 gel volume of isopropanol to the sample and mix by inverting the tube several times.
7. Place a Minelute column in a provided 2 mL collection tube.
8. To bind DNA, apply the sample to the Minelute column and spin for 1 min. The maximum volume of the column reservoir is 800 µL. For sample volumes of more than 800 µL, simply load and spin again.
9. Discard the flow-through and place the Minelute column back in the same collection tube.
10. Add 500 µL QG buffer to the spin column and spin for 1 min.
11. Discard the flow-through and place the Minelute column back in the same collection tube.
12. To wash, add 750 µL PE buffer to the Minelute column and spin for 1 min.
13. Discard the flow-through and spin the column for an additional 1 min at >10,000g.
14. Place the Minelute column into a clean 1.5 mL tube.
15. To elute DNA, add 10 µL EB buffer to the center of the membrane, let the column stand for 1 min. and spin for 1 min.
16. Repeat the elution to get a higher yield of DNA.
17. Proceed to ethanol precipitation.

Quantification

1. After drying the pellet, resuspend in 20 µL H₂O.
2. Measure the concentration on the Nanodrop.
3. Run 1 µL on the High sensitivity DNA Bioanalyzer chip.

