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# A real-time PCR method to genotype mutant mouse models with altered affinity for cardiotonic steroids on the Na,K-ATPase V.3

 PLOS One ✓

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The highly conserved, cardiotonic steroid binding site (also termed ouabain binding site) on the primary  $\alpha$  subunit of Na,K-ATPase plays a receptor signaling role in a range of vital cell processes and is a therapeutic target for human disease. Mouse lines with altered affinity for cardiotonic steroids on the  $\alpha 1$  or  $\alpha 2$  subunit isoform of Na,K-ATPase, without any change in pump activity, were developed by the late Jerry B Lingrel and are a valuable tool for studying its physiological roles and drug actions. In one model, the normally ouabain resistant  $\alpha 1$  isoform was rendered sensitive to ouabain binding. In a second model, the normally sensitive  $\alpha 2$  isoform was rendered resistant to ouabain binding. Additional useful models are obtained by mating these mice. To further advance their use, we developed a rapid, real-time PCR method that detects mutant alleles using specific primers and fluorescent probes. PCR is performed in fast mode with up to 15 samples processed in 40 min. The method was validated by Sanger sequencing using mice of known genotype, and by comparing results with a previous two-step method that used PCR amplification followed by gel electrophoresis. In addition, we clarified inconsistencies in published sequences, updated numbering to current reference sequences, and confirmed the continued presence of the mutations in the colony. It is expected that a wider availability of these models and a more efficient genotyping protocol will advance studies of the Na,K-ATPase and its cardiotonic steroid receptor.

DOI

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protocol

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SWAP mouse, ATP1A1, ATP1A2, Ouabain binding site, Mouse models, NaK ATPase

protocol ,

Diagrams created by BioRender.com. Screenshots from ABI StepOne software.

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**Common reagents:**

1M Tris pH 8.0

0.5 M EDTA pH 8.0

5 M NaCL

SDS 10% w/v

NP40 detergent (10%)

Tween-20

proteinase K (20 mg/mL)

ddH<sub>2</sub>O

Bio-Rad iTaq Universal Probes Supermix (cat. no. 1725131) or compatible equivalent

**Protocol-specific primers and probes:**

ATP1A1 FWD primer (100 mM): CAG CTC TTT GGA GGC TTT

ATP1A1 REV primer (100 mM): GCT ACC GTA ACT ACA CAA CTC

ATP1A1 WT probe (100 mM): /56-FAM/CA+T +CC+G +A+AG T+GC /3IABkFQ/

ATP1A1 mutant probe (100 mM): /56-FAM/TGG AAT +TC+A +G+AG T+GC /3IABkFQ/

ATP1A2 FWD primer (100 mM): TCC TCT GCT TCT TAG CCT ATG G

ATP1A2 REV primer (100 mM): CAG GGC TAT AAG CAG GTC CA

ATP1A2 WT probe (100 mM): /56-FAM/CAC ATT ATC /ZEN/GTT GGA TGG TTC GTC CTC C/3IABkFQ/

ATP1A2 mutant probe (100 mM): /56-FAM/CTC ACA TCA /ZEN/TCG TTC GAA GGC TCG TC/3IABkFQ/

**Pre-experiment preparation**

- 1 In the interest of time and consistency, it is recommended that certain stock solutions and buffers be prepared ahead.

- 1.1 Prepare a **10X stock solution of Tail Lysis Buffer** and store in freezer.<sup>15m</sup>

Reagent	Vol. to make 10 mL
1M Tris pH 8.0	1 mL
0.5 M EDTA pH 8.0	2 mL
5 M NaCL	2 mL
SDS 10% w/v	5 mL

**Tail Lysis Buffer, 10X stock solution**

- 1.2 20m

Prepare **assay mixes**.

Primers and probes should be pre-mixed and stored frozen for convenience.

Be mindful of the reagent stock concentrations to ensure a successful outcome. Mixes can be scaled as necessary.

Reagent	For 200 rxn
ATP1A1 FWD primer (100 $\mu$ M)	20 $\mu$ L
ATP1A1 REV primer (100 $\mu$ M)	20 $\mu$ L
ATP1A1 WT probe (100 $\mu$ M)	10 $\mu$ L
ddH <sub>2</sub> O	150 $\mu$ L

**$\alpha 1^R$  assay mix**

Reagent	For 200 rxn
ATP1A1 FWD primer (100 $\mu$ M)	20 $\mu$ L
ATP1A1 REV primer (100 $\mu$ M)	20 $\mu$ L
ATP1A1 mutant probe (100 $\mu$ M)	10 $\mu$ L
ddH <sub>2</sub> O	150 $\mu$ L

**$\alpha 1^S$  assay mix**

Reagent	For 200 rxn
ATP1A2 FWD primer (100 $\mu$ M)	20 $\mu$ L
ATP1A2 REV primer (100 $\mu$ M)	20 $\mu$ L
ATP1A2 WT probe (100 $\mu$ M)	10 $\mu$ L
ddH <sub>2</sub> O	150 $\mu$ L

**$\alpha 2^S$  assay mix**

Reagent	For 200 rxn
ATP1A2 FWD primer (100 µM)	20 µL
ATP1A2 REV primer (100 µM)	20 µL
ATP1A2 mutant probe (100 µM)	10 µL
ddH <sub>2</sub> O	150 µL

**α<sup>2</sup>R assay mix**

- 1.3 Prepare **Tail Digestion Buffer** fresh for each experiment, per the following<sup>15m</sup> table. Add proteinase K last from a frozen and thawed aliquot.

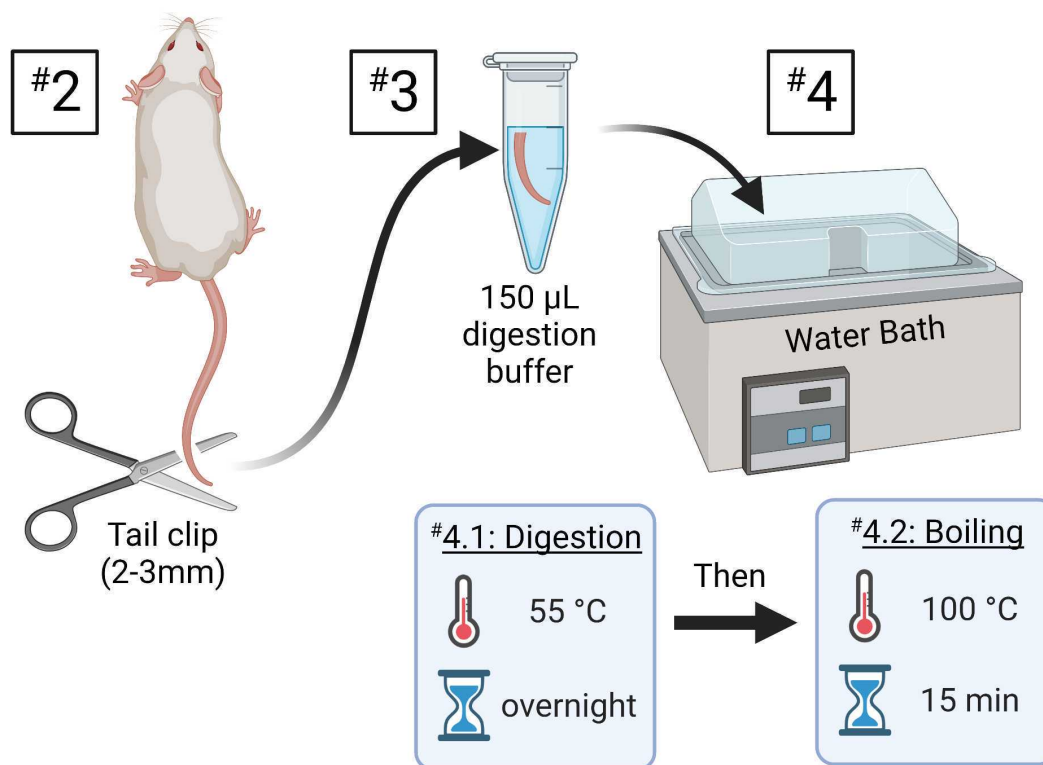
Reagent	Vol. to make 10 mL
10X Tail Lysis Buffer *	1 mL
NP40	45 µL
Tween-20	45 µL
proteinase K (20 mg/mL)	200 µL
ddH <sub>2</sub> O	to 10 mL

**Tail Digestion Buffer**

\* final working concentrations are: 10 mM Tris pH 8, 10 mM EDTA, 100 mM NaCl, 0.5% SD

Tail clip digestion 12h 45m

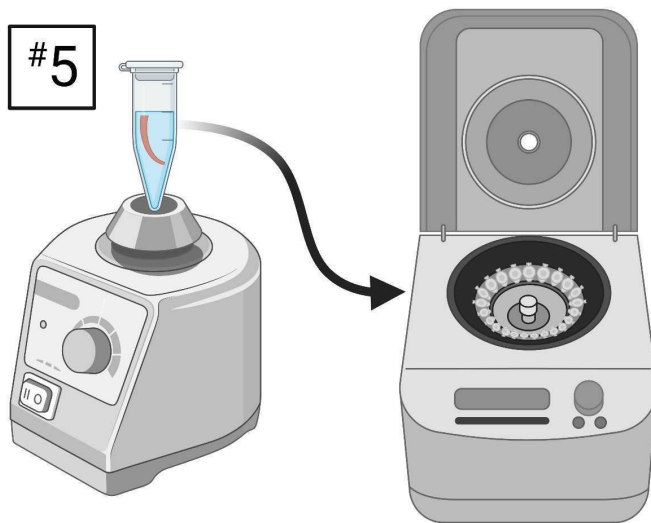
- 2 Clip 2-3 mm from the tail of each mouse to be genotyped. Place in a clean, labelled 1.5 mL<sup>30m</sup> microcentrifuge tube.



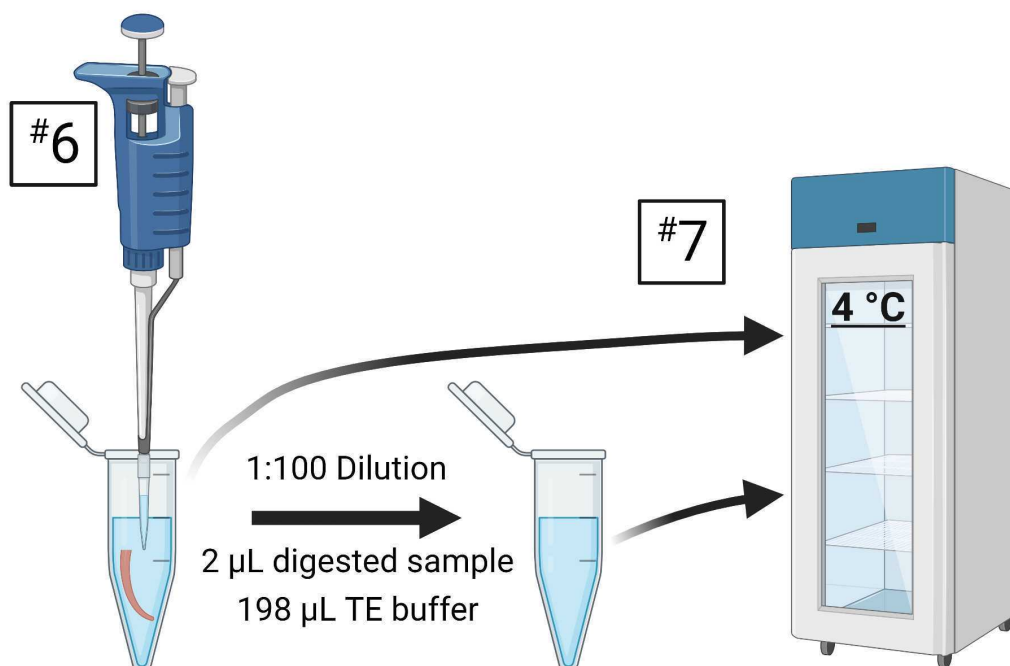
Steps 2-4 visual overview

- 3 Add 150 µL of **Tail Digestion Buffer** containing proteinase K to each tube. 5m
- 4 Place the tail samples in a heat block or water bath. 3m
  - 4.1 Incubate **Overnight** at **55 °C** . 15m
  - 4.2 Raise the temperature to **100 °C** for **00:15:00** . 15m
  - 4.3 Remove the tubes and allow to cool to **Room temperature** . 10m

- 5 Briefly vortex and centrifuge the tubes to pellet insoluble material. DNA will remain in the <sup>5m</sup> supernatant.



- 6 Create a 1:100 dilution of each sample in a new, labelled 1.5 mL microcentrifuge tube. Add <sup>10m</sup> **198  $\mu$ L** of TE buffer (or ddH<sub>2</sub>O) to each tube, then add **2.0  $\mu$ L** of supernatant from the digested sample.



- 7 Store samples and dilutions at  $4^{\circ}\text{C}$  until ready to genotype. If storing samples longer than 14 days, keep in  $-20^{\circ}\text{C}$  freezer.

#### PCR machine setup

- 8 Create a new experiment on your PCR machine's software. The instructions here are based on<sup>2m</sup> ABI StepOne machines but other manufacturers' procedures are generally similar.

Templates for ABI StepOne and StepOnePlus machines are attached, which have the probe list and thermocycling program pre-set. To use the templates, download the version corresponding to your machine type. Open StepOne Software and choose [File] -> [New Experiment] -> [From Template...] and select the template file.

[SWAP mouse genotype StepOnePlus template.edt](#)

[SWAP mouse genotype StepOne template.edt](#)

- 9 Set the thermocycling program (run method) as per the following table.<sup>2m</sup>

Stage	Duration (m:ss)	Temperature	Cycles
Initial denaturation	3:00	95 C	1
Denaturation	0:03	95 C	35 Cycles
Annealing/Extension	0:30	95 C	

- 10 Enter the 4 probes into the targets list as per the following table. Populate the sample list with<sup>2m</sup> your mouse sample numbers, plus a no-template control (NTC) sample.

Probe	Reporter	Quencher
a1R	VIC	None
a1S	FAM	None
a2S	FAM	None
a2R	FAM	None

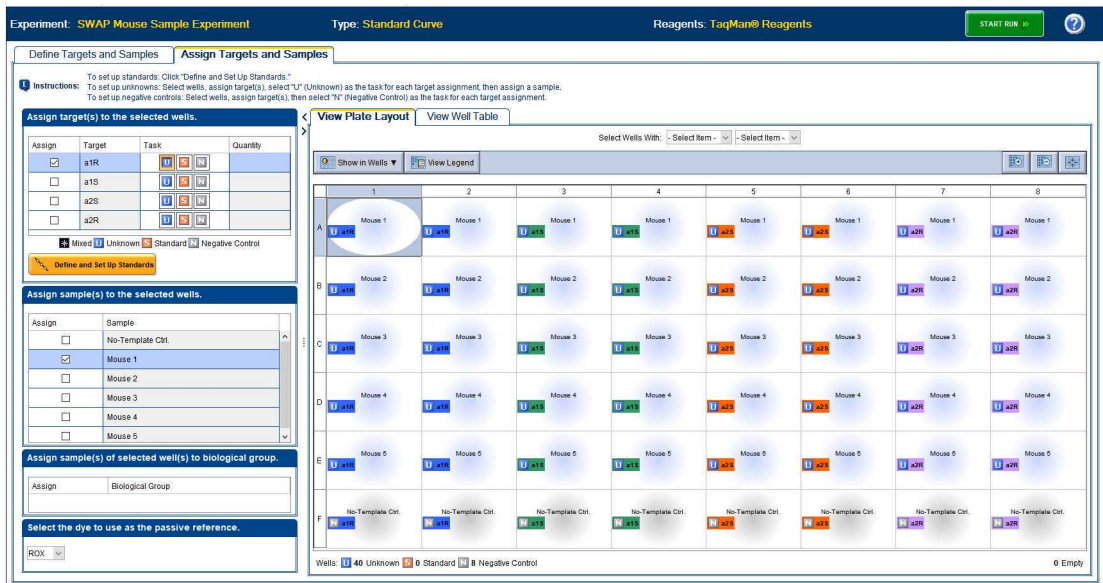
Genotyping probe configurations

- 11 Assign 8 wells for each sample (including the NTC); 2 wells for a1<sup>R</sup>, 2 wells for a1<sup>S</sup>, 2 wells for<sup>5m</sup> a2<sup>S</sup>, and 2 wells for a2<sup>R</sup>. For the NTC, mark the wells as negative controls for the respective



targets.

A sample plate layout for genotyping 5 mice is shown here (ABI StepOne).






PCR reaction setup 2m

- 12
- Prepare 4 reaction mixes as follows, 1 for each of the assay mixes. Create enough mix for the total number of reactions of each assay on your plate map, plus 2 extra to account for potential pipetting loss.  
For example, the plate shown in Step 11 (having 5 samples + 1 NTC) would need a 14 rxn mix for each assay. A full 96-well plate with 11 mouse samples and 1 NTC would require a 26 rxn mix for each assay.
- 15m

Reagent	1 rxn	14 rxn	26 rxn
iTaq Probe mix (2X)	10.0 µL	140 µL	260 µL
Assay mix	1.0 µL	14 µL	26 µL
ddH2O	4.0 µL	56 µL	104 µL

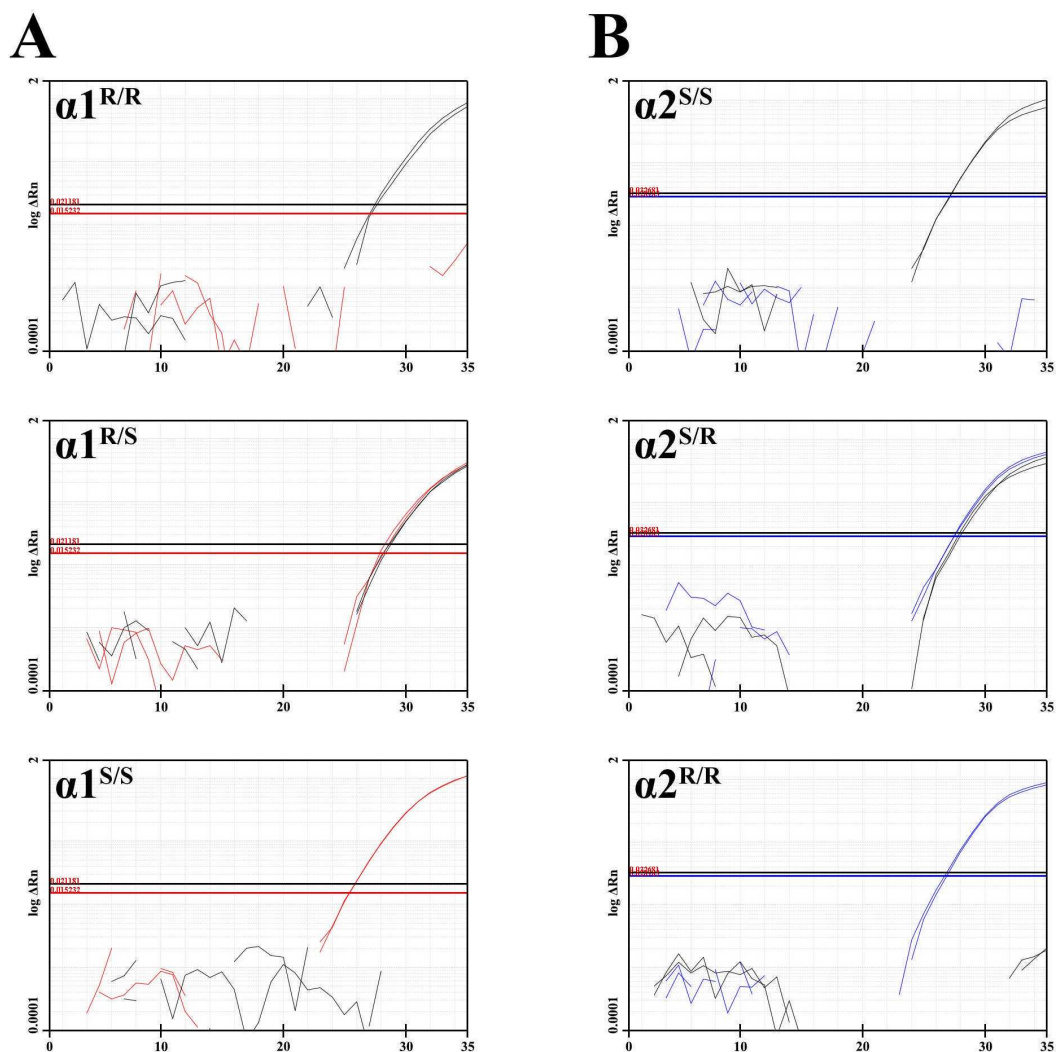
PCR reaction mix

- 13
- Pipet 15 µL reaction mix into each well of a fresh PCR plate.
- 5m

- 14 Pipet  **5  $\mu$ L** of each diluted sample into its assigned wells. Pipet  **5  $\mu$ L** ddH<sub>2</sub>O into each no-template control well. 7m
- 15 Cover the plate with optical sealing film. Ensure that the film is fully adhered to the plate. 1m
- 16 Briefly vortex the plate. 1m
- 17 Centrifuge the plate at  **1700 rpm, 00:02:00** . 2m
- 18 Insert the plate into the instrument and initiate the run. 1h 45m

#### Interpretation

- 19 Analysis of the PCR results begins by checking the outcome of the negative control wells. If all NTC wells show no amplification, you may proceed with the analysis. If one or more negative control wells show amplification, the results are invalid and the experiment must be repeated. An invalid outcome is typically due to contamination of the reaction mix or of a reagent.
- 20 Genotyping is based on the presence or absence of signal from the 2 probes of each gene. The example below shows representative amplification plots for the possible genotypes of  $\alpha 1$  (**A**) and  $\alpha 2$  (**B**). The graphs show results from a sample's  $\alpha 1^R$  (black) and  $\alpha 1^S$  (red) wells plotted together (**A**), and a sample's  $\alpha 2^S$  (black) and  $\alpha 2^R$  (blue) wells plotted together (**B**).



Representative amplification curves

Samples considered positive for a specific allele show  $C_T$  values of 26-31 for the corresponding probe, while negative samples do not reach threshold in 35 cycles. Heterozygous samples show amplification of both probes within 2  $C_T$  of each-other.