June 2021

miRNeasy Tissue/Cells Advanced Micro Kit Handbook

For purification of total RNA, including miRNA from tissue and cells

Sample to Insight

QIAGEN

Contents

Kit Contents 4

Storage 5

Intended Use 5

Safety Information 6

Quality Control 6

Introduction 7

- Principles and procedures 7
- Automated purification of RNA on QIAcube instruments 10
- Real-time RT-PCR detection of miRNAs using the one of the miRCURY® LNA® miRNA PCR systems 11
- Description of protocols 11

Equipment and Reagents to be supplied by User 12

Important Notes 13

- Determining the amount of starting material 13
- Determining the correct amount of starting material — cells 14
- Determining the correct amount of starting material — tissue 15
- Handling and storage of starting material 17
- Disrupting and homogenizing starting material 17
- Disruption and homogenization using the TissueRuptor II 19
- Disruption and homogenization using the TissueLyser II or TissueLyser LT 19
- Disruption using a mortar and pestle 20

Protocol: Purification of Total RNA, Including Small RNAs, from Animal Cells 21

Protocol: Purification of Total RNA, Including Small RNAs, from Animal Tissues 26

Troubleshooting Guide 33

Appendix A: Guidelines for Disruption and Homogenization of Tissues using the TissueLyser II 36

Appendix B: Optional On-column DNase digestion with the RNase-Free DNase Set 37

Appendix C: General Remarks on Handling RNA 40

Appendix D: Storage, Quantification, and Determination of Quality of RNA 42

Ordering Information 46

Document Revision History 50

Kit Contents

miRNeasy Tissue/Cells Advanced Micro Kit **Catalog no.** **Number of Reactions**	**(50)** **217684** **50**
RNeasy® UCP MinElute® Spin Columns (each packaged with a 2 ml Collection Tube)	50
gDNA Eliminator Spin Column	50
Collection Tubes (1.5 ml)	50
Collection Tubes (2 ml)	50
Buffer RLT*	45 ml
Buffer AL	12 ml
Buffer RPP	8 ml
Buffer RWT*†	15 ml
Buffer RPE‡	11 ml
RNase-Free Water	10 ml
Quick-Start Protocol	1

* Contains a guanidine salt. Not compatible with disinfectants containing bleach. See page 6 for Safety Information.

† Buffer RWT is supplied as a concentrate. Before using for the first time, add 2 volumes of ethanol (96–100%) as indicated on the bottle to obtain a working solution.

‡ 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.

Storage

The miRNeasy Tissue/Cells Advanced Micro Kit (cat. no. 217684) is shipped at ambient temperature. Store the RNeasy UCP MinElute spin columns immediately at 2–8°C. All other components can be stored dry at room temperature. Under these conditions, all kit components are stable for at least 9 months, if not otherwise stated on the label.

Intended Use

The miRNeasy Tissue/Cells Advanced Micro Kit is intended for molecular biology applications. These products are 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 products. 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 a convenient and compact PDF format at **www.qiagen.com/safety** where you can find, view, and print the SDS for each QIAGEN kit and kit component.

WARNING

DO NOT add bleach or acidic solutions directly to the sample preparation waste.

Buffer RWT contains guanidine thiocyanate, which can form highly reactive compounds when combined with bleach. If liquid containing these solutions 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 miRNeasy Tissue/Cells Advanced Micro Kit is tested against predetermined specifications to ensure consistent product quality.

Introduction

Interest in smaller RNA species, such as miRNA, has increased over the past years as researchers understand the regulatory role of small non-coding RNAs. The miRNeasy Tissue/Cells Advanced Micro Kit is designed for purification of total RNA — including miRNA and other small RNA — from cultured cells and various animal and human tissues.

The miRNeasy Tissue/Cells Advanced Micro Kit offers a phenol-free protocol to isolate high yields of total RNA including miRNA from small amounts of cultured cells and various animal and human tissues.

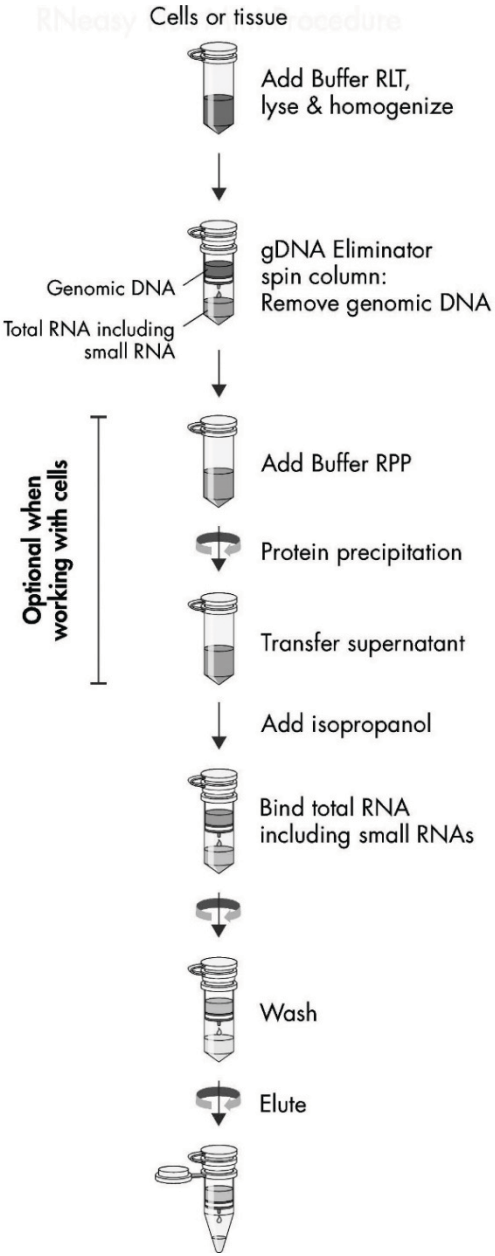
Principles and procedures

The miRNeasy Tissue/Cells Advanced Micro Kit combines guanidine-based lysis of samples, an inhibitor removal step, and silica-membrane-based purification of total RNA, including miRNA and other small RNA. Buffer RLT, included in the kit, contains guanidine thiocyanate designed to facilitate lysis and to denature protein complexes and RNases. Therefore, RNA in samples lysed in buffer RLT are stable and protected from degradation.

Buffer RLT is added to tissue or cell samples, and a thorough disruption and homogenization is done immediately to ensure a complete lysis and inactivation of RNases. Subsequently, Buffer AL is added to the lysate to optimize the gDNA removal by the gDNA Eliminator Spin Column. Depending on the type and amount of starting material, an optional on column DNase digestion can be carried out (not included in the kit).

Buffer RPP is added to the flow-through to precipitate inhibitors (mostly proteins, which are highly concentrated in tissue and cell samples and might interfere with the RNA isolation or the downstream analysis) by centrifugation.

The supernatant containing the RNA including miRNA and other small RNA is transferred into a new reaction tube, and isopropanol is added to provide appropriate binding conditions for all RNA molecules from approximately 18 nucleotides (nt) upwards. The sample is then applied to the RNeasy UCP MinELute spin column, where the total RNA including miRNA and other small RNA binds to the membrane and all contaminants are efficiently washed away. High-quality RNA including miRNA and other small RNA is eluted in a small volume of RNase-Free Water.


Cells or tissue
Add Buffer RLT,
lyse & homogenize
gDNA Eliminator
spin column:
Remove genomic DNA
Genomic DNA
Total RNA including
small RNA
Optional when
working with cells
Add Buffer RPP
Protein precipitation
Transfer supernatant
Add isopropanol
Bind total RNA
including small RNAs
Wash
Elute

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 miRNeasy Tissue/Cells Advanced Micro Kit for purification of high-quality miRNA.

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**.

Figure 1. QIAcube Connect.

Real-time RT-PCR detection of miRNAs using the one of the miRCURY® LNA® miRNA PCR systems

In general, real-time RT-PCR is recommended to accurately quantify yields of miRNA. The miRCURY LNA miRNA PCR system allows sensitive and specific quantification and profiling of miRNA expression using SYBR® Green-based or probe-based real-time PCR. Both the SYBR® Green detection-based miRCURY LNA miRNA PCR system and the probe-based miRCURY LNA miRNA Probe PCR System comprise all the required components to set up and conduct miRNA quantification and expression profiling, from conversion of RNA into cDNA to real-time PCR detection of miRNAs and straightforward data analysis. The systems both use the same miRCURY LNA RT Kit for generation of a universal first-strand cDNA synthesis – one cDNA reaction for all miRNAs. Each system then has their own dedicated master mix kit, the miRCURY LNA SYBR® Green PCR Kit and the miRCURY LNA miRNA Probe PCR Kit, as well as a broad variety of system-specific LNA-enhanced miRCURY LNA assay and panel products. The RNA Spike-In Kit enables quality control of the RNA isolation, cDNA synthesis, and PCR amplification steps of miRCURY LNA miRNA qPCR experiments.

For both systems, individual assays for mature miRNAs for a variety of different species can be ordered on GeneGlobe® (**www.qiagen.com/GeneGlobe**). Alternatively, for high-throughput and screening experiments, miRCURY LNA PCR Panels and miRCURY LNA Probe PCR Panels enable rapid profiling of the complete miRNome. Other Focus panels like the miRCURY LNA miRNA Serum/Plasma Focus PCR Panel and Serum/Plasma Focus Probe PCR Panel are available for the detection of mature miRNAs. Find out more about the miRCURY LNA miRNA PCR systems at **www.qiagen.com**.

Description of protocols

This handbook contains two protocols for purification of total RNA, including miRNA, from tissues or cells using the miRNeasy Tissue/Cells Advanced Micro Kit. In addition, protocols are provided for sample disruption, on-column DNase digestion, and for general remarks on handling RNA.

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.

- Ethanol (80%)*
- Isopropanol (100%)
- 14.3 M β-mercaptoethanol (β-ME, commercially available solutions are usually 14.3 M), alternatively dithiothreitol (DTT, 2 M stock solution)
- Sterile, RNase-free pipet tips
- 1.5 ml or 2 ml microcentrifuge tubes
- Microcentrifuge(s) (with rotor for 2 ml tubes) for centrifugation at room temperature (15–25°C)
- Disposable gloves

  For animal tissues: RNAprotect® Tissue Reagent (see Ordering Information, page 46) or liquid nitrogen

  Optional: RNase-Free DNase Set (see Ordering Information, page 46)
- Equipment and tubes for disruption and homogenization (see page 17). Depending on the method chosen, one or more of the following are required:
  - TissueRuptor® II with TissueRuptor Disposable Probes (see Ordering Information, page 46)
  - TissueLyser II or TissueLyser LT (see Ordering Information, page 46)
  - Mortar and pestle
  - QIAshredder homogenizer (see Ordering Information, page 46)
  - Blunt-ended needle and syringe
  - Trypsin and PBS

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

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 depends on:

- The volume of Lysis Buffer RLT required for efficient lysis
- The RNA-binding capacity of the RNeasy UCP MinElute spin column (45 µg)
- The RNA content of the sample type

When processing samples containing high amounts of RNA, less than the maximum amount of starting material shown in Table 1 should be used so that the RNA binding capacity of the column is 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 UCP MinElute 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 UCP MinElute spin column membrane, resulting in lower RNA yield and purity.

Table 1. RNeasy UCP MinElute spin column specifications

Maximum binding capacity	45 µg RNA
Maximum loading volume	700 µl
RNA size distribution	RNA >18 nucleotides
Minimum elution volume	10 µl
Maximum amount of starting material	
Animal cells	1×10^6
Animal tissues	5 mg

Note: If the binding capacity of the RNeasy UCP MinElute 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 UCP MinElute spin column is not exceeded.

Determining the correct amount of starting material — cells

The maximum amount of starting material depends on the RNA content of the cell type. RNA content can vary greatly between cell types and growth rates. If processing a cell type where there is no information about its RNA content, we recommend starting with no more than 1×10^6 cells. Depending on RNA yield and purity, it may be possible to increase the cell number in subsequent preparations.

Counting cells is the most accurate way to quantify the amount of starting material. As a guide, the number of HeLa cells obtained in various culture vessels after confluent growth is given in Table 2.

Table 2. Growth area and number of HeLa cells in various culture vessels

Cell-culture vessel	Growth area (cm^2)*	Number of cells†
Multiwell plates		
96-well	0.32–0.6	4–5 x 10^4
48-well	1	1 x 10^5
24-well	2	2.5 x 10^5
12-well	4	5 x 10^5
6-well	9.5	1 x 10^6
Dishes		
35 mm	8	1 x 10^6
Flasks		
40–50 ml	25	25

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

† 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.

Determining the correct amount of starting material — tissue

The maximum amount of tissue that can be processed depends on the RNA content of the tissue. To help to estimate the RNA content of your tissue type, Table 3 shows expected RNA yields from various sources.

In general, a maximum of 5 mg tissue can be processed with the miRNeasy Tissue/Cells Advanced Micro procedure. For adipose tissues, up to 10 mg can be processed. The binding capacity of the column (45 µg RNA) and the lysing capacity of Buffer RLT will not be exceeded by these amounts.

Table 3. Average yields of total RNA with miRNeasy Tissue/Cells Advanced Micro Kit

Sample	Average RNA yield* (µg)
Mouse/rat tissue (5 mg)	
Kidney	2–20
Liver	8–40
Lung	2–8
Heart	2–12
Muscle	2–15
Brain	2–10
Adipose tissue	0.2–1.5
Spleen	8–50
Intestine	5–30
Skin	1–3
Cell culture (1 x 10^6 cells)	
NIH/3T3	10
HeLa	15
COS-7	35
LMH	12
Huh	15
Jurkat	15

* Amounts can vary due to species, developmental stage, etc.

Weighing tissue is the most accurate way to quantify the amount of starting material. However, the following may be used as a guide. A 1.5 mm cube (volume, 3.4 mm^3) of most animal tissues weighs 3.5–4.5 mg.

Handling and storage of starting material

RNA is not protected after harvesting until the sample is treated with RNAprotect Cell Reagent (cultured cells only) or RNAprotect Tissue Reagent (animal tissues only), 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 samples are immediately frozen in liquid nitrogen and stored at –90 to –65°C (animal tissues only), processed as soon as harvested, or immediately immersed in RNAprotect Cell Reagent or RNAprotect Tissue Reagent. Animal cells can be pelleted and then stored at –90 to –65°C until required for RNA purification.

An alternative to RNAprotect Tissue Reagent is Allprotect® Tissue Reagent, which provides immediate stabilization of DNA, RNA, and protein in tissues samples at room temperature.

The procedures for harvesting and RNA protection should be carried out as quickly as possible. Frozen samples should not be allowed to thaw during handling or weighing. After disruption and homogenization in Buffer RLT, samples can be stored at –90 to –65°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. Different samples require different methods to achieve complete disruption. Incomplete disruption significantly reduces 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. In the miRNeasy procedure, genomic DNA is removed by organic extraction, which makes it possible to homogenize up to 3 x 10^6 cells by vortexing without additional homogenization. Incomplete homogenization results in inefficient binding of RNA to the RNeasy UCP MinElute spin column membrane, significantly reducing RNA yields.

Some disruption methods simultaneously homogenize the sample, while others require an additional homogenization step. Table 4 gives an overview of different disruption and homogenization methods and is followed by a detailed description of each method. This information can be used as a guide to choose the appropriate methods for your starting material.

Table 4. Guide to methods of disruption and homogenization of samples

Sample	Disruption method	Homogenization method	Comments
Animal cells	Addition of lysis buffer	TissueRuptor II or QIAshredder homogenizer or syringe and needle or vortexing (≤3 x 10^6 cells)	For cell numbers recommended with the miRNeasy Tissue/Cells Advanced Micro Kit, lysate can usually be homogenized by thorough vortexing
Animal tissues	TissueLyser II or TissueLyser LT	TissueLyser II or TissueLyser LT	The TissueLyser II and TissueLyser LT give results comparable to using a rotor–stator homogenizer
	TissueRuptor II	TissueRuptor II	Simultaneously disrupts and homogenizes
	Mortar and pestle	QIAshredder homogenizer or syringe and needle	The TissueRuptor II usually gives higher yields than mortar and pestle

Disruption and homogenization using the TissueRuptor II

The TissueRuptor II is a rotor–stator homogenizer that thoroughly disrupts and simultaneously homogenizes single animal tissue samples in the presence of lysis buffer in 15–90 seconds, depending on the toughness and size of the sample. The TissueRuptor II can also be used to homogenize cell lysates. The blade of the TissueRuptor II 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 disruption and homogenization of animal tissues using the TissueRuptor II, refer to the *TissueRuptor II Handbook*. For other rotor–stator homogenizers, please refer to suppliers' guidelines for further details.

Disruption and homogenization using the TissueLyser II or TissueLyser LT

In bead-milling, cells and 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. Disruption efficiency is influenced by:

- Size and composition of beads
- Ratio of buffer to beads
- Amount of starting material
- Speed and configuration of the TissueLyser II or TissueLyser LT
- Disintegration time

Stainless-steel beads with a 3–7 mm diameter are optimal for use with animal tissues. All other disruption parameters must be determined empirically for each application. For guidelines on disruption and homogenization of tissues using the TissueLyser II and stainless-steel beads, refer to Appendix A (page 36). For other bead mills, please refer to the suppliers' guidelines for further details.

Disruption using a mortar and pestle

For disruption using a mortar and pestle, freeze the animal tissue immediately in liquid nitrogen and grind to a fine powder under liquid nitrogen. Transfer the suspension (tissue powder and liquid nitrogen) into a liquid-nitrogen–cooled, appropriately sized tube and allow the liquid nitrogen to evaporate without allowing the sample to thaw. Add lysis buffer and continue as quickly as possible with the homogenization according to one of the 2 methods below.

> **Note**: Grinding the sample using a mortar and pestle will disrupt the sample but will not homogenize it. Homogenization must be performed afterwards.

Homogenization using QIAshredder homogenizers

Using QIAshredder homogenizers is a fast and efficient way to homogenize cell and tissue lysates without cross-contamination of samples. Up to 700 µl of lysate is loaded onto a QIAshredder spin column placed in a 2 ml collection tube and spun for 2 minutes at maximum speed in a microcentrifuge. The lysate is homogenized as it passes through the spin column.

Homogenization using a syringe and needle

Cell and tissue lysates can be homogenized using a syringe and needle. Lysate is passed through a 20-gauge (0.9 mm) needle attached to a sterile plastic syringe at least 5–10 times or until a homogeneous lysate is achieved. Increasing the volume of lysis buffer may be required to facilitate handling and minimize loss.

Protocol: Purification of Total RNA, Including Small RNAs, from Animal Cells

Important points before starting

- If using the miRNeasy Tissue/Cells Advanced Micro Kit for the first time, read "Important Notes" (page 13).
- It is important not to overload the RNeasy UCP MinElute spin column, as overloading will significantly reduce RNA yield and quality. Read "Determining the amount of starting material" (page 13).
- If working with RNA for the first time, read Appendix C (page 40).
- Cell pellets can be stored at –90 to –65°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 –90 to –65°C for several months. To process frozen homogenized lysates, incubate at 37°C in a water bath until completely thawed and salts are dissolved. Avoid prolonged incubation, which may compromise RNA integrity.
- Generally, DNase digestion is not required because the RNeasy technologies in combination with the gDNA Eliminator efficiently removes most of the DNA without DNase treatment. In addition, miRCURY Assays and most other assays for mature miRNA are not affected by the presence of small amounts of genomic DNA. However, further DNA removal may be necessary for certain RNA applications that are sensitive to very small amounts of DNA. In these cases, small residual amounts of DNA can be removed by
  on-column DNase digestion (see Appendix B, page 37) or by DNase digestion after RNA purification (please contact QIAGEN Technical Service for a protocol).
- Buffer RLT and Buffer RWT may form a precipitate upon storage. If necessary, redissolve by warming and then place at room temperature (15–25°C).

- Buffer RLT, Buffer AL, and Buffer RWT contain a guanidine salt and are therefore not compatible with disinfecting reagents containing bleach. See page 6 for Safety Information.

All protocol and centrifugation steps should be performed at room temperature. During the procedure, work quickly.

Things to do before starting

- Equilibrate buffers to room temperature.
- All steps should be performed at room temperature. Work quickly.
- Add ethanol (96–100%) to Buffer RWT and Buffer RPE concentrates before use (see bottle label for volume).
- If purifying RNA from cell lines rich in RNases, we recommend adding β-mercaptoethanol (β-ME) to Buffer RLT before use. Add 10 µl β-ME per 1 ml Buffer RLT. Dispense in a fume hood and wear appropriate protective clothing. Buffer RLT containing β-ME can be stored at room temperature (15–25°C) for up to 1 month. Alternatively, add 20 µl of 2 M dithiothreitol (DTT) per 1 ml Buffer RLT. The stock solution of 2 M DTT in water should be prepared fresh or frozen in single-use aliquots. Buffer RLT containing DTT can be stored at room temperature for up to 1 month.

Procedure

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

   1a. Cells grown in suspension (do not use more than 5 x 10^5 cells):
   Determine the number of cells. Pellet the appropriate number of cells by centrifuging for 5 min at 300 x *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 binding of RNA to the RNeasy UCP MinElute spin column membrane. Both effects may reduce RNA yield.

1b. Cells grown in a monolayer (do not use more than 5 x 10^5 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 binding of RNA to the RNeasy UCP MinElute spin column membrane. Both effects may reduce RNA 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 0.1–0.25% trypsin. 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 x *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 binding of RNA to the RNeasy UCP MinElute spin column membrane. Both effects may reduce RNA yield.

2. Disrupt the cells by adding 260 µl Buffer RLT. For pelleted cells, loosen the cell pellet thoroughly by flicking the tube. 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 β-ME is added to Buffer RLT before use (see "Important points before starting").

For direct lysis of cells grown in a monolayer, add 260µl of Buffer RLT 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.

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

   See "Disrupting and homogenizing starting material", page 17, for more details on homogenization. If processing ≤1 x 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. Add 40 µl Buffer AL and mix thoroughly. Incubate at room temperature for 3 min.
5. Transfer the homogenized lysate to a gDNA Eliminator Spin Column placed in a 2 ml collection tube (supplied). Centrifuge for 30 s at ≥8000 x *g* (≥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.

   Optional: Steps 6 and 7 do not need to be carried out when working with cell samples.

6. Transfer the flow-through to a new 2 ml reaction tube (not provided). Add 20 µl Buffer RPP. Close the tube cap and mix vigorously by vortexing for >20 s. Incubate at room temperature for 3 min.
7. Centrifuge at 12,000 x *g* for 3 min at room temperature to pellet the precipitate.

   Note: Supernatant should be clear and colorless. Transfer supernatant to a new 2 ml reaction tube.

8. Add 1.3 volume isopropanol (usually 370 µl) and mix well by pipetting. Do not centrifuge.

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

9. Transfer up to 700 µl of the sample to an RNeasy UCP MinElute column placed in a 2 ml collection tube (provided). Close the lid and centrifuge for 15 s at ≥8000 x *g*. Discard the flow-through.

   Reuse the collection tube in step 10.

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

10. Pipet 700 µl Buffer RWT to the RNeasy UCP MinElute spin column. Close the lid and centrifuge for 15 s at ≥8000 x *g*. Discard the flow-through.

    Reuse the collection tube in step 11.

    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.

11. Pipet 500 µl Buffer RPE onto the RNeasy UCP MinElute spin column. Close the lid and centrifuge for 15 s at ≥8000 x *g*. Discard the flow-through.

    Reuse the collection tube in step 12.

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

12. Add 500 µl of 80% ethanol to the RNeasy UCP MinElute spin column. Close the lid and centrifuge for 2 min at ≥8000 x *g*. Discard the flow-through and the collection tube.

13. Place the RNeasy UCP MinElute spin column in a new 2 ml collection tube (supplied). Open the lid of the spin column, and centrifuge at full speed for 5 min to dry the membrane. Discard the flow-through and collection tube.

14. Place the RNeasy UCP MinElute spin column in a new 1.5 ml collection tube (supplied). Add 20 µl RNase-Free Water directly to the center of the spin column membrane and incubate for 1 min. Close the lid and centrifuge for 1 min at full speed to elute the RNA.

Protocol: Purification of Total RNA, Including Small RNAs, 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 5 mg fresh, frozen or RNAprotect-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 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 3 (page 16). Some tissues, such as spleen and thymus, contain very high amounts of DNA, which will overload the gDNA Eliminator Spin Column. For fibrous tissues, such as muscle and skin, that contain contractile proteins, connective tissue, and collagen, we recommend the RNeasy Plus Universal Mini Kit, which efficiently removes these components in the phase separation.

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 miRNeasy Tissue/Cells Advanced Micro Kit for the first time, read "Important Notes" (page 13).
- It is important not to overload the RNeasy UCP MinElute spin column, as overloading will significantly reduce RNA yield and quality. Read "Determining the amount of starting material" (page 13).
- If working with RNA for the first time, read Appendix C (page 40).

- For optimal results, stabilize harvested tissues immediately in RNAprotect Tissue Reagent or Allprotect Stabilization Reagent. Tissues can be stored in the reagent for up to 1 day at 37°C, 7 days at 15–25°C, or 4 weeks at 2–8°C, or archived at –95 to –15°C.
- Fresh, frozen, or RNAprotect- or AllProtect-stabilized tissues can be used. Tissues can be stored for several months at –90 to –65°C. Do not allow tissues to thaw during weighing or handling prior to disruption in Buffer RLT. Homogenized tissue lysates (in Buffer RLT, step 3) can also be stored at –90 to –65°C for several months. To process frozen homogenized lysates, incubate at 37°C in a water bath until completely thawed and salts are dissolved. Avoid prolonged incubation, which may compromise RNA integrity. Continue with step 4.
- Generally, DNase digestion is not required because the combination of the RNeasy technologies in combination with the gDNA Eliminator efficiently removes most of the DNA without DNase treatment. In addition, miRCURY Assays and most other assays for mature miRNA are not affected by the presence of small amounts of genomic DNA. However, further DNA removal may be necessary for certain RNA applications that are sensitive to very small amounts of DNA. In these cases, small residual amounts of DNA can be removed by on-column DNase digestion (see Appendix B, page 37) or by DNase digestion after RNA purification (please contact QIAGEN Technical Service for a protocol).
- Buffer RLT und Buffer RWT may form a precipitate upon storage. If necessary, redissolve by warming and then place at room temperature (15–25°C).
- Buffer RLT, Buffer AL, and Buffer RWT contain a guanidine salt and are therefore not compatible with disinfecting reagents containing bleach. See page 6 for Safety Information.
- All protocol and centrifugation steps should be performed at room temperature. During the procedure, work quickly.

Things to do before starting

- Buffers RWT and RPE are supplied as concentrates. Before using for the first time, add the required amounts of ethanol (96–100%), as indicated on the bottle, to obtain a working solution.
- If performing optional on-column DNase digestion, prepare DNase I stock solution as described in Appendix B (page 37).

Notes before starting

- Equilibrate buffers to room temperature.
- All steps should be performed at room temperature. Work quickly.
- β-Mercaptoethanol (β-ME) must be added to Buffer RLT before use. Add 10 µl β-ME per 1 ml Buffer RLT. Dispense in a fume hood and wear appropriate protective clothing. Buffer RLT is stable at room temperature (15–25°C) for 1 month after addition of β-ME. Alternatively, add 20 µl 2 M dithiothreitol (DTT) per 1 ml Buffer RLT. The stock solution of 2 M DTT in water should be prepared fresh or frozen in single-use aliquots. Buffer RLT containing DTT can be stored at room temperature for up to 1 month.

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 5 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 tube 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 Tissue 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 (do not use more than 5 mg tissue) according to step 3a, 3b, 3c, or 3d.

   See "Determining the amount of starting material", page 13, for more details on disruption and homogenization.

   Optional: Ensure that β-ME is added to Buffer RLT before use (see "Important points before starting").

   Note: 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.

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

3a. Disruption and homogenization using the TissueRuptor II: Place the weighed (fresh, frozen, or RNAprotect Tissue-stabilized) tissue in a suitably sized vessel. Add 260 µl Buffer RLT. Immediately disrupt and homogenize the tissue until it is uniformly homogeneous (usually 20–40 s); see the *TissueRuptor II 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 Tissue-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 260 µl Buffer RLT. 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 Tissue-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 260 µl Buffer RLT, 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 into a new tube.

   Note: 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.

5. Add 40 µl Buffer AL and mix thoroughly. Incubate at room temperature for 3 min.
6. Transfer the homogenized lysate to a gDNA Eliminator Spin Column placed in a 2 ml collection tube (supplied). Centrifuge for 30 s at ≥8000 x *g* (≥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.

7. Transfer the flow-through to a new 2 ml reaction tube (not provided). Add 20 µl Buffer RPP. Close the tube cap and mix vigorously by vortexing for >20 s. Incubate at room temperature for 3 min.
8. Centrifuge at 12,000 x *g* for 3 min at room temperature to pellet the precipitate.

   Note: Supernatant should be clear and colorless. Transfer supernatant to a new 2 ml reaction tube.

9. Add 1.3 volume isopropanol (usually 350 µl) and mix well by pipetting. Do not centrifuge.

   Note: When purifying RNA from certain tissues, precipitates may be visible after addition of isopropanol. This does not affect the procedure.

10. Transfer up to 700 µl of the sample to an RNeasy UCP MinElute column placed in a 2 ml collection tube (provided). Close the lid and centrifuge for 15 s at ≥8000 x *g*. Discard the flow-through.

    Reuse the collection tube in step 11.

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

11. Pipet 700 µl Buffer RWT to the RNeasy UCP MinElute spin column. Close the lid and centrifuge for 15 s at ≥8000 x *g*. Discard the flow-through.

    Reuse the collection tube in step 12.

    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.

12. Pipet 500 µl Buffer RPE onto the RNeasy UCP MinElute spin column. Close the lid and centrifuge for 15 s at ≥8000 x *g*. Discard the flow-through.

    Reuse the collection tube in step 13.

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

13. Add 500 µl of 80% ethanol to the RNeasy UCP MinElute spin column. Close the lid and centrifuge for 2 min at ≥8000 x *g*. Discard the flow-through and the collection tube.

14. Place the RNeasy UCP MinElute spin column in a new 2 ml collection tube (supplied). Open the lid of the spin column, and centrifuge at full speed for 5 min to dry the membrane. Discard the flow-through and collection tube.

15. Place the RNeasy UCP MinElute spin column in a new 1.5 ml collection tube (supplied). Add 20 µl RNase-Free Water directly to the center of the spin column membrane and incubate for 1 min. Close the lid and centrifuge for 1 min at full speed to elute the RNA.

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**. 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**).

		Comments and suggestions
RNA degraded		
a)	Inappropriate handling of starting material	Ensure that tissue samples are properly stabilized and stored in RNAprotect Tissue Reagent. For frozen cell pellets or frozen tissue samples, ensure that they were flash-frozen immediately in liquid nitrogen and properly stored at –70°C. Perform the RNeasy procedure quickly, especially the first few steps. See Appendix A (page 36) and "Handling and storage of starting material" (page 15).
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 36) 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 µg genomic DNA). If the eluted RNA contains substantial DNA contamination, try processing smaller cell numbers or perform DNase digestion of the eluted RNA followed by RNA cleanup.
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 µg genomic DNA) or perform DNase I digestion of the eluted RNA followed by RNA cleanup.

		Comments and suggestions
Clogged gDNA Eliminator Spin Column		
a)	Inefficient disruption and/or homogenization	See "Determining the amount of starting material" (page 13) for details on disruption and homogenization methods. Increase *g*-force and centrifugation time if necessary. In subsequent preparations, reduce the amount of starting material (see protocols, pages 21 and 26) 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 13).
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.
Clogged RNeasy UCP MinElute column		
a)	Too much starting material	In subsequent preparations, reduce the amounts of starting material. It is essential to use the correct amount of starting material (see page 13).
b)	Inefficient disruption and/or	See "Disrupting and homogenizing starting material" (page 17) for a detailed description of homogenization methods. Increase *g*-force and centrifugation time if necessary. In subsequent preparations, reduce the amount of starting material (see page 13) and/or increase the homogenization time.
c)	Centrifugation temperature too low	All centrifugation steps should be performed at room temperature (15–25°C). Some centrifuges may cool to below 20°C even when set at 20°C. This can cause precipitates to form that can clog the RNeasy UCP MinElute spin column and reduce RNA yield. If this happens, set the centrifugation temperature to 25°C. Warm the ethanol-containing lysate to 37°C before transferring to the RNeasy UCP MinElute spin column.
Low RNA yield or poor performance of RNA in downstream applications		
a)	Incorrect isopropanol concentration	Be sure to use the ethanol concentrations specified in the protocol steps.
b)	Interference from large RNAs	In some assays, the presence of mRNA and rRNA can result in increased background. In this case, follow the protocol in Appendix A: Preparation of miRNA-Enriched Fractions Separate from Larger RNAs (>200 nt) of the *miRNeasy Mini Kit Handbook* to isolate a separate, miRNA-enriched fraction. An additional kit, the RNeasy MinElute Cleanup Kit, is required for this protocol.
c)	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.

		Comments and suggestions
Low or no recovery of RNA		
a)	Too much starting material	In subsequent preparations, reduce the amounts of starting material. It is essential to use the correct amount of starting material (see page 13).
b)	Inefficient disruption and/or homogenization	See "Disrupting and homogenizing starting material" (page 17) for a detailed description of homogenization methods. Increase g-force and centrifugation time if necessary. In subsequent preparations, reduce the amount of starting material (see page 13) and/or increase the homogenization time.
c)	Elution buffer incorrectly dispensed	Add elution buffer to the center of the RNeasy UCP MinElute spin column membrane to ensure that the buffer completely covers the membrane.
d)	RNA still bound to the membrane	Repeat the elution step of the protocol, but incubate the RNeasy UCP MinElute spin column on the bench for 10 min after adding RNase- free water and before centrifugation.
Low A_{260}/A_{280} value		
a)	Not enough Buffer RLT used for homogenization	Reduce the amount of starting material and/or increase the volume of Lysis Buffer RLT and the homogenization time.
b)	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 D, page 40).
RNA degraded		
a)	Sample inappropriately handled	For frozen tissue samples, ensure that they were flash-frozen immediately in liquid nitrogen and properly stored at –90 to –65°C. Perform the protocol quickly, especially the first few steps. See "Appendix C: General Remarks on Handling RNA" (page 40) and "Handling and storage of starting material" (page 15).
b)	RNase contamination	Although all buffers have been tested and are guaranteed RNase-free, RNases can be introduced during use. Make sure not to introduce any RNases during the procedure or later handling. See "Appendix C: General Remarks on Handling RNA" (page 40). Do not put RNA samples into a vacuum dryer that has been used in DNA preparations where RNases may have been used.

Appendix A: Guidelines for Disruption and Homogenization of Tissues using the TissueLyser II

The TissueLyser II and TissueLyser Adapter Set 2 x 24 allow high-throughput, rapid, and effective disruption of 48 biological samples in 2–4 minutes. Homogenization and disruption with the TissueLyser II give results comparable to using rotor–stator homogenization.

The following guidelines can be used for disruption and homogenization of tissues using the TissueLyser II. Alternatively, for small sample numbers, we recommend the TissueLyser LT. For more information, consult the *TissueLyser LT Handbook*. Be sure to work quickly to prevent RNA degradation.

Procedure

1. Pipet 260 µl Buffer RLT into a 2 ml collection tube.
2. Add one stainless steel bead to each tube. For best results, we recommend using a 5 mm (mean diameter) stainless steel bead.
3. Add up to 30 mg tissue per tube.
4. Homogenize on the TissueLyser II for 2 min at 20 Hz.

   Homogenization time depends on the tissue used and can be extended until the tissue is completely homogenized (up to 5 min at 25 Hz).
5. Rotate the TissueLyser rack to allow even homogenization and homogenize for another 2 min at 20 Hz.

   The TissueLyser Adapter Set should be disassembled, and the rack of tubes should be rotated so that the tubes that were nearest to the TissueLyser are now outermost.
6. Carefully transfer the homogenate to a new microcentrifuge tube (not supplied) by pipetting. Do not reuse the stainless-steel bead.
7. Proceed with step 4 of the protocol on page 31.

Appendix B: Optional On-column DNase digestion with the RNase-Free DNase Set

The RNase-Free DNase Set (cat. no. 79254) provides efficient on-column digestion of DNA during RNA purification. The DNase is efficiently removed in subsequent wash steps.

> **Note**: Standard DNase buffers are not compatible with on-column DNase digestion. Use of other buffers may affect the binding of RNA to the RNeasy membrane, reducing RNA yield and integrity.

Lysis and homogenization of the sample and binding of RNA to the RNeasy membrane are performed according to the standard protocol. After washing with a reduced volume of Buffer RWT, the RNA is treated with DNase I while bound to the RNeasy membrane. The DNase I is removed by a second wash with Buffer RWT. Washing with Buffer RPE and elution of RNA are then performed according to the standard protocol.

Important points before starting

- Generally, DNase digestion is not required because RNeasy technologies efficiently remove most of the DNA without DNase treatment. However, further DNA removal may be necessary for certain RNA applications that are sensitive to very small amounts of DNA (e.g., TaqMan RT-PCR analysis with a low-abundant target).
- Do not vortex the reconstituted DNase I. DNase I is especially sensitive to physical denaturation. Mixing should only be carried out by gently inverting the tube.

Things to do before starting

- Prepare DNase I stock solution before using the RNase-Free DNase Set for the first time. Dissolve the lyophilized DNase I (1500 Kunitz units) in 550 µl of the RNase-Free Water provided. To avoid loss of DNase I, do not open the vial. Inject RNase-Free Water into the vial using an RNase-free needle and syringe. Mix gently by inverting the vial. Do not vortex.

- For long-term storage of DNase I, remove the stock solution from the glass vial, divide it into single-use aliquots, and store at –30 to –15°C for up to 9 months. Thawed aliquots can be stored at 2–8°C for up to 6 weeks. Do not refreeze the aliquots after thawing.

Procedure

Prepare and load samples onto the RNeasy UCP MinElute spin column as indicated in steps 1–9 of "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Cells" on pages 22–25 or steps 1–10 of "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Tissues" on pages 28–31. Instead of performing step 10 of "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Cells" on page 21 or step 11 of "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Tissues" on page 26, follow steps 1–3 below.

1. Add 350 µl Buffer RWT to the RNeasy UCP MinELute spin column. Close the lid gently, and centrifuge for 15 s at 8000 x *g* (10,000 rpm) to wash the membrane. Discard the flow-through.*

   Reuse the collection tube in step 2.

2. Add 10 µl DNase I stock solution (see aforementioned instruction) to 70 µl Buffer RDD. Mix by gently inverting the tube, and centrifuge briefly to collect residual liquid from the sides of the tube.

   Buffer RDD is supplied with the RNase-Free DNase Set.

   Note: DNase I is especially sensitive to physical denaturation. Mixing should only be carried out by gently inverting the tube. Do not vortex.Add 80 µl of the DNase I incubation mix directly to the RNeasy spin column membrane, and place on the benchtop (20–30°C) for 15 min.

   Note: Be sure to add the DNase I incubation mix directly to the RNeasy UCP MinElute spin column membrane. DNase digestion will be incomplete if part of the mix sticks to the walls or the O-ring of the spin column.

* Flow-through contains Buffer RWT and is therefore not compatible with bleach. See page 6 for Safety Information.

3. Add 350 µl Buffer RWT to the RNeasy UCP MinElute spin column. Close the lid gently, and centrifuge for 15 s at 8000 x *g* (10,000 rpm). Discard the flow-through and place the spin column in a new 2 ml collection tube (supplied).
4. Continue with step 11 of "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Cells" on page 21 or step 12 of "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Tissues" on page 26.

Appendix C: General Remarks on Handling RNA

Handling RNA

Ribonucleases (RNases) are very stable and active enzymes that generally do not require cofactors to function. Because 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 41), 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.

* 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.

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 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" hereafter.

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_2. 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.

* 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.

Appendix D: Storage, Quantification, and Determination of Quality of RNA

Storage of RNA

Purified RNA may be stored at –70 to –15°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" hereafter). 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/qiaxpert-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 µg of RNA per ml (A_{260} = 1 → 4 µg/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 44), 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 41). 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:

Volume of RNA sample	= 100 µl
Dilution	= 10 µl of RNA sample + 490 µl 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 µg/ml x A_{260} x dilution factor = 44 µg/ml x 0.2 x 50 = 440 µg/ml
Total amount	= concentration x volume in milliliters = 440 µg/ml x 0.1 ml = 44 µg of RNA

* 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.

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/qiaxpert-system/user-manual**).

For standard photometric measurements, the ratio of the readings at 260 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. Because 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† 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 because the relationship between absorbance and concentration (A_{260} reading of 1 = 44 µg/ml RNA) is based on an extinction coefficient calculated for RNA at neutral pH (see "Spectrophotometric quantification of RNA", page 42).

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; 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.

* 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.

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

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. QuantiTect® 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**). For real-time RT-PCR assays where amplification of genomic DNA cannot be avoided, we recommend using the QuantiTect Reverse Transcription Kit for reverse transcription. The kit integrates fast cDNA synthesis with rapid removal of genomic DNA contamination (see Ordering Information, page 46).

Integrity of RNA

The integrity and size distribution of total RNA purified with miRNeasy Tissue/Cells Advanced Micro Kit 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.

Ordering Information

Product	Contents	Cat. no.
miRNeasy Tissue/Cells Advanced Micro Kit (50)	For 50 preps: RNeasy UCP MinElute spin columns, gDNA Eliminator Spin Columns, Collection Tubes, RNase-Free Water and Buffers	217684
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
miRNeasy Serum/Plasma Advanced Kit (50)	For 50 total RNA preps: 50 RNeasy MinElute Spin Columns, Collection Tubes (1.5 ml and 2 ml), RNase-Free Reagents and Buffers	217204
miRNeasy 96 Advanced QIAcube HT Kit (5)	For 480 preps: RNeasy 96 plates, RNase-Free Water, buffers	217261
QIAcube Connect — for fully automated nucleic acid extraction with QIAGEN spin-column kits		
QIAcube Connect*	Instrument, connectivity package, 1-year warranty on parts and labor	9002864
Starter Pack, QIAcube	200 µl filter-tips (1024), 1000 µl filter-tips (1024), 30 ml reagent bottles (12), rotor adapters (240), 1.5 ml elution tubes (240), rotor adapter holder (1)	990395

Product	Contents	Cat. no.
Related products		
RNAprotect Tissue Reagent (250 ml)	250 ml RNAprotect Tissue Reagent for stabilization of RNA in 125 x 200 mg tissue samples	76106
QIAshredder (250)	250 disposable cell-lysate homogenizers	79656
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	990890
TissueLyser II	Universal laboratory mixer-mill disruptor	85300†
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
Stainless Steel Beads, 5 mm (200)	Stainless Steel Beads, suitable for use with the TissueLyser system	69989
TissueLyser Single-Bead Dispenser, 5 mm	For dispensing individual beads (5 mm diameter)	69965

Product	Contents	Cat. no.
Related products for quantitative, real-time RT-PCR		
miRCURY LNA RT Kit	For 8–64 cDNA synthesis reactions: 5x RT SYBR Green Reaction Buffer, 5x RT Probe Reaction Buffer, 10x RT Enzyme Mix, UniSp6, RNA Spike-in template, RNase-Free Water	339340
RNA Spike-in Kit, for RT	Contains the UniSp2, UniSp4, and UniSp5 RNA Spike-in Template Mix and the cel-miR-39-3p RNA Spike-in Template	339390
miRCURY Probe PCR Kit (200)‡	For 200 reactions: 2X QuantiNova Probe Master Mix, 10X miRCURY Probe Univ. Primer, ROX Reference Dye, RNase-Free Water	339371
miRCURY LNA miRNA Probe PCR Assay	Complete premixed assays containing LNA-enhanced target-specific forward primer and probe. For 200 reactions	339350§
miRCURY LNA miRNA Custom Probe PCR Assay	Custom-designed, target-specific forward primer and probe for any user-defined miRNA target. Complete premixed assay for 200 reactions	339351§

Product	Contents	Cat. no.
Related products for next-generation sequencing		
QIAseq miRNA Library Kit (12)	For 12 sequencing prep reactions: 3′ ligation, 5′ ligation, reverse-transcription, cDNA cleanup, library amplification and library cleanup reagents; quality control primers	331502
QIAseq miRNA NGS 12 Index IL (12)	Sequencing adapters, primers and indexes compatible with Illumina platforms; 12 indexes for 12 samples	331592
QIAseq miRNA Library Kit (96)	For 96 sequencing prep reactions: 3′ ligation, 5′ ligation, reverse-transcription, cDNA cleanup, library amplification and library cleanup reagents; quality control primers	331505
QIAseq miRNA NGS 48 Index IL (96)	Sequencing adapters, primers and indexes compatible with Illumina platforms; two 48 indexes for 96 samples	331595

* All QIAcube Connect instruments are provided with a region-specific connectivity package, including tablet and equipment necessary to connect to the local network. Furthermore, 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.

† Visit **www.qiagen.com/automation** to find out more about the TissueRuptor II and TissueLyser II and to order.

‡ Other kit sizes available, **visit www.qiagen.com**.

§ Exact catalog number varies depending on the particular assay or panel configuration.

For up-to-date licensing information and product-specific disclaimers, see the respective QIAGEN kit handbook or user manual. QIAGEN kit handbooks and user manuals are available at **www.qiagen.com** or can be requested from QIAGEN Technical Services or your local distributor.

Document Revision History

Date	Changes
April 2021	Initial release
June 2021	Corrected the maximum binding capacity of RNeasy UCP MinElute spin column in Table 1. Corrected the maximum amount of fresh, frozen, or RNAprotect-stabilized tissue in section "Protocol: Purification of Total RNA, Including Small RNAs, from Animal Tissues". Updated the HB number on the last page.

Limited License Agreement for miRNeasy Tissue/Cells Advanced Micro Kit (50)

Use of this product signifies the agreement of any purchaser or user of the product to the following terms:

1. The product may be used solely in accordance with the protocols provided with the product and this handbook and for use with components contained in the kit only. QIAGEN grants no license under any of its intellectual property to use or incorporate the enclosed components of this kit with any components not included within this kit except as described in the protocols provided with the product, this handbook, and additional protocols available at **www.qiagen.com**. Some of these additional protocols have been provided by QIAGEN users for QIAGEN users. These protocols have not been thoroughly tested or optimized by QIAGEN. QIAGEN neither guarantees them nor warrants that they do not infringe the rights of third-parties.
2. Other than expressly stated licenses, QIAGEN makes no warranty that this kit and/or its use(s) do not infringe the rights of third-parties.
3. This kit and its components are licensed for one-time use and may not be reused, refurbished, or resold.
4. QIAGEN specifically disclaims any other licenses, expressed or implied other than those expressly stated.
5. The purchaser and user of the kit agree not to take or permit anyone else to take any steps that could lead to or facilitate any acts prohibited above. QIAGEN may enforce the prohibitions of this Limited License Agreement in any Court, and shall recover all its investigative and Court costs, including attorney fees, in any action to enforce this Limited License Agreement or any of its intellectual property rights relating to the kit and/or its components.

For updated license terms, see **www.qiagen.com**.

Trademarks: QIAGEN®, Sample to Insight®, QIAcube®, QIAxcel®, Allprotect®, GeneGlobe®, LNA®, MinElute®, miRCURY®, QuantiTect®, Rotor-Gene®, RNAprotect®, RNeasy®, TissueRuptor® (QIAGEN group); Agilent® (Agilent Technologies, Inc.); Applied Biosystems®, SYBR® (Life Technologies Corporation). Registered names, trademarks, etc. used in this document, even when not specifically marked as such, are not to be considered unprotected by law.

06/2021 HB-2902-002 © 2021 QIAGEN, all rights reserved.

HB-2902-002 06/2021