

HCR™ RNA-FISH (v3.0) protocol for whole-mount zebrafish embryos and larvae

This protocol has not been optimized for all stages and should only be used as a template.

Technical Support

support@molecularinstruments.com

Safety Data Sheets (SDS)

www.molecularinstruments.com/safety-v3

Patents

www.molecularinstruments.com/patents

Ordering for Multiplex Experiment

Order one HCR™ RNA-FISH (v3.0) kit per target RNA

Example 2-Plex Experiment

- HCR™ RNA-FISH (v3.0) kit for target mRNA1
 - HCR™ Probe (v3.0): target mRNA1 for use with amplifier B1
 - HCR™ Amplifier (v3.0): B1-647
 - HCR™ RNA-FISH Buffers (v3.0): HCR™ Probe Hybridization Buffer (v3.0), HCR™ Probe Wash Buffer (v3.0), HCR™ Amplifier Buffer (v3.0) (for use with all kits)
- HCR™ RNA-FISH (v3.0) kit for target mRNA2
 - HCR™ Probe (v3.0): target mRNA2 for use with amplifier B2
 - HCR™ Amplifier (v3.0): B2-488

Storage conditions

- Store HCR™ Probes (v3.0), HCR™ Amplifiers (v3.0), HCR™ Probe Hybridization Buffer (v3.0), and HCR™ Probe Wash Buffer (v3.0) at -20 °C.
- Store HCR™ Amplifier Buffer (v3.0) at 4 °C.
- On the bench top, keep stock solutions on ice.
- Make sure all solutions are well mixed before use.

Preparation of fixed whole-mount zebrafish embryos and larvae

1. Collect zebrafish embryos and incubate at 28 °C in a petri dish with egg H₂O.
2. Exchange egg H₂O with egg H₂O containing 0.003% of 1-phenyl 2-thiourea (PTU) when embryos reach 12 hpf.
NOTE: PTU treatment is not necessary if working with embryos younger than 30 hpf.
NOTE: PTU inhibits melanogenesis but can be toxic at high concentrations. PTU treatment must start before the initial pigmentation occurs as PTU does not remove pigment that has already formed. PTU treatment is not necessary for nacre embryos used in this paper.
3. Replace with fresh egg H₂O containing 0.003% of PTU everyday until the larvae reach 5 dpf (days post-fertilization).
4. Transfer ~40 embryos/larvae (5 dpf) to a 2 mL eppendorf tube and remove excess egg H₂O.
5. Fix embryos/larvae in 2 mL of 4% paraformaldehyde (PFA) for 24 h at 4 °C.
CAUTION: use PFA with extreme care as it is a hazardous material.
NOTE: use fresh PFA and cool to 4 °C before use to avoid increased autofluorescence.
6. Wash embryos/larvae 3 × 5 min with 1 mL of 1× phosphate-buffered saline (PBS) to stop the fixation.
NOTE: avoid using calcium chloride and magnesium chloride in PBS as this leads to increased autofluorescence in the embryos/larvae.
7. Dehydrate and permeabilize with a series of methanol (MeOH) washes (1 mL each):
 - (a) 100% MeOH for 4 × 10 min
 - (b) 100% MeOH for 1 × 50 min.
8. Store embryos/larvae at -20 °C overnight before use.
NOTE: Embryos/larvae can be stored for six months at -20 °C.
9. Transfer the required number of embryos/larvae for an experiment to a 2 mL eppendorf tube.
10. Rehydrate with a series of graded 1 mL MeOH/PBST washes for 5 min each at room temperature:
 - (a) 75% MeOH / 25% PBST
 - (b) 50% MeOH / 50% PBST
 - (c) 25% MeOH / 75% PBST
 - (d) 5 × 100% PBST.
11. Treat 5 dpf embryos/larvae with 1 mL of proteinase K (30 µg/mL) for 45 min at room temperature.
NOTE: Proteinase K concentration and treatment time should be reoptimized for each batch of proteinase K, or for samples at a different developmental stage. Skip proteinase K treatment and postfixation (steps 11–14) for embryos 30 hpf and younger.

12. Wash embryos/larvae two times with PBST (1 mL each) without incubation.
13. Postfix with 1 mL of 4% PFA for 20 min at room temperature.
14. Wash embryos/larvae 5×5 min with 1 mL of PBST.

Multiplexed HCR™ RNA-FISH (v3.0) protocol

Detection stage

1. For each sample, transfer 8 embryos/larvae to a 1.5 mL tube.
2. Pre-hybridize with 500 μ L of HCR™ Probe Hybridization Buffer (v3.0) for 30 min at 37 °C.
CAUTION: HCR™ Probe Hybridization Buffer (v3.0) contains formamide, a hazardous material.
3. Prepare probe solution by adding 2 pmol of each HCR™ Probe (v3.0) (e.g. 2 μ L of 1 μ M stock) to 500 μ L of HCR™ Probe Hybridization Buffer (v3.0) at 37 °C.
NOTE: For single-molecule RNA imaging, use higher probe concentration (e.g., 16 nM) to increase probe hybridization yield. If desired, this approach can also be used to increase signal for subcellular quantitative RNA imaging.
4. Remove the pre-hybridization solution and add the probe solution.
5. Incubate embryos/larvae overnight (>12 h) at 37 °C.
6. Remove excess probes by washing embryos/larvae 4 \times 15 min with 500 μ L of HCR™ Probe Wash Buffer (v3.0) at 37 °C.
CAUTION: HCR™ Probe Wash Buffer (v3.0) contains formamide, a hazardous material.
NOTE: pre-heat HCR™ Probe Wash Buffer (v3.0) to 37 °C before use.
7. Wash embryos/larvae 2 \times 5 min with 5 \times SSCT at room temperature.

Amplification stage

1. Pre-amplify embryos/larvae with 500 μ L of HCR™ Amplifier Buffer (v3.0) for 30 min at room temperature.
NOTE: equilibrate HCR™ Amplifier Buffer (v3.0) to room temperature before use.
2. Separately prepare 30 pmol of hairpin h1 and 30 pmol of hairpin h2 by snap cooling 10 μ L of 3 μ M stock (heat at 95 °C for 90 seconds and cool to room temperature in a dark drawer for 30 min).
NOTE: Hairpins h1 and h2 are provided in hairpin storage buffer ready for snap cooling. h1 and h2 should be snap cooled in separate tubes.
3. Prepare hairpin solution by adding snap-cooled h1 hairpins and snap-cooled h2 hairpins to 500 μ L of HCR™ Amplifier Buffer (v3.0) at room temperature.
4. Remove the pre-amplification solution and add the hairpin solution.
5. Incubate the embryos/larvae overnight (>12 h) in the dark at room temperature.
NOTE: For single-molecule RNA imaging, amplify for a shorter period of time to ensure single-molecule dots are diffraction-limited.
6. Remove excess hairpins by washing with 500 μ L of 5 \times SSCT at room temperature:
 - (a) 2 \times 5 min
 - (b) 2 \times 30 min
 - (c) 1 \times 5 min
7. Samples can be stored at 4 °C protected from light before microscopy.

Buffer recipes

6% PTU stock solution

6% PTU

For 100 mL of solution

6 g of 1-phenyl 2-thiourea powder

Fill up to 100 mL with egg H₂O

Heat solution at 50–60 °C overnight to dissolve powder

0.003% PTU in egg H₂O

0.003% PTU

For 50 mL of solution

25 µL of 6% PTU

Fill up to 50 mL with egg H₂O

4% paraformaldehyde (PFA)

4% PFA

1× PBS

For 25 mL of solution

1 g of PFA powder

25 mL of 1× PBS

Heat solution at 50–60 °C to dissolve powder

PBST

1× PBS

0.1% Tween 20

For 50 mL of solution

5 mL of 10× PBS

500 µL of 10% Tween 20

Fill up to 50 mL with ultrapure H₂O

Proteinase K solution

30 µg/mL proteinase K

For 1 mL of solution

1.5 µL of 20 mg/mL proteinase K

Fill up to 1 mL with PBST

5× SSCT

5× sodium chloride sodium citrate (SSC)

0.1% Tween 20

For 40 mL of solution

10 mL of 20× SSC

400 µL of 10% Tween 20

Fill up to 40 mL with ultrapure H₂O

NOTE: avoid using calcium chloride and magnesium chloride in PBS as this leads to increased autofluorescence in the samples.

S1 HCR™ Technology Citation Notes

For citation, please select from the list below as appropriate for your application:

- **HCR™ RNA-ISH**

HCR™ RNA in situ hybridization (RNA-ISH) offers unmatched performance, robustness, and versatility imaging RNA targets in diverse organisms and sample types (Choi et al., 2010, Choi et al., 2014, Choi et al., 2018):

- **HCR™ RNA-FISH**

HCR™ RNA-FISH enables 10-plex, quantitative, high-resolution RNA fluorescence in situ hybridization (RNA-FISH) with automatic background suppression throughout the protocol for dramatically enhanced performance (signal-to-background, quantitative precision, single-molecule fidelity) and ease-of-use (no probe set optimization for new targets and organisms).

- **Enzymatic HCR™ RNA-CISH/RNA-FISH**

Enzymatic HCR™ RNA-ISH integrates enzymatic signal amplification to enable extreme-sensitivity RNA imaging using either chromogenic or fluorescent staining (RNA-CISH/RNA-FISH). In tissue sections, entirely protease-free workflows preserve sample morphology and maintain protein target integrity, enabling seamless compatibility with existing immunohistochemistry (IHC)/immunofluorescence (IF) assays. HCR™ RNA-CISH offers the convenience of brightfield microscopy and the option of archival staining.

- **10-Plex HCR™ Spectral Imaging**

HCR™ RNA-FISH/IF enables quantitative high-resolution imaging of 10 RNA and/or protein targets with 1-step HCR™ signal amplification for all targets simultaneously. The method is suitable even for whole-mounts and delicate samples as it requires no repeated staining, imaging, registration, or stripping (Schulte et al., 2024).

- **HCR™ RNA-FISH/IF**

HCR™ RNA-FISH/IF enables a unified approach to multiplex, quantitative, high-resolution RNA fluorescence in situ hybridization (RNA-FISH) and protein immunofluorescence (IF), with quantitative 1-step enzyme-free signal amplification performed for all RNA and protein targets simultaneously (Schwarzkopf et al., 2021).

- **HCR™ IF**

HCR™ IF enables multiplex, quantitative, high-resolution protein immunofluorescence (IF) in highly autofluorescent samples (e.g., FFPE brain tissue sections) (Schwarzkopf et al., 2021).

- **Subcellular Quantitative RNA and Protein Imaging**

HCR™ RNA-FISH enables analog relative quantitation of RNA and/or protein targets with subcellular resolution in the anatomical context of thick autofluorescent samples (e.g., whole-mount vertebrate embryos) (Trivedi et al., 2018, Choi et al., 2018, Schwarzkopf et al., 2021).

- **Single-Molecule Quantitative RNA Imaging**

HCR™ RNA-FISH enables digital RNA absolute quantitation with single-molecule resolution in the anatomical context of thick autofluorescent samples (e.g., 0.5 mm adult mouse brain sections) (Shah et al., 2016, Choi et al., 2018).

- **Read-Out/Read-In Analysis Framework**

The read-out/read-in analysis framework enables bidirectional quantitative discovery in an anatomical context (Trivedi et al., 2018).

- **Protocols in Diverse Sample Types**

Protocols for HCR™ RNA-FISH and/or IF in diverse sample types are adapted from the zoo paper ([Choi et al., 2016](#)):

- bacteria in suspension
- FFPE human tissue sections
- generic sample in solution
- generic sample on a slide
- mammalian cells on a slide
- mammalian cells in suspension
- whole-mount chicken embryos
- whole-mount fruit fly embryos
- whole-mount mouse embryos
- whole-mount nematode larvae
- whole-mount sea urchin embryos
- whole-mount zebrafish embryos and larvae

- **HCR™ RNA Flow Cytometry**

HCR™ RNA Flow Cytometry enables analog RNA relative quantitation for high-throughput expression profiling of mammalian cells and bacteria without the need to engineer reporter lines ([Choi et al., 2018](#)).

- **HCR™ Northern Blots**

HCR™ Northern Blots enable simultaneous quantification of RNA target size and abundance with automatic background suppression throughout the protocol ([Schwarzkopf & Pierce, 2016](#)).

- **HCR™ Amplifiers**

HCR™ Amplifiers enable multiplex, quantitative, 1-step, isothermal, enzyme-free signal amplification in diverse technological settings ([Dirks & Pierce, 2004](#)).