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September 2020

# RNeasy<sup>®</sup> Plus Mini Handbook

For purification of total RNA from animal cells and easy-to-lyse  
animal tissues using gDNA Eliminator columns

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## Kit Contents

<b>RNeasy Plus Mini Kit</b>	<b>(50)</b>	<b>(250)</b>
<b>Catalog no.</b>	<b>74134</b>	<b>74136</b>
<b>Number of preps</b>	<b>50</b>	<b>250</b>
gDNA Eliminator Mini Spin Columns (uncolored) (each in a 2 ml Collection Tube)	50	250
RNeasy Mini Spin Columns (pink) (each in a 2 ml Collection Tube)	50	250
Collection Tubes (1.5 ml)	50	250
Collection Tubes (2 ml)	50	250
Buffer RLT Plus*	45 ml	220 ml
Buffer RW1 *	45 ml	220 ml
Buffer RPE† (concentrate)	11 ml	55 ml
RNase-Free Water	10 ml	50 ml
Quick-Start Protocol	1	1

\* Contains a guanidine salt. Not compatible with disinfectants containing bleach. See page 4 for safety information.

† Before using for the first time, add 4 volumes of ethanol (96–100%) as indicated on the bottle to obtain a working solution.

## Storage

The RNeasy Plus Mini Kit should be stored dry at room temperature (15–25°C) and is stable for at least 9 months under these conditions, if not otherwise stated on the label.

## Intended Use

The RNeasy Plus Mini Kit is intended for molecular biology applications. This product is not intended for the diagnosis, prevention or treatment of a disease.

QIAcube® Connect is designed to perform fully automated purification of nucleic acids and proteins in molecular biology applications. The system is intended for use by professional users trained in molecular biological techniques and the operation of QIAcube Connect.

All due care and attention should be exercised in the handling of the product. We recommend all users of QIAGEN® products to adhere to the NIH guidelines that have been developed for recombinant DNA experiments or to other applicable guidelines.

## Safety Information

When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, please consult the appropriate safety data sheets (SDSs). These are available online in convenient and compact PDF format at [www.qiagen.com/safety](http://www.qiagen.com/safety) where you can find, view and print the SDS for each QIAGEN kit and kit component.

<p><b>CAUTION</b></p> 	<p><b>CAUTION:</b> DO NOT add bleach or acidic solutions directly to the sample-preparation waste.</p>
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Buffer RLT Plus contains guanidine thiocyanate and Buffer RW1 contains a small amount of guanidine thiocyanate. This chemical can form highly reactive compounds when combined with bleach. If liquid containing these buffers is spilt, clean with suitable laboratory detergent and water. If the spilt liquid contains potentially infectious agents, clean the affected area first with laboratory detergent and water, and then with 1% (v/v) sodium hypochlorite.

## Quality Control

In accordance with QIAGEN's ISO-certified Quality Management System, each lot of RNeasy Plus Mini Kit is tested against predetermined specifications to ensure consistent product quality.

# Introduction

The RNeasy Plus Mini Kit is designed to purify RNA from small amounts of animal cells or tissues. The kit is compatible with a wide range of cultured cells and with easy-to-lyse tissues. Genomic DNA contamination is effectively removed using a specially designed gDNA Eliminator spin column. The purified RNA is ready to use and is ideally suited for downstream applications that are sensitive to low amounts of DNA contamination, such as quantitative, real-time RT-PCR.\* The purified RNA can also be used in other applications, including:

- Next generation sequencing
- RT-PCR
- Differential display
- cDNA synthesis
- Northern, dot and slot blot analyses
- Primer extension
- Poly A+ RNA selection
- RNase/S1 nuclease protection
- Microarrays

The RNeasy Plus Mini Kit allows the parallel processing of multiple samples in less than 25 minutes. Time-consuming and tedious methods, such as CsCl step-gradient ultracentrifugation and alcohol precipitation steps, or methods involving the use of toxic substances, such as phenol and/or chloroform, are replaced by the RNeasy Plus procedure.

## Principle and procedure

The RNeasy Plus procedure integrates QIAGEN's patented technology for selective removal of double-stranded DNA with well-established RNeasy technology. Efficient purification of high-quality RNA is guaranteed, without the need for additional DNase digestion.

Biological samples are first lysed and homogenized in a highly denaturing guanidine-isothiocyanate-containing buffer, which immediately inactivates RNases to ensure isolation of intact RNA. The lysate is then passed through a gDNA Eliminator spin column. This column, in combination with the optimized high-salt buffer, allows efficient removal of genomic DNA.

\* Visit [www.qiagen.com/geneXpression](http://www.qiagen.com/geneXpression) for information on standardized solutions for gene expression analysis, including QuantiNova® Kits and Assays for quantitative, real-time RT-PCR.

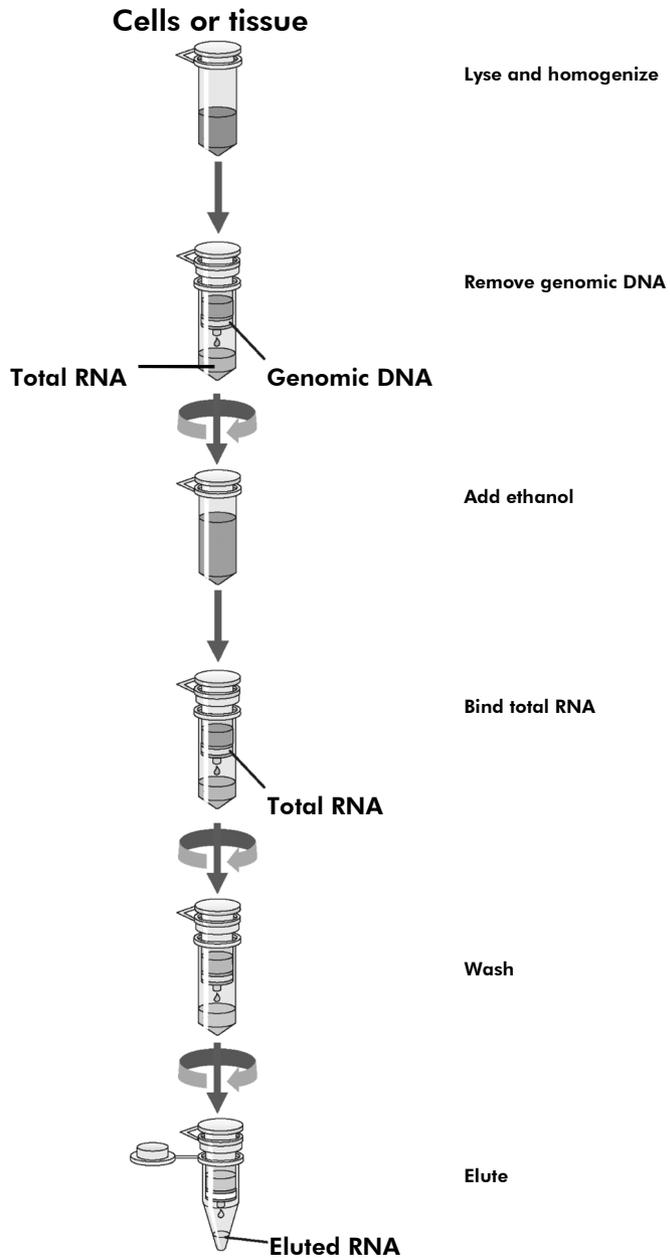
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Ethanol is added to the flow-through to provide appropriate binding conditions for RNA, and the sample is then applied to an RNeasy spin column, where total RNA binds to the membrane and contaminants are efficiently washed away. High-quality RNA is then eluted in 30 µl, or more, of water.

With the RNeasy Plus procedure, all RNA molecules longer than 200 nucleotides are isolated. The procedure provides an enrichment for mRNA, since most RNAs <200 nucleotides (such as 5.8S rRNA, 5S rRNA and tRNAs, which together comprise 15–20% of total RNA) are selectively excluded. The size distribution of the purified RNA is comparable to that obtained by centrifugation through a CsCl cushion, where small RNAs do not sediment efficiently.

In this handbook, different protocols are provided for different starting materials. The protocols differ primarily in the lysis and homogenization of the sample. Once the sample is applied to the gDNA Eliminator spin column, the protocols are similar (see flowchart, next page).

**RNeasy Plus Procedure**



## Automated purification of RNA on QIAcube Instruments

Purification of RNA can be fully automated on QIAcube Connect or the classic QIAcube. The innovative QIAcube instruments use advanced technology to process QIAGEN spin columns, enabling seamless integration of automated, low-throughput sample prep into your laboratory workflow. Sample preparation using QIAcube instruments follows the same steps as the manual procedure (i.e., lyse, bind, wash and elute), enabling you to continue using the RNeasy Plus Mini Kit for purification of high-quality RNA.

QIAcube instruments are preinstalled with protocols for purification of plasmid DNA, genomic DNA, RNA, viral nucleic acids and proteins, plus DNA and RNA cleanup. The range of protocols available is continually expanding, and additional QIAGEN protocols can be downloaded free of charge at [www.qiagen.com/qiacubeprotocols](http://www.qiagen.com/qiacubeprotocols).



**QIAcube Connect.**

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## Equipment and Reagents to Be Supplied by User

When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

For all protocols

- 14.3 M  $\beta$ -mercaptoethanol ( $\beta$ -ME) (commercially available solutions are usually 14.3 M), alternatively dithiothreitol (DTT, 2 M stock solution);
- Sterile, RNase-free pipet tips
- Microcentrifuge (with rotor for 2 ml tubes)
- 96–100% ethanol\*
- 70% ethanol\* in water
- Disposable gloves
- For tissue samples: RNAprotect<sup>®</sup> Tissue Reagent (see ordering information, page 43) or liquid nitrogen
- Equipment for sample disruption and homogenization (see pages 13–13). Depending on the method chosen, one or more of the following are required:
  - Trypsin and PBS
  - QIAshredder homogenizer (see ordering information, page 43)
  - Blunt-ended needle and syringe
  - Mortar and pestle
  - TissueLyser II or TissueLyser LT (see ordering information, page 43)
  - TissueRuptor<sup>®</sup> II homogenizer (see ordering information, page 43)

\* Do not use denatured alcohol, which contains other substances, such as methanol or methylethylketone.

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## Important Notes

### Determining the amount of starting material

It is essential to use the correct amount of starting material to obtain optimal RNA yield and purity. The maximum amount that can be used is limited by:

- The type of sample and its DNA and RNA content
- The volume of Buffer RLT Plus required for efficient lysis and the maximum loading volume of the RNeasy spin column
- The DNA removal capacity of the gDNA Eliminator spin column
- The RNA binding capacity of the RNeasy spin column

When processing samples containing high amounts of DNA or RNA, less than the maximum amount of starting material shown in Table 1 should be used, so that the DNA removal capacity of the gDNA Eliminator spin column and the RNA binding capacity of the RNeasy spin column are not exceeded.

When processing samples containing average or low amounts of RNA, the maximum amount of starting material shown in Table 1 can be used. However, even though the RNA binding capacity of the RNeasy spin column is not reached, the maximum amount of starting material must not be exceeded. Otherwise, lysis will be incomplete and cellular debris may interfere with the binding of RNA to the RNeasy spin column membrane, resulting in lower RNA yield and purity.

More information on using the correct amount of starting material is given in each protocol. Table 2 shows expected RNA yields from various cells and tissues.

**Note:** If the DNA removal capacity of the gDNA Eliminator spin column is exceeded, the purified RNA will be contaminated with DNA. Although the gDNA Eliminator spin column can bind more than 100 µg DNA, we recommend using samples containing less than 20 µg DNA to ensure removal of virtually all genomic DNA. If the binding capacity of the RNeasy spin column is exceeded, RNA yields will not be consistent and may be reduced. If lysis of the starting material is incomplete, RNA yields will be lower than expected, even if the binding capacity of the RNeasy spin column is not exceeded.

**Table 1. RNeasy Mini spin column specifications**

<b>Maximum binding capacity</b>	<b>100 µg RNA</b>
Maximum loading volume	700 µl
RNA size distribution	RNA >200 nucleotides
Minimum elution volume	30 µl
Maximum amount of starting material	
Animal cells	1 × 10 <sup>7</sup> cells
Animal tissues	30 mg

**Table 2. Yields of total RNA with the RNeasy Plus Mini Kit**

Cell cultures (1 × 10 <sup>6</sup> cells)	Average yield of total RNA* (µg)	Mouse/rat tissues (10 mg)	Average yield of total RNA* (µg)
NIH/3T3	10	Embryo (13 day)	25
HeLa	15	Brain	5–10
COS-7	35	Heart	4–8
LMH	12	Kidney	20–30
Huh	15	Liver	40–60
		Lung	10–20

\* Amounts can vary due to factors, such as species, developmental stage and growth conditions. Since the RNeasy procedure enriches for mRNA and other RNA species >200 nucleotides, the total RNA yield does not include 5S rRNA, tRNA and other low-molecular-weight RNAs, which make up 15–20% of total cellular RNA.

Counting cells or weighing tissue is the most accurate way to quantitate the amount of starting material. However, the following may be used as a guide.

## Animal cells

The number of HeLa cells obtained in various culture vessels after confluent growth is given in Table 3.

**Table 3. Growth area and number of HeLa cells in various culture vessels**

Cell-culture vessel	Growth area (cm <sup>2</sup> )*	Number of cells <sup>†</sup>
<b>Multiwell plates</b>		
96-well	0.32–0.6	4–5 × 10 <sup>4</sup>
48-well	1	1 × 10 <sup>5</sup>
24-well	2	2.5 × 10 <sup>5</sup>
12-well	4	5 × 10 <sup>5</sup>
6-well	9.5	1 × 10 <sup>6</sup>
<b>Dishes</b>		
35 mm	8	1 × 10 <sup>6</sup>
60 mm	21	2.5 × 10 <sup>6</sup>
100 mm	56	7 × 10 <sup>6</sup>
145–150 mm	145	2 × 10 <sup>7</sup>
<b>Flasks</b>		
40–50 ml	25	3 × 10 <sup>6</sup>
250–300 ml	75	1 × 10 <sup>7</sup>
650–750 ml	162–175	2 × 10 <sup>7</sup>

\* Per well, if multiwell plates are used; varies slightly depending on the supplier.

<sup>†</sup> Cell numbers are given for HeLa cells (approximate length = 15 µm), assuming confluent growth. Cell numbers will vary for different kinds of animal cells, which vary in length from 10 to 30 µm.

## Animal tissues

A 3 mm cube (27 mm<sup>3</sup>) of most animal tissues weighs 30–35 mg.

## Handling and storing starting material

RNA in harvested tissue is not protected until the sample is treated with RNAprotect Tissue Reagent, flash-frozen or disrupted and homogenized in the presence of RNase-inhibiting or denaturing reagents. Otherwise, unwanted changes in the gene expression profile will occur. It is therefore important that tissue samples are immediately frozen in liquid nitrogen and stored at –70°C, or immediately immersed in RNAprotect Tissue Reagent.

The procedures for tissue harvesting and RNA protection should be carried out as quickly as possible. Frozen tissue samples should not be allowed to thaw during handling or weighing. After

disruption and homogenization in Buffer RLT Plus (lysis buffer), samples can be stored at  $-70^{\circ}\text{C}$  for months.

## Disrupting and homogenizing starting material

Efficient disruption and homogenization of the starting material is an absolute requirement for all total RNA purification procedures. Disruption and homogenization are 2 distinct steps:

- **Disruption:** Complete disruption of plasma membranes of cells and organelles is absolutely required to release all the RNA contained in the sample. Incomplete disruption results in significantly reduced RNA yields.
- **Homogenization:** Homogenization is necessary to reduce the viscosity of the lysates produced by disruption. Homogenization shears high-molecular-weight genomic DNA and other high-molecular-weight cellular components to create a homogeneous lysate. Incomplete homogenization results in inefficient binding of RNA to the RNeasy spin column membrane and therefore significantly reduced RNA yields.

Disruption and homogenization of tissue samples can be carried out rapidly and efficiently using either the TissueRuptor II (for processing samples individually) or a TissueLyser system (for processing multiple samples simultaneously). Disruption and homogenization with TissueRuptor and TissueLyser systems generally results in higher RNA yields than with other methods.

### Disruption and homogenization using the TissueRuptor II

The TissueRuptor II is a rotor–stator homogenizer that thoroughly disrupts and simultaneously homogenizes single tissue samples in the presence of lysis buffer in 15–90 seconds, depending on the toughness and size of the sample. The blade of the TissueRuptor disposable probe rotates at a very high speed, causing the sample to be disrupted and homogenized by a combination of turbulence and mechanical shearing. For guidelines on using the TissueRuptor II, refer to the *TissueRuptor Handbook*. For other rotor–stator homogenizers, refer to suppliers' guidelines.

### Disruption and homogenization using TissueLyser systems

In bead-milling, tissues can be disrupted by rapid agitation in the presence of beads and lysis buffer. Disruption and simultaneous homogenization occur by the shearing and crushing action of the beads as they collide with the cells. Two bead mills are available from QIAGEN: the TissueLyser LT, for low- to medium-throughput disruption, and the TissueLyser II, for medium- to high-throughput disruption.

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The TissueLyser LT disrupts and homogenizes up to 12 samples at the same time. The instrument needs to be used in combination with the TissueLyser LT Adapter, which holds 12 x 2 ml microcentrifuge tubes containing stainless steel beads of 5 mm or 7 mm mean diameter. For guidelines on using the TissueLyser LT, refer to the *TissueLyser LT Handbook*.

The TissueLyser II disrupts and homogenizes up to 48 tissue samples simultaneously when used in combination with the TissueLyser Adapter Set 2 x 24, which holds 48 x 2 ml microcentrifuge tubes containing stainless steel beads of 5 mm mean diameter. For guidelines on using the TissueLyser II, refer to the *TissueLyser Handbook*. If using other bead mills for sample disruption and homogenization, refer to suppliers' guidelines.

**Note:** Tungsten carbide beads react with QIAzol Lysis Reagent and must not be used to disrupt and homogenize tissues.

The TissueLyser II can also disrupt and homogenize up to 192 tissue samples simultaneously when used in combination with the TissueLyser Adapter Set 2 x 96, which holds 192 x 1.2 ml microtubes containing stainless steel beads of 5 mm mean diameter. In this case, we recommend using the RNeasy 96 Universal Tissue Kit, which provides high-throughput RNA purification from all types of tissue in 96-well format. For ordering information, see page 43.

# Protocol: Purification of Total RNA from Animal Cells

## Determining the correct amount of starting material

It is essential to use the correct amount of starting material to obtain optimal RNA yield and purity. The minimum amount is generally 100 cells, while the maximum amount depends on:

- RNA content of the cell type
- DNA removal capacity of the gDNA Eliminator spin column
- RNA binding capacity of the RNeasy spin column (100 µg RNA)
- Volume of Buffer RLT Plus required for efficient lysis (the maximum volume of Buffer RLT Plus that can be used limits the maximum amount of starting material to  $1 \times 10^7$  cells)

RNA content can vary greatly between cell types. The following examples illustrate how to determine the maximum amount of starting material:

- COS cells have high RNA content (approximately 35 µg RNA per  $10^6$  cells). Do not use more than  $3 \times 10^6$  cells, otherwise the RNA binding capacity of the RNeasy spin column will be exceeded.
- HeLa cells have average RNA content (approximately 15 µg RNA per  $10^6$  cells). Do not use more than  $7 \times 10^6$  cells, otherwise the RNA binding capacity of the RNeasy spin column will be exceeded.
- NIH/3T3 cells have low RNA content (approximately 10 µg RNA per  $10^6$  cells). The maximum amount of starting material ( $1 \times 10^7$  cells) can be used.

If processing a cell type not listed in Table 2 (page 11) and if there is no information about its RNA content, we recommend starting with no more than  $3\text{--}4 \times 10^6$  cells. Depending on RNA yield and purity, it may be possible to increase the cell number in subsequent preparations.

**Do not overload the gDNA Eliminator spin column, as this will lead to copurification of DNA with RNA. Do not overload the RNeasy spin column, as this will significantly reduce RNA yield and purity.**

As a guide, Table 3 (page 11) shows the expected numbers of HeLa cells in different cell-culture vessels.

## Important points before starting

- If using the RNeasy Plus Mini Kit for the first time, read “Important Notes” (page 10).
- If preparing RNA for the first time, read Appendix A (page 30).
- Cell pellets can be stored at  $-70^{\circ}\text{C}$  for later use or used directly in the procedure. Determine the number of cells before freezing. Frozen cell pellets should be thawed slightly so that they can be dislodged by flicking the tube in step 2. Homogenized cell lysates from step 3 can be stored at  $-70^{\circ}\text{C}$  for several months. Frozen lysates should be incubated at  $37^{\circ}\text{C}$  in a water bath until completely thawed and salts are dissolved. Avoid prolonged incubation, which may compromise RNA integrity. If any insoluble material is visible, centrifuge for 5 min at  $3000\text{--}5000 \times g$ . Transfer supernatant to a new RNase-free glass or polypropylene tube, and continue with step 4.
- If purifying RNA from cell lines rich in RNases, we recommend adding  $\beta$ -mercaptoethanol ( $\beta$ -ME) to Buffer RLT Plus before use. Add  $10 \mu\text{l}$   $\beta$ -ME per 1 ml Buffer RLT Plus. Dispense in a fume hood and wear appropriate protective clothing. Buffer RLT Plus containing  $\beta$ -ME can be stored at room temperature ( $15\text{--}25^{\circ}\text{C}$ ) for up to 1 month. Alternatively, add  $20 \mu\text{l}$  of 2 M dithiothreitol (DTT) per 1 ml Buffer RLT Plus. The stock solution of 2 M DTT in water should be prepared fresh or frozen in single-use aliquots. Buffer RLT Plus containing DTT can be stored at room temperature for up to 1 month.
- Buffer RPE is supplied as a concentrate. Before using for the first time, add 4 volumes of ethanol (96–100%), as indicated on the bottle, to obtain a working solution.
- Buffer RLT Plus may form a precipitate during storage. If necessary, redissolve by warming, and then place at room temperature.
- Buffer RLT Plus and Buffer RW1 contain a guanidine salt and are therefore not compatible with disinfecting reagents containing bleach. See page 4 for safety information.
- Perform all steps of the procedure at room temperature. During the procedure, work quickly.
- Perform all centrifugation steps at  $20\text{--}25^{\circ}\text{C}$  in a standard microcentrifuge. Ensure that the centrifuge does not cool below  $20^{\circ}\text{C}$ .

## Procedure

### 1. Harvest cells according to step 1a or 1b.

#### 1a. Cells grown in suspension (do not use more than $1 \times 10^7$ cells):

Determine the number of cells. Pellet the appropriate number of cells by centrifuging for 5 min at  $300 \times g$  in a centrifuge tube (not supplied). Carefully remove all supernatant by aspiration, and proceed to step 2.

**Note:** Incomplete removal of cell-culture medium will inhibit lysis and dilute the lysate, affecting the conditions for DNA removal and RNA purification. Both effects may reduce RNA quality and yield.

#### 1b. Cells grown in a monolayer (do not use more than $1 \times 10^7$ cells):

Cells grown in a monolayer in cell-culture vessels can be either lysed directly in the vessel (up to 10 cm diameter) or trypsinized and collected as a cell pellet prior to lysis. Cells grown in a monolayer in cell-culture flasks should always be trypsinized.

##### **To lyse cells directly:**

**Determine the number of cells. Completely aspirate the cell-culture medium, and proceed immediately to step 2.**

**Note:** Incomplete removal of cell-culture medium will inhibit lysis and dilute the lysate, affecting the conditions for DNA removal and RNA purification. Both effects may reduce RNA quality and yield.

##### **To trypsinize and collect cells:**

**Determine the number of cells. Aspirate the medium, and wash the cells with PBS. Aspirate the PBS, and add 0.10–0.25% trypsin in PBS. After the cells detach from the dish or flask, add medium (containing serum to inactivate the trypsin), transfer the cells to an RNase-free glass or polypropylene centrifuge tube (not supplied), and centrifuge at  $300 \times g$  for 5 min. Completely aspirate the supernatant, and proceed to step 2.**

**Note:** Incomplete removal of cell-culture medium will inhibit lysis and dilute the lysate, affecting the conditions for DNA removal and RNA purification. Both effects may reduce RNA quality and yield.

### 2. Disrupt the cells by adding Buffer RLT Plus.

**For pelleted cells, loosen the cell pellet thoroughly by flicking the tube. Add the appropriate volume of Buffer RLT Plus (see Table 4). Vortex or pipet to mix, and proceed to step 3.**

**Note:** Incomplete loosening of the cell pellet may lead to inefficient lysis and reduced RNA yields. Ensure that  $\beta$ -ME is added to Buffer RLT Plus before use (see “Important points before starting”).

**Table 4. Volumes of Buffer RLT Plus for lysing pelleted cells**

Number of pelleted cells	Volume of Buffer RLT Plus
<5 × 10 <sup>6</sup>	350 µl
5 × 10 <sup>6</sup> – 1 × 10 <sup>7</sup>	600 µl

**For direct lysis of cells grown in a monolayer, add the appropriate volume of Buffer RLT Plus (see Table 5) to the cell-culture dish. Collect the lysate with a rubber policeman. Pipet the lysate into a microcentrifuge tube (not supplied). Vortex or pipet to mix, and ensure that no cell clumps are visible before proceeding to step 3.**

**Note:** Ensure that β-ME is added to Buffer RLT Plus before use (see “Important points before starting”).

**Table 5. Volumes of Buffer RLT Plus for direct cell lysis**

Dish diameter	Volume of Buffer RLT Plus*
<6 cm	350 µl
6–10 cm	600 µl

\* Regardless of the cell number, use the buffer volumes indicated to completely cover the surface of the dish.

3. Homogenize the lysate according to step 3a, 3b or 3c.

See “Disrupting and homogenizing starting material”, page 13, for more details on homogenization. If processing  $\leq 1 \times 10^5$  cells, they can be homogenized by vortexing for 1 min. After homogenization, proceed to step 4.

**Note:** Incomplete homogenization leads to significantly reduced RNA yields and can cause clogging of the RNeasy spin column. Homogenization with a rotor–stator or QIAshredder homogenizer generally results in higher RNA yields than with a syringe and needle.

3a. Pipet the lysate directly into a QIAshredder spin column placed in a 2 ml collection tube, and centrifuge for 2 min at maximum speed. Proceed to step 4.

3b. Homogenize the lysate for 30 s using the TissueRuptor II. Proceed to step 4.

3c. Pass the lysate at least 5 times through a 20-gauge needle (0.9 mm diameter) fitted to an RNase-free syringe. Proceed to step 4.

4. Transfer the homogenized lysate to a gDNA Eliminator spin column placed in a 2 ml collection tube (supplied). Centrifuge for 30 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the column, and save the flow-through.

**Note:** Make sure that no liquid remains on the column membrane after centrifugation. If necessary, repeat the centrifugation until all liquid has passed through the membrane.

5. Add 1 volume (usually 350  $\mu$ l or 600  $\mu$ l) of 70% ethanol to the flow-through, and mix well by pipetting. Do not centrifuge.

If some lysate was lost during homogenization and DNA removal, adjust the volume of ethanol accordingly.

**Note:** When purifying RNA from certain cell lines, precipitates may be visible after addition of ethanol. This does not affect the procedure.

6. Transfer up to 700  $\mu$ l of the sample, including any precipitate that may have formed, to an RNeasy spin column placed in a 2 ml collection tube (supplied). Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the flow-through.\*

Reuse the collection tube in step 7.

If the sample volume exceeds 700  $\mu$ l, centrifuge successive aliquots in the same RNeasy spin column. Discard the flow-through after each centrifugation.

7. Add 700  $\mu$ l Buffer RW1 to the RNeasy spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through.\*

Reuse the collection tube in step 8.

**Note:** After centrifugation, carefully remove the RNeasy spin column from the collection tube so that the column does not contact the flow-through. Be sure to empty the collection tube completely.

8. Add 500  $\mu$ l Buffer RPE to the RNeasy spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through.

Reuse the collection tube in step 9.

**Note:** Buffer RPE is supplied as a concentrate. Ensure that ethanol is added to Buffer RPE before use (see "Important points before starting").

9. Add 500  $\mu$ l Buffer RPE to the RNeasy spin column. Close the lid gently, and centrifuge for 2 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane.

The long centrifugation dries the spin column membrane, ensuring that no ethanol is carried over during RNA elution. Residual ethanol may interfere with downstream reactions.

**Note:** After centrifugation, carefully remove the RNeasy spin column from the collection tube so that the column does not contact the flow-through. Otherwise, carryover of ethanol will occur.

\* Flow-through contains Buffer RLT Plus or Buffer RW1 and is therefore not compatible with bleach. See page 6 for safety information.

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10. **Optional:** Place the RNeasy spin column in a new 2 ml collection tube (supplied), and discard the old collection tube with the flow-through. Centrifuge at full speed for 1 min.

Perform this step to eliminate any possible carryover of Buffer RPE, or if residual flow-through remains on the outside of the RNeasy spin column after step 9.

11. Place the RNeasy spin column in a new 1.5 ml collection tube (supplied). Add 30–50  $\mu$ l RNase-free water directly to the spin column membrane. Close the lid gently, and centrifuge for 1 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to elute the RNA.

12. If the expected RNA yield is  $>30 \mu\text{g}$ , repeat step 11 using another 30–50  $\mu$ l of RNase-free water, or using the eluate from step 11 (if high RNA concentration is required). Reuse the collection tube from step 11. 0.

If using the eluate from step 11, the RNA yield will be 15–30% less than that obtained using a second volume of RNase-free water, but the final RNA concentration will be higher.

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# Protocol: Purification of Total RNA from Animal Tissues

## Determining the correct amount of starting material

It is essential to use the correct amount of starting material to obtain optimal RNA yield and purity. A maximum amount of 30 mg fresh or frozen tissue or 15–20 mg RNAlater-stabilized tissue (which is partially dehydrated) can generally be processed. For most tissues, the DNA removal capacity of the gDNA Eliminator spin column, the RNA binding capacity of the RNeasy spin column and the lysing capacity of Buffer RLT Plus will not be exceeded by these amounts. However, smaller amounts may allow more efficient DNA removal. Average RNA yields from various tissues are given in Table 2 (page 11).

For maximum RNA yields from liver, 50% ethanol (instead of 70% ethanol) should be used in step 5 of the procedure.

Some tissues, such as spleen and thymus, contain very high amounts of DNA, which will overload the gDNA Eliminator spin column. For these tissues, we recommend using the RNeasy Mini Kit in combination with the RNase-Free DNase Set (see page 43 for ordering information).

RNA yields from fibrous tissues, such as skeletal muscle, heart and skin, may be low due to the abundance of contractile proteins, connective tissue and collagen. Proteinase K digestion is not compatible with the RNeasy Plus Mini Kit. For maximum RNA yields from these tissues, we recommend using RNeasy Fibrous Tissue Kits (see page 43 for ordering information).

If there is no information about the nature of your starting material, we recommend starting with no more than 10 mg tissue. Depending on RNA yield and purity, it may be possible to use up to 30 mg tissue in subsequent preparations.

**Do not overload the gDNA Eliminator spin column, as this will lead to copurification of DNA with RNA. Do not overload the RNeasy spin column, as this will significantly reduce RNA yield and quality.**

## Important points before starting

- If using the RNeasy Plus Mini Kit for the first time, read “Important Notes” (page 10).
- If preparing RNA for the first time, read Appendix A (page 30).
- For optimal results, stabilize harvested tissues immediately in RNAprotect Tissue Reagent (see the *RNAprotect Handbook*). Tissues can be stored in the reagent for up to 1 day at 37°C, 7 days at 18–25°C, or 4 weeks at 2–8°C, or archived at –30°C to –15°C or –80°C.
- Fresh, frozen or RNAprotect-stabilized tissues can be used. Tissues can be stored at –70°C for several months. Flash-freeze tissues in liquid nitrogen, and immediately transfer to –70°C. Do not allow tissues to thaw during weighing or handling prior to disruption in Buffer RLT Plus. Homogenized tissue lysates from step 3 can also be stored at –70°C for several months. Incubate frozen lysates at 37°C in a water bath until completely thawed and salts are dissolved before continuing with step 4. Avoid prolonged incubation, which may compromise RNA integrity.
- If desired, more than 30 mg tissue can be disrupted and homogenized at the start of the procedure (increase the volume of Buffer RLT Plus proportionately). Use a portion of the homogenate corresponding to no more than 30 mg tissue for RNA purification, and store the rest at –80°C.
- $\beta$ -mercaptoethanol ( $\beta$ -ME) must be added to Buffer RLT Plus before use. Add 10  $\mu$ l  $\beta$ -ME per 1 ml Buffer RLT Plus. Dispense in a fume hood and wear appropriate protective clothing. Buffer RLT Plus is stable at room temperature (15–25°C) for 1 month after addition of  $\beta$ -ME. Alternatively, add 20  $\mu$ l 2 M dithiothreitol (DTT) per 1 ml Buffer RLT Plus. The stock solution of 2 M DTT in water should be prepared fresh or frozen in single-use aliquots. Buffer RLT Plus containing DTT can be stored at room temperature for up to 1 month.
- Buffer RPE is supplied as a concentrate. Before using for the first time, add 4 volumes of ethanol (96–100%), as indicated on the bottle, to obtain a working solution.
- Buffer RLT Plus may form a precipitate upon storage. If necessary, redissolve by warming, and then place at room temperature.
- Buffer RLT Plus and Buffer RW1 contain a guanidine salt and are therefore not compatible with disinfecting reagents containing bleach. See page 4 for safety information.
- Perform all steps of the procedure at room temperature. During the procedure, work quickly.
- Perform all centrifugation steps at 20–25°C in a standard microcentrifuge. Ensure that the centrifuge does not cool below 20°C.

---

## Procedure

1. Excise the tissue sample from the animal or remove it from storage. Remove RNAprotect-stabilized tissues from the reagent using forceps. Determine the amount of tissue. Do not use more than 30 mg.

Weighing tissue is the most accurate way to determine the amount.

2. Follow either step 2a or 2b.

- 2a. For RNAprotect-stabilized tissues:

If using the entire tissue, place it directly into a suitably sized vessel for disruption and homogenization, and proceed to step 3.

If using only a portion of the tissue, cut it on a clean surface. Weigh the piece to be used, and place it into a suitably sized vessel for disruption and homogenization.

Proceed to step 3.

RNA in RNAprotect-stabilized tissues is protected during cutting and weighing of tissues at ambient temperature (18–25°C). It is not necessary to cut the tissues on ice or dry ice or in a refrigerated room. Remaining tissues can be stored in RNAprotect Tissue Reagent. Previously stabilized tissues can be stored at –80°C without the reagent.

- 2b. For unstabilized fresh or frozen tissues:

If using the entire tissue, place it directly into a suitably sized vessel for disruption and homogenization, and proceed immediately to step 3.

If using only a portion of the tissue, weigh the piece to be used, and place it into a suitably sized vessel for disruption and homogenization. Proceed immediately to step 3.

RNA in harvested tissues is not protected until the tissues are treated with RNAprotect Tissue Reagent, flash-frozen or disrupted and homogenized in step 3. Frozen tissues should not be allowed to thaw during handling. The relevant procedures should be carried out as quickly as possible.

**Note:** Remaining fresh tissues can be placed into RNAprotect Tissue Reagent to stabilize RNA (see the *RNAprotect Handbook*). However, previously frozen tissues thaw too slowly in the reagent, preventing the reagent from diffusing into the tissues quickly enough to prevent RNA degradation.

3. Disrupt the tissue and homogenize the lysate in Buffer RLT Plus (do not use more than 30 mg tissue) according to step 3a, 3b, 3c or 3d.

See “Disrupting and homogenizing starting material”, page 13, for more details on disruption and homogenization.

**Note:** Ensure that  $\beta$ -ME is added to Buffer RLT Plus before use (see “Important points before starting”).

After storage in RNAprotect Tissue Reagent, tissues may become slightly harder than fresh or thawed tissues. Disruption and homogenization using standard methods is usually not a problem. For easier disruption and homogenization, we recommended using 600  $\mu$ l Buffer RLT Plus.

**Note:** Incomplete homogenization leads to significantly reduced RNA yields and can cause clogging of the RNeasy spin column. Homogenization with the TissueLyser and rotor–stator homogenizers generally results in higher RNA yields than with other methods.

**Table 6. Volumes of Buffer RLT Plus for tissue disruption and homogenization**

Amount of starting material	Volume of Buffer RLT Plus
<20 mg	350 $\mu$ l or 600 $\mu$ l*
20–30 mg	600 $\mu$ l

\* Use 600  $\mu$ l Buffer RLT Plus for tissues stabilized in RNAprotect Tissue Reagent or for difficult-to-lyse tissues.

- 3a. Disruption and homogenization using the TissueRuptor II:

Place the weighed (fresh, frozen or RNAprotect-stabilized) tissue in a suitably sized vessel. Add the appropriate volume of Buffer RLT Plus (see Table 6). Immediately disrupt and homogenize the tissue until it is uniformly homogeneous (usually 20–40 s); see the *TissueRuptor Handbook*. Proceed to step 4.

- 3b. Disruption using a mortar and pestle followed by homogenization using a QIAshredder homogenizer:

Immediately place the weighed (fresh, frozen or RNAprotect-stabilized) tissue in liquid nitrogen, and grind thoroughly with a mortar and pestle. Decant tissue powder and liquid nitrogen into an RNase-free, liquid-nitrogen-cooled, 2 ml microcentrifuge tube (not supplied). Allow the liquid nitrogen to evaporate, but do not allow the tissue to thaw. Add the appropriate volume of Buffer RLT Plus (see Table 6). Pipet the lysate directly into a QIAshredder spin column placed in a 2 ml collection tube, and centrifuge for 2 min at maximum speed. Proceed to step 4.

- 3c. Disruption using a mortar and pestle followed by homogenization using a needle and syringe:

Immediately place the weighed (fresh, frozen or RNAprotect-stabilized) tissue in liquid nitrogen, and grind thoroughly with a mortar and pestle. Decant tissue powder and liquid nitrogen into an RNase-free, liquid-nitrogen-cooled, 2 ml microcentrifuge tube (not supplied). Allow the liquid nitrogen to evaporate, but do not allow the tissue to thaw. Add the appropriate volume of Buffer RLT Plus (see Table 6), and homogenize by passing lysate at least 5 times through a 20-gauge needle fitted to an RNase-free syringe. Proceed to step 4.

- 3d. Disruption and homogenization using the TissueLyser II or TissueLyser LT: See the *TissueLyser Handbook* or the *TissueLyser LT Handbook*. Then proceed to step 4.

4. Centrifuge the lysate for 3 min at maximum speed. Carefully remove the supernatant by pipetting, and transfer it to a gDNA Eliminator spin column placed in a 2 ml collection tube (supplied). Centrifuge for 30 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the column, and save the flow-through.

This step is important, as it removes insoluble material that could clog the gDNA Eliminator spin column and interfere with DNA removal. In some preparations, very small amounts of insoluble material will be present after the 3 min centrifugation, making the pellet invisible.

**Note:** Make sure that no liquid remains on the column membrane after centrifugation. If necessary, repeat the centrifugation until all liquid has passed through the membrane.

5. Add 1 volume (usually 350  $\mu$ l or 600  $\mu$ l) of 70% ethanol to the flow-through, and mix well by pipetting. Do not centrifuge. Proceed immediately to step 6.

If some lysate was lost during homogenization and DNA removal, adjust the volume of ethanol accordingly.

**Note:** Precipitates may be visible after addition of ethanol, but this does not affect the procedure.

**Note:** For maximum RNA yields from liver, use 50% ethanol instead of 70% ethanol.

6. Transfer up to 700  $\mu$ l of the sample, including any precipitate that may have formed, to an RNeasy spin column placed in a 2 ml collection tube (supplied). Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the flow-through.\*

Reuse the collection tube in step 7.

If the sample volume exceeds 700  $\mu$ l, centrifuge successive aliquots in the same RNeasy spin column. Discard the flow-through after each centrifugation.

\* Flow-through contains Buffer RLT Plus or Buffer RW1 and is therefore not compatible with bleach. See page 6 for safety information.

7. Add 700  $\mu$ l Buffer RW1 to the RNeasy spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through.\*

Reuse the collection tube in step 8.

**Note:** After centrifugation, carefully remove the RNeasy spin column from the collection tube so that the column does not contact the flow-through. Be sure to empty the collection tube completely.

8. Add 500  $\mu$ l Buffer RPE to the RNeasy spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through.

Reuse the collection tube in step 9.

**Note:** Buffer RPE is supplied as a concentrate. Ensure that ethanol is added to Buffer RPE before use (see “Important points before starting”).

9. Add 500  $\mu$ l Buffer RPE to the RNeasy spin column. Close the lid gently, and centrifuge for 2 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane.

The long centrifugation dries the spin column membrane, ensuring that no ethanol is carried over during RNA elution. Residual ethanol may interfere with downstream reactions.

**Note:** After centrifugation, carefully remove the RNeasy spin column from the collection tube so that the column does not contact the flow-through. Otherwise, carryover of ethanol will occur.

10. **Optional:** Place the RNeasy spin column in a new 2 ml collection tube (supplied), and discard the old collection tube with the flow-through. Centrifuge at full speed for 1 min.

Perform this step to eliminate any possible carryover of Buffer RPE, or if residual flow-through remains on the outside of the RNeasy spin column after step 9.

11. Place the RNeasy spin column in a new 1.5 ml collection tube (supplied). Add 30–50  $\mu$ l RNase-free water directly to the spin column membrane. Close the lid gently, and centrifuge for 1 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to elute the RNA.

12. If the expected RNA yield is  $>30 \mu$ g, repeat step 11 using another 30–50  $\mu$ l of RNase-free water, or using the eluate from step 11 (if high RNA concentration is required). Reuse the collection tube from step 11.

If using the eluate from step 11, the RNA yield will be 15–30% less than that obtained using a second volume of RNase-free water, but the final RNA concentration will be higher.

\* Flow-through contains Buffer RLT Plus or Buffer RW1 and is therefore not compatible with bleach. See page 6 for safety information.

# Troubleshooting Guide

This troubleshooting guide may be helpful in solving any problems that may arise. For more information, see also the Frequently Asked Questions page at our Technical Support Center: [www.qiagen.com/FAQ/FAQList.aspx](http://www.qiagen.com/FAQ/FAQList.aspx). The scientists in QIAGEN Technical Services are always happy to answer any questions you may have about either the information and protocols in this handbook or sample and assay technologies (for contact information, see back cover or visit [www.qiagen.com](http://www.qiagen.com)).

	Comments and suggestions
<b>Clogged gDNA Eliminator spin column</b>	
a) Inefficient disruption and/or homogenization	See “Disrupting and homogenizing starting material” (page 13) for details on disruption and homogenization methods. Increase <i>g</i> -force and centrifugation time if necessary. In subsequent preparations, reduce the amount of starting material (see protocols, pages 15 and 21) and/or increase the homogenization time.
b) Too much starting material	Reduce the amount of starting material. It is essential to use the correct amount of starting material (see page 10).
c) Centrifugation temperature too low	The centrifugation temperature should be 20–25°C. Some centrifuges may cool to below 20°C even when set at 20°C. This can cause formation of precipitates that can clog the gDNA Eliminator spin column. If this happens, set the centrifugation temperature to 25°C. Warm the lysate to 37°C before transferring it to the gDNA Eliminator spin column.
<b>Low RNA yield</b>	
a) Insufficient disruption and homogenization	See “Disrupting and homogenizing starting material” (page 13) for details on disruption and homogenization methods. In subsequent preparations, reduce the amount of starting material (see protocols, pages 15 and 21) and/or increase the volume of lysis buffer and the homogenization time.
b) Too much starting material	Overloading the RNeasy spin column significantly reduces RNA yield. Reduce the amount of starting material (see page 10).
c) Ethanol added to lysate before DNA removal	Pass the lysate through the gDNA Eliminator spin column before adding ethanol to it.
d) RNA still bound to RNeasy spin column membrane	Repeat RNA elution, but incubate the RNeasy spin column on the benchtop for 10 min with RNase-free water before centrifuging.
e) Ethanol carryover	During the second wash with Buffer RPE, be sure to centrifuge at $\geq 8000 \times g$ ( $\geq 10,000$ rpm) for 2 min at 20–25°C to dry the RNeasy spin column membrane. Perform the optional centrifugation to dry the RNeasy spin column membrane if any flow-through is present on the outside of the column (step 10 of the protocols).

### Comments and suggestions

- |                                                             |                                                                                                                                |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| f) Incomplete removal of cell-culture medium (cell samples) | When processing cultured cells, ensure complete removal of cell-culture medium after harvesting cells (see protocol, page 15). |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|

#### Low $A_{260}/A_{280}$ value

- |                                                            |                                                                                                                            |
|------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Water used to dilute RNA for $A_{260}/A_{280}$ measurement | Use 10 mM Tris-Cl, * pH 7.5, not RNase-free water, to dilute the sample before measuring purity (see Appendix B, page 32). |
|------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|

#### RNA degraded

- |                                                |                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a) Inappropriate handling of starting material | Ensure that tissue samples are properly stabilized and stored in RNAprotect Tissue Reagent.<br><br>For frozen cell pellets or frozen tissue samples, ensure that they were flash-frozen immediately in liquid nitrogen and properly stored at $-70^{\circ}\text{C}$ . Perform the RNeasy procedure quickly, especially the first few steps. See Appendix A (page 30) and "Handling and storing starting material" (page 13). |
| b) RNase contamination                         | Although all RNeasy buffers have been tested and are guaranteed RNase-free, RNases can be introduced during use. Be certain not to introduce any RNases during the RNeasy procedure or later handling. See Appendix A (page 30) for general remarks on handling RNA.                                                                                                                                                         |

#### DNA contamination in downstream experiments

- |                                                                       |                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a) Cell number too high                                               | For some cell types, the efficiency of DNA removal may be reduced when processing very high cell numbers (containing more than 20 $\mu\text{g}$ genomic DNA). If the eluted RNA contains substantial DNA contamination, try processing smaller cell numbers. |
| b) Incomplete removal of cell-culture medium or stabilization reagent | Be sure to remove any excess cell-culture medium or stabilization reagent to prevent significant dilution of the lysis buffer. The gDNA Eliminator spin column will not work effectively if the lysis buffer is diluted.                                     |
| c) Tissue has high DNA content                                        | For certain tissues with extremely high DNA content (e.g., thymus), DNA may not be completely removed. Try using smaller samples (containing less than 20 $\mu\text{g}$ genomic DNA), or perform DNase digestion of the eluted RNA followed by RNA cleanup.  |

#### RNA concentration too low

- |                         |                                                                                                                                                                                                                                               |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Elution volume too high | Elute RNA with less than 2 x 50 $\mu\text{l}$ of water. Do not use less than 1 x 30 $\mu\text{l}$ of water. Although eluting with less than 2 x 50 $\mu\text{l}$ of water results in increased RNA concentrations, RNA yields may be reduced. |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

### Comments and suggestions

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#### RNA does not perform well in downstream experiments

- a) Salt carryover during elution      Ensure that Buffer RPE is at 20–30°C.  
When reusing collection tubes between washing steps, remove residual flow-through from the rim by blotting on clean paper towels.
- b) Ethanol carryover      During the second wash with Buffer RPE, be sure to centrifuge at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) for 2 min at 20–25°C to dry the RNeasy spin column membrane. After centrifugation, carefully remove the column from the collection tube so that the column does not contact the flow-through. Otherwise, carryover of ethanol will occur.  
Perform the optional centrifugation to dry the RNeasy spin column membrane if any flow-through is present on the outside of the column (step 10 of the protocols).

# Appendix A: General Remarks on Handling RNA

## Handling RNA

Ribonucleases (RNases) are very stable and active enzymes that generally do not require cofactors to function. Since RNases are difficult to inactivate and even minute amounts are sufficient to destroy RNA, do not use any plasticware or glassware without first eliminating possible RNase contamination. Great care should be taken to avoid inadvertently introducing RNases into the RNA sample during or after the purification procedure. To create and maintain an RNase-free environment, the following precautions must be taken during pretreatment and use of disposable and nondisposable vessels and solutions while working with RNA.

### General handling

Proper microbiological, aseptic technique should always be used when working with RNA. Hands and dust particles may carry bacteria and molds and are the most common sources of RNase contamination. Always wear latex or vinyl gloves while handling reagents and RNA samples to prevent RNase contamination from the surface of the skin or from dusty laboratory equipment. Change gloves frequently and keep tubes closed whenever possible. Keep purified RNA on ice when aliquots are pipetted for downstream applications. To remove RNase contamination from bench surfaces, nondisposable plasticware and laboratory equipment (e.g., pipets and electrophoresis tanks), use general laboratory reagents. To decontaminate plasticware, rinse with 0.1 M NaOH, 1 mM EDTA,\* followed by RNase-free water (see "Solutions", page 31), or rinse with chloroform\* if the plasticware is chloroform-resistant. To decontaminate electrophoresis tanks, clean with detergent (e.g., 0.5% SDS),\* rinse with RNase-free water, then rinse with ethanol (if the tanks are ethanol resistant) and allow to dry.

### Disposable plasticware

The use of sterile, disposable polypropylene tubes is recommended throughout the procedure. These tubes are generally RNase-free and do not require pretreatment to inactivate RNases.† When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier. Glassware should be treated before use to ensure that it is RNase-free. Glassware used for RNA work should be cleaned with a detergent,\* thoroughly rinsed and oven

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

† When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

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baked at 240°C for at least 4 hours (overnight, if more convenient) before use. Autoclaving alone will not fully inactivate many RNases. Alternatively, glassware can be treated with diethyl pyrocarbonate (DEPC)\*, as described in “Solutions” below.

## Solutions

Solutions (water and other solutions) should be treated with 0.1% DEPC. DEPC is a strong, but not absolute, inhibitor of RNases. It is commonly used at a concentration of 0.1% to inactivate RNases on glass or plasticware or to create RNase-free solutions and water. DEPC inactivates RNases by covalent modification. Add 0.1 ml DEPC to 100 ml of the solution to be treated and shake vigorously to bring the DEPC into solution. Let the solution incubate for 12 hours at 37°C. Autoclave for 15 minutes to remove any trace of DEPC. DEPC will react with primary amines and cannot be used directly to treat Tris\* buffers. DEPC is highly unstable in the presence of Tris buffers and decomposes rapidly into ethanol and CO<sub>2</sub>. When preparing Tris buffers, treat water with DEPC first, and then dissolve Tris to make the appropriate buffer. Trace amounts of DEPC will modify purine residues in RNA by carbethoxylation. Carbethoxylated RNA is translated with very low efficiency in cell-free systems. However, its ability to form DNA:RNA or RNA:RNA hybrids is not seriously affected unless a large fraction of the purine residues has been modified. Residual DEPC must always be eliminated from solutions or vessels by autoclaving or heating to 100°C for 15 minutes.

**Note:** RNeasy buffers are guaranteed RNase-free without using DEPC treatment and are therefore free of any DEPC contamination.

## Appendix B: Storage, Quantification and Determination of Quality of RNA

### Storage of RNA

Purified RNA may be stored at  $-70^{\circ}\text{C}$  to  $-15^{\circ}\text{C}$  in RNase-free water. Under these conditions, no degradation of RNA is detectable after 1 year.

### Quantification of RNA

The concentration of RNA should be determined by measuring the absorbance at 260 nm ( $A_{260}$ ) in a spectrophotometer (see "Spectrophotometric quantification of RNA" below). For small amounts of RNA, however, it may be difficult to determine amounts photometrically. Small amounts of RNA can be quantified using quantitative RT-PCR or fluorometric quantification.

### Spectrophotometric quantification of RNA

#### Using the QIAxpert UV/VIS Spectrophotometer for microvolume analysis

To determine the concentration of your RNA sample purified with RNeasy QIAGEN kit, use the corresponding RNeasy App on the QIAxpert. For more information, see the QIAxpert product page ([www.qiagen.com/qiexpert-system](http://www.qiagen.com/qiexpert-system)).

#### Using a standard spectrophotometer

To ensure significance,  $A_{260}$  readings should be greater than 0.15. An absorbance of 1 unit at 260 nm corresponds to 44  $\mu\text{g}$  of RNA per ml ( $A_{260} = 1 \rightarrow 4 \mu\text{g/ml}$ ). This relation is valid only for measurements at a neutral pH. Therefore, if it is necessary to dilute the RNA sample, this should be done in a buffer with neutral pH.\* As discussed below (see "Purity of RNA", page 33), the ratio between the absorbance values at 260 and 280 nm gives an estimate of RNA purity. When measuring RNA samples, be certain that cuvettes are RNase-free, especially if the RNA is to be recovered after spectrophotometry. This can be accomplished by washing cuvettes with 0.1 M NaOH, 1 mM EDTA,\* followed by washing with RNase-free water (see "Solutions", page 31). Use the buffer in which the RNA is diluted to zero the spectrophotometer. An example of the calculation involved in RNA quantification is shown below:

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

Volume of RNA sample = 100  $\mu$ l  
Dilution = 10  $\mu$ l of RNA sample + 490  $\mu$ l of 10 mM Tris·Cl, \* pH 7.0 (1/50 dilution)

Measure absorbance of diluted sample in a 1 ml cuvette (RNase-free)

$A_{260}$  = 0.2  
Concentration of RNA sample = 44  $\mu$ g/ml  $\times$   $A_{260}$   $\times$  dilution factor  
= 44  $\mu$ g/ml  $\times$  0.2  $\times$  50  
= 440  $\mu$ g/ml

Total amount = concentration  $\times$  volume in milliliters  
= 440  $\mu$ g/ml  $\times$  0.1 ml  
= 44  $\mu$ g of RNA

### Purity of RNA

The assessment of RNA purity will be performed routinely, when using the QIAxpert with the corresponding RNeasy App. See the QIAxpert user manual for more information ([www.qiagen.com/qiexpert-system/user-manual](http://www.qiagen.com/qiexpert-system/user-manual))

For standard photometric measurements, the ratio of the readings at 260 nm and 280 nm ( $A_{260}/A_{280}$ ) provides an estimate of the purity of RNA with respect to contaminants, such as protein, that absorb in the UV spectrum. However, the  $A_{260}/A_{280}$  ratio is influenced considerably by pH. Since water is not buffered, the pH and the resulting  $A_{260}/A_{280}$  ratio can vary greatly when using pure water. Lower pH results in a lower  $A_{260}/A_{280}$  ratio and reduced sensitivity to protein contamination.\* For accurate values, we recommend measuring absorbance in 10 mM Tris·Cl, pH 7.5. Pure RNA has an  $A_{260}/A_{280}$  ratio of 1.9–2.1<sup>†</sup> in 10 mM Tris·Cl, pH 7.5. Always be sure to calibrate the spectrophotometer with the same solution used for dilution. For determination of RNA concentration, however, we recommend dilution of the sample in a buffer with neutral pH since the relationship between absorbance and concentration ( $A_{260}$  reading of 1 = 44  $\mu$ g/ml RNA) is based on an extinction coefficient calculated for RNA at neutral pH (see “Spectrophotometric quantification of RNA”, page 32).

### DNA contamination

No currently available purification method can guarantee that RNA is completely free of DNA, even when it is not visible on an agarose gel. RNeasy Kits will, however, remove the vast majority of cellular DNA. gDNA Eliminator Solution helps to further reduce genomic DNA contamination;

\* Wilfinger, W.W., Mackey, M., and Chomczynski, P. (1997) Effect of pH and ionic strength on the spectrophotometric assessment of nucleic acid purity. *BioTechniques* **22**, 474.

<sup>†</sup> Values up to 2.3 are routinely obtained for pure RNA (in 10 mM Tris·Cl, pH 7.5) with some spectrophotometers.

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however, trace amounts of genomic DNA may still remain, depending on the amount and nature of the sample. For analysis of very low abundance targets, any interference by residual DNA contamination can be detected by performing real-time RT-PCR control experiments in which no reverse transcriptase is added prior to the PCR step.

To prevent any interference by DNA in real-time RT-PCR applications, such as with Applied Biosystems® and Rotor-Gene® instruments, we recommend designing primers that anneal at intron splice junctions so that genomic DNA will not be amplified. QuantiNova Primer Assays from QIAGEN are designed for SYBR® Green-based real-time RT-PCR analysis of RNA sequences (without detection of genomic DNA) where possible (see [www.qiagen.com/GeneGlobe](http://www.qiagen.com/GeneGlobe)). For real-time RT-PCR assays where amplification of genomic DNA cannot be avoided, we recommend using the QuantiNova Reverse Transcription Kit for reverse transcription. The kit integrates fast cDNA synthesis with rapid removal of genomic DNA contamination (see ordering information, page 43).

### Integrity of RNA

The integrity and size distribution of total RNA purified with RNeasy Plus Universal Kits can be checked by denaturing agarose gel electrophoresis and ethidium bromide staining\* or by using the QIAxcel system or Agilent 2100 Bioanalyzer. Ribosomal RNAs should appear as sharp bands or peaks. The apparent ratio of 28S rRNA to 18S rRNA should be approximately 2:1. If the ribosomal bands or peaks of a specific sample are not sharp, but appear as a smear towards smaller sized RNAs, it is likely that the sample suffered major degradation either before or during RNA purification. As a useful measure of RNA integrity, the QIAxcel Advanced® system and the Agilent 2100 Bioanalyzer provide an RNA integrity score (RIS) and an RNA integrity number (RIN), respectively. Ideally, the value should be close to 10, but in many cases (particularly with tissue samples), RNA quality is greatly influenced by how well the original sample was preserved.

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

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## Appendix C: Protocol for Formaldehyde Agarose Gel Electrophoresis

The following protocol for formaldehyde agarose (FA) gel electrophoresis is routinely used at QIAGEN and gives enhanced sensitivity for gel and subsequent analysis (e.g., northern blotting). A key feature is the concentrated RNA loading buffer that allows a larger volume of RNA sample to be loaded onto the gel than conventional protocols (e.g., Sambrook et al., eds. (1989) *Molecular cloning — a laboratory manual*, 2nd ed. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press).

### FA gel preparation

To prepare FA gel (1.2% agarose) of size 10 x 14 x 0.7 cm, mix:

- 1.2 g agarose\*
- 10 ml 10x FA gel buffer (see composition below)
- Add RNase-free water to 100 ml

If smaller or larger gels are needed, adjust the quantities of components proportionately.

Heat the mixture to melt agarose. Cool to 65°C in a water bath. Add 1.8 ml of 37% (12.3 M) formaldehyde\* and 1 µl of a 10 mg/ml ethidium bromide\* stock solution. Mix thoroughly and pour onto gel support. Prior to running the gel, equilibrate in 1x FA gel running buffer (see composition below) for at least 30 min.

### RNA sample preparation for FA gel electrophoresis

Add 1 volume of 5x loading buffer (see composition below) to 4 volumes of RNA sample (for example, 10 µl of loading buffer and 40 µl of RNA) and mix.

Incubate for 3–5 min at 65°C, chill on ice and load onto the equilibrated FA gel.

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

## Gel running conditions

Run gel at 5–7 V/cm in 1x FA gel running buffer.

## Composition of FA gel buffers

### 10x FA gel buffer

200 mM 3-[N-morpholino]propanesulfonic acid (MOPS) (free acid)\*  
50 mM sodium acetate\*  
10 mM EDTA\*  
pH to 7.0 with NaOH\*

### 1x FA gel running buffer

100 ml 10x FA gel buffer  
20 ml 37% (12.3 M) formaldehyde  
880 ml RNase-free water

### 5x RNA loading buffer

16 µl saturated aqueous bromophenol blue solution\*†  
80 µl 500 mM EDTA, pH 8.0  
720 µl 37% (12.3 M) formaldehyde  
2 ml 100% glycerol\*  
3.084 ml formamide\*  
4 ml 10 x FA gel buffer  
RNase-free water to 10 ml  
Stability: approximately 3 months at 4°C

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

† To make a saturated solution, add solid bromophenol blue to distilled water. Mix and continue to add more bromophenol blue until no more will dissolve. Centrifuge to pellet the undissolved powder, and carefully pipet the saturated supernatant.

## Appendix D: Purification of Total RNA Containing Small RNAs from Cells

The following procedure allows the purification of total RNA containing small RNAs, such as miRNA from **cultured** animal and human cells. **This protocol is not suitable for miRNA purification from animal or human tissues.** If you need to purify miRNA from animal or human tissues, we recommend using the miRNeasy Mini Kit (cat. no. 217004).

### Reagents to be supplied by user

- Ethanol (100%)\*

### Important points before starting

- This protocol is for use with up to  $5 \times 10^6$  cells.
- Perform all centrifugation steps at room temperature (15–25°C).

### Things to do before starting

- If purifying RNA from cell lines rich in RNases, we recommend adding  $\beta$ -mercaptoethanol ( $\beta$ -ME) to Buffer RLT Plus before use. Add 10  $\mu$ l  $\beta$ -ME per 1 ml Buffer RLT Plus. Dispense in a fume hood and wear appropriate protective clothing. Buffer RLT Plus containing  $\beta$ -ME can be stored at room temperature (15–25°C) for up to 1 month. Alternatively, add 20  $\mu$ l of 2 M dithiothreitol (DTT) per 1 ml Buffer RLT Plus. The stock solution of 2 M DTT in water should be prepared fresh or frozen in single-use aliquots. Buffer RLT Plus containing DTT can be stored at room temperature for up to 1 month.
- Buffer RPE is supplied as a concentrate. Before using for the first time, add 4 volumes of ethanol (96–100%) as indicated on the bottle to obtain a working solution.

### Procedure

1. Add 350  $\mu$ l Buffer RLT Plus to the sample, and disrupt and homogenize immediately (see “Disrupting and homogenizing starting material”, page 13, for more information).

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

2. Transfer the homogenate to a gDNA Eliminator spin column placed in a 2 ml collection tube. Centrifuge for 30 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the column, and save the flow-through.

**Note:** If necessary, repeat the centrifugation until all liquid has passed through the membrane.

3. Add 1.5 volumes (usually 525  $\mu$ l) of 100% ethanol to the flow-through, and mix thoroughly by vortexing. Do not centrifuge. Proceed immediately to step 4.
4. Transfer 700  $\mu$ l of the sample, including any precipitate that may have formed, to an RNeasy Mini spin column placed in a 2 ml collection tube. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the flow-through.

Repeat step 4 until the whole sample has passed through the membrane. Discard the flow-through each time.

5. Place the RNeasy Mini spin column in a new 2 ml collection tube. Add 500  $\mu$ l Buffer RPE to the spin column. Close the lid gently, and centrifuge for 2 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through.

**Note:** Buffer RPE is supplied as a concentrate. Ensure that ethanol is added to Buffer RPE before use (see “Things to do before starting”, page 37).

6. Add 500  $\mu$ l Buffer RPE to the RNeasy Mini spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through and the collection tube.
7. Place the RNeasy Mini spin column in a new 2 ml collection tube. Close the lid, and centrifuge at full speed for 1 min.
8. Place the RNeasy Mini spin column in a 1.5 ml collection tube. Add 30–50  $\mu$ l RNase-free water directly to the spin column membrane. Close the lid gently, and centrifuge for 1 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to elute the RNA (total RNA containing miRNA).

If the expected RNA yield is  $>30 \mu$ g, repeat step 8 with a second volume of RNase-free water. Elute into the same collection tube.

For real-time RT-PCR with the purified RNA, QIAGEN offers the miRCURY<sup>®</sup> LNA<sup>®</sup> PCR System, which allows detection of hundreds of miRNAs from a single cDNA synthesis reaction. For details, visit [www.qiagen.com/miRNA](http://www.qiagen.com/miRNA).

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## Appendix E: Separate Purification of Small RNA (Containing miRNA) and Larger RNA from Animal Cells using the RNeasy Plus Mini Kit and RNeasy MinElute<sup>®</sup> Cleanup Kit

The following procedure allows the purification of total RNA containing small RNAs, such as miRNA from cultured animal and human cells. **This protocol is not suitable for miRNA purification from animal or human tissues.** If you need to purify miRNA from animal or human tissues, we recommend using the miRNeasy Mini Kit (cat. no. 217004).

### Reagents to be supplied by user

- RNeasy MinElute Cleanup Kit (50), cat. no. 74204
- Ethanol (70%, 80% and 100%)\*
- Collection tubes (2 ml and 1.5 ml) are supplied with both RNeasy Kits; if necessary, extra 2 ml collection tubes can be purchased separately (cat. no. 19201)

### Important points before starting

- This protocol is for use with up to  $5 \times 10^6$  cells.
- Perform all centrifugation steps at room temperature (15–25°C).
- Read the handbook supplied with the RNeasy MinElute Cleanup Kit.

\* When working with chemicals, always wear a suitable lab coat, disposable gloves and protective goggles. For more information, consult the appropriate safety data sheets (SDSs), available from the product supplier.

## Things to do before starting

- Buffer RPE is supplied as a concentrate. Before using for the first time, add 4 volumes of ethanol (96–100%) as indicated on the bottle to obtain a working solution.
- If purifying RNA from cell lines rich in RNases, we recommend adding  $\beta$ -mercaptoethanol ( $\beta$ -ME) to Buffer RLT Plus before use. Add 10  $\mu$ l  $\beta$ -ME per 1 ml Buffer RLT Plus. Dispense in a fume hood and wear appropriate protective clothing. Buffer RLT Plus containing  $\beta$ -ME can be stored at room temperature (15–25°C) for up to 1 month. Alternatively, add 20  $\mu$ l of 2 M dithiothreitol (DTT) per 1 ml Buffer RLT Plus. The stock solution of 2 M DTT in water should be prepared fresh or frozen in single-use aliquots. Buffer RLT Plus containing DTT can be stored at room temperature for up to 1 month.

## Procedure

### Separating small RNA from total RNA using the RNeasy Plus Mini Kit

1. Add 350  $\mu$ l Buffer RLT Plus to the sample, and disrupt and homogenize immediately (see “Disrupting and homogenizing starting material”, page 13, for more information).
2. Transfer the homogenate to a gDNA Eliminator spin column placed in a 2 ml collection tube. Centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the column, and save the flow-through.  
**Note:** If necessary, repeat the centrifugation until all liquid has passed through the membrane.
3. Add 1 volume (usually 350  $\mu$ l) of 70% ethanol, and mix thoroughly by vortexing. Do not centrifuge. Proceed immediately to step 4.
4. Transfer the sample, including any precipitate that may have formed, to an RNeasy Mini spin column placed in a 2 ml collection tube. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm).
5. If purifying small RNA (containing miRNA) only, discard the RNeasy Mini spin column and follow steps 6–12 only.

If purifying both small RNA (containing miRNA) and larger RNA (>200 nt), save the RNeasy Mini spin column for use in step 13 (the spin column can be stored at 4°C or at room temperature [15–25°C], but not for long periods). Follow steps 6–12 to purify small RNA, and then steps E3–17 to purify larger RNA.

### Purifying small RNA (containing miRNA) using the RNeasy MinElute Cleanup Kit

6. Transfer the flow-through from step 4 (which contains miRNA) to a 2 ml reaction tube (not supplied).

7. Add 0.65 volumes (usually 455  $\mu$ l) of 100% ethanol, and mix thoroughly by vortexing. Do not centrifuge. Proceed immediately to step 8.
8. Transfer 700  $\mu$ l of the sample to an RNeasy MinElute spin column placed in a 2 ml collection tube. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the flow-through.  
Repeat step 8 until the whole sample has passed through the membrane. Discard the flow-through each time.
9. Add 500  $\mu$ l Buffer RPE to the RNeasy MinElute spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the flow-through.  
**Note:** Buffer RPE is supplied as a concentrate. Ensure that ethanol is added to Buffer RPE before use (see "Things to do before starting", page 40).
10. Add 500  $\mu$ l of 80% ethanol to the RNeasy MinElute spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm). Discard the flow-through and the collection tube.
11. Place the RNeasy MinElute spin column in a new 2 ml collection tube. Open the lid, and centrifuge for 1 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm).
12. Place the RNeasy MinElute spin column in a 1.5 ml collection tube. Add 14  $\mu$ l RNase-free water directly to the spin column membrane. Close the lid gently, and centrifuge for 1 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to elute the RNA (small RNA containing miRNA).

This RNA eluate is enriched in various RNAs of <200 nucleotides, including miRNA, 5S rRNA and tRNA. For this reason, the miRNA yield cannot be quantified by OD measurement or fluorogenic assays. To determine yield, we recommend using quantitative, real-time RT-PCR assays specific for the type of small RNA under study. For example, to estimate miRNA yield, an assay directed against any miRNA known to be adequately expressed in the samples being processed may be used.

#### **Purifying larger RNA (>200 nt) using the RNeasy Plus Mini Kit**

13. Add 700  $\mu$ l Buffer RW1 to the RNeasy Mini spin column from step 4. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through and the collection tube.
14. Place the RNeasy Mini spin column in a new 2 ml collection tube. Add 500  $\mu$ l Buffer RPE to the spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through.  
**Note:** Buffer RPE is supplied as a concentrate. Ensure that ethanol is added to Buffer RPE before use (see "Things to do before starting", page 40).
15. Add 500  $\mu$ l Buffer RPE to the RNeasy Mini spin column. Close the lid gently, and centrifuge for 15 s at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to wash the spin column membrane. Discard the flow-through and the collection tube.

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16. Place the RNeasy Mini spin column in a new 2 ml collection tube. Open the lid, and centrifuge at full speed for 1 min.

To avoid damage to their lids, place the spin columns into the centrifuge with at least one empty position between columns. Orient the lids so that they point in a direction opposite to the rotation of the rotor (e.g., if the rotor rotates clockwise, orient the lids counterclockwise).

It is important to dry the spin column membrane, since residual ethanol may interfere with downstream reactions. Centrifugation with the lids open ensures that no ethanol is carried over during RNA elution.

17. Place the RNeasy Mini spin column in a 1.5 ml collection tube. Add 30–50  $\mu$ l RNase-free water directly to the spin column membrane. Close the lid gently, and centrifuge for 1 min at  $\geq 8000 \times g$  ( $\geq 10,000$  rpm) to elute the RNA ( $>200$  nt).

If the expected RNA yield is  $>30$   $\mu$ g, repeat step 17 with a second volume of RNase-free water. Elute into the same collection tube.

For real-time RT-PCR with the purified RNA, QIAGEN offers the miRCURY LNA PCR System, which allows detection of hundreds of miRNAs from a single cDNA synthesis reaction. For details, visit [www.qiagen.com/miRNA](http://www.qiagen.com/miRNA).

## Ordering Information

Product	Description	Cat. no.
RNeasy Plus Mini Kit (50)	50 RNeasy Mini Spin Columns, 50 gDNA Eliminator Mini Spin Columns, Collection Tubes, RNase-Free Reagents and Buffers	74134
RNeasy Plus Mini Kit (250)	250 RNeasy Mini Spin Columns, 250 gDNA Eliminator Mini Spin Columns, Collection Tubes, RNase-Free Reagents and Buffers	74136
<b>Accessories</b>		
Collection Tubes (2 ml)	1000 x 2 ml Collection Tubes	19201
Allprotect Tissue Reagent (100 ml)	100 ml Allprotect Tissue Reagent, Allprotect Reagent Pump	76405
RNAprotect Tissue Reagent (50 ml)	50 ml RNAprotect Tissue Reagent for stabilization of RNA in 25 x 200 mg tissue samples	76104
RNAprotect Tissue Reagent (250 ml)	250 ml RNAprotect Tissue Reagent for stabilization of RNA in 125 x 200 mg tissue samples	76106
RNAprotect Tissue Tubes (50 x 1.5 ml)	For stabilization of RNA in 50 x 50 mg tissue samples: 50 screw-top tubes containing 1.5 ml RNAprotect Tissue Reagent each	76154
RNAprotect Tissue Tubes (20 x 5 ml)	For stabilization of RNA in 20 x 500 mg tissue samples: 20 screw-top tubes containing 5 ml RNAprotect Tissue Reagent each	76163
QIAshredder (50)*	50 disposable cell-lysate homogenizers	79654
TissueRuptor II	Handheld rotor-stator homogenizer, 5 TissueRuptor Disposable Probes	Varies
TissueRuptor Disposable Probes (25)	25 nonsterile plastic disposable probes for use with the TissueRuptor II (and the old TissueRuptor)	990890
TissueLyser LT	Compact bead mill, 100–240 V AC, 50–60 Hz; requires the TissueLyser LT Adapter, 12-Tube (available separately)	85600
TissueLyser LT Adapter, 12-Tube	Adapter for disruption of up to 12 samples in 2 ml microcentrifuge tubes on the TissueLyser LT	69980

Product	Description	Cat. no.
TissueLyser II	Bead mill; requires the TissueLyser Adapter Set 2 x 24 or TissueLyser Adapter Set 2 x 96 (available separately)	Various
TissueLyser Adapter Set 2 x 24	2 sets of Adapter Plates and 2 racks for use with 2 ml microcentrifuge tubes on the TissueLyser II	69982
TissueLyser Adapter Set 2 x 96	2 sets of Adapter Plates for use with Collection Microtubes (racked) on the TissueLyser II	69984
TissueLyser Single-Bead Dispenser, 5 mm	For dispensing individual beads (5 mm diameter)	69965
Stainless Steel Beads, 5 mm (200)	200 stainless steel beads (5 mm diameter), suitable for use with TissueLyser systems	69989
Stainless Steel Beads, 7 mm (200)	200 stainless steel beads (7 mm diameter), suitable for use with TissueLyser systems	69990
<b>QIAcube Connect – for fully automated nucleic acid extraction with QIAGEN spin-column kits</b>		
QIAcube Connect†	Instrument, connectivity package, 1-year warranty on parts and labor	Inquire
Starter Pack, QIAcube	Filter-tips, 200 µl (1024), 1000 µl filter-tips (1024), 30 ml reagent bottles (12), rotor adapters (240), elution tubes (240), rotor adapter holder	990395
<b>Related products for RNA purification</b>		
RNeasy Midi Kit (50)*‡	50 RNeasy Midi Spin Columns, Collection Tubes (15 ml), RNase-Free Reagents and Buffers	75144
RNeasy Maxi Kit (12)‡	12 RNeasy Maxi Spin Columns, Collection Tubes, RNase-Free Reagents and Buffers	75162
miRNeasy Tissue/Cells Advanced Mini Kit (50)	For 50 preps: RNeasy Mini Spin Columns, gDNA Eliminator Spin Columns, Collection Tubes, RNase-Free Water and Buffers	217604
RNase-Free DNase Set (50)	1500 Kunitz units RNase-free DNase I, RNase-free Buffer RDD, and RNase-free water for 50 RNA minipreps	79254
RNeasy MinElute Cleanup Kit (50)	50 RNeasy MinElute Spin Columns, Collection Tubes, RNase-Free Reagents and Buffers	74204

Product	Description	Cat. no.
<b>Related products for downstream applications</b>		
Omniscript RT Kit (50)*	For 50 reverse-transcription reactions: 200 units Omniscript Reverse Transcriptase, 150 µl 10x Buffer RT, 100 µl dNTP Mix (contains 5 mM each dNTP), 1.1 ml RNase-free water	205111
Sensiscript RT Kit (50)*	For 50 reverse-transcription reactions: Sensiscript Reverse Transcriptase, 150 µl 10x Buffer RT, 100 µl dNTP Mix (contains 5 mM each dNTP), 1.1 ml RNase-free water	205211
QuantiNova Rev. Transcription Kit (10)*	For 10 x 20 µl reactions: 20 µl 8x gDNA Removal Mix, 10 µl Reverse Transcription Enzyme, 40 µl Reverse Transcription Mix (containing RT primers), 20 µl Internal Control RNA, 1.9 ml RNase-Free Water	205410
QuantiNova SYBR Green PCR Kit (100)*	For 100 x 20 µl reactions: 1 ml 2x QuantiNova SYBR Green PCR Master Mix, 500 µl QuantiNova Yellow Template Dilution Buffer, 250 µl QN ROX Reference Dye, 1.9 ml Water	208052
QuantiNova SYBR Green RT-PCR Kit (100)*	For 100 x 20 µl reactions: 1 ml QuantiNova SYBR Green RT-PCR Master Mix, 20 µl QuantiNova SYBR Green RT Mix, 20 µl Internal Control RNA, 500 µl Yellow Template Dilution Buffer, 250 µl ROX Reference Dye, 1.9 µl RNase-Free Water	208152
QuantiNova Probe PCR Kit (100)*	For 100 x 20 µl reactions: 1 ml 2x QuantiNova Probe PCR Master Mix, 250 µl QN ROX Reference Dye, 500 µl QuantiNova Yellow Template Dilution Buffer, 1.9 ml Water	208252
QuantiNova Probe RT-PCR Kit (100)*	For 100 x 20 µl reactions: 1 ml QuantiNova Probe RT-PCR Master Mix, 20 µl QuantiNova Probe RT Mix, 20 µl Internal Control RNA, 500 µl Yellow Template Dilution Buffer, 250 µl ROX Reference Dye, 1.9 µl RNase-Free Water	208352
QuantiNova Multiplex PCR Kit (100)*	For 100 x 20µl reactions: 500µl QuantiNova Multiplex PCR Mastermix, 500µl yellow template dilution buffer, 250µl ROX reference dye, 1.9µl RNase-Free water	208452
QuantiNova Multiplex RT-PCR Kit (100)*	For 100 x 20 µl reactions: 0.5 ml 4x QuantiNova Multiplex RT-PCR Master Mix, 20 µl QuantiNova Multiplex RT-Mix, 20 µl QuantiNova IC RNA, 500 µl	208552

Product	Description	Cat. no.
	QuantiNova Yellow Template Dilution Buffer, 250 µl QN ROX Reference Dye, 1.9 ml RNase-Free Water	
miRCURY LNA SYBR® Green PCR Kit (200)	For 200 reactions: 2X miRCURY SYBR Green Master Mix, RNase-Free Water	339345
miRCURY LNA SYBR Green PCR Kit (600)	For 600 reactions: 2X miRCURY SYBR Green Master Mix, RNase-Free Water	339346
miRCURY LNA miRNA PCR Assay	Contains forward and reverse primers for 200 reactions; for SYBR® Green-based detection	339306

\* Larger kit size available; see [www.qiagen.com](http://www.qiagen.com).

† All QIAcube Connect instruments are provided with a region-specific connectivity package, including tablet and equipment necessary to connect to the local network. Further, QIAGEN offers comprehensive instrument service products, including service agreements, installation, introductory training and preventive subscription. Contact your local sales representative to learn about your options.

‡ Requires use of a centrifuge capable of attaining 3000–5000 x g equipped with a swing-out rotor for 15 ml (Midi) or 50 ml (Maxi) centrifuge tubes.

§ Visit [www.qiagen.com/GeneGlobe](http://www.qiagen.com/GeneGlobe) to search for and order this product.

¶ Visit [www.qiagen.com/GeneGlobe](http://www.qiagen.com/GeneGlobe) to search for and order primer sets or primer-probe sets.

\*\* Recommended for ABI PRISM and Applied Biosystems® cyclers.

†† Recommended for all other cyclers.

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## Document Revision History

Date	Changes
January 2020	Updated text, ordering information and intended use for QIAcube Connect.
September 2020	Updated branding of RNA protection products. Added bullet points about β-mercaptoethanol and dithiothreitol to “Things to do before starting”.

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