Cre-lox Basics - Generating Knockout Mice

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  - April 7, 2016, 1:00 pm ET USA

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  - April 14, 2016, 1:00 pm ET USA

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THE ABC’S OF CHOOSING A CRE STRAIN TO GENERATE KO MICE

Dolores Garcia-Arocena, Ph.D.

There are over 480 Cre-recombinase expressing strains that are available from the JAX® Mice repository alone. With so many choices, how can you decide which Cre strain will generate the right KO model for you? The choice largely depends on when and where you want your target gene knocked out and the genetic background that your mouse model must be for your data to be meaningful.

The simplest Cre-lox system to generate a knockout (KO) mouse model has two components that need to be genetically engineered in the murine genome: a target sequence surrounded by loxP sites (often called a “flxed” allele) and a Cre recombinase gene controlled by a specific promoter. Typically, researchers first generate (or acquire) the two necessary strains, and then breed them together in order to generate the desired KO mice.
The Jackson Laboratory’s Mission

Performing Research
Investigating genetics and biology of human disease

Providing Resources
JAX® Mice Clinical & Research Services, bioinformatics data, technical publications and more…

Educating Scientists
World-class courses, internships and other programs

https://www.jax.org/education-and-learning | THE JACKSON LABORATORY
JAX® Mice
The Gold Standard for Biomedical Research

- NIH funded resource
- >8,000 - strains and growing
  - 2.7 million mice shipped annually
- Unsurpassed genetic quality & animal health
- Best characterized & referenced ~100 new pubs/week
- Common inbred strains (C57BL/6J, BALB/cJ, DBA/2J) support development/collection of specialty strains and other valuable community research resources
Online Resources to Expedite Research

- JAX® Mice Database
  www.jax.org/jax-mice-and-services/

- Mouse Genome Informatics
  www.informatics.jax.org

- Mouse Phenome Database
  phenome.jax.org/

- And many more unique resources
Presentation Overview

- Basic Cre-lox mechanism
- Strain types and breeding schemes
  - Tissue-specific knockouts
  - General knockouts
  - Inducible knockouts
  - Reporters
- Cre-lox web resources (finding mice, Cre activity data, and more)
A Revolutionary Genetic Tool

Cre-lox system

- Natural part of P1 bacteriophage viral life cycle
- Viral DNA injected into bacteria, circularized using Cre-lox, and replicated for development of new viruses
Cre-lox Successfully Engineered in Other Organisms

Organisms

- Yeast
- Plants
- Mammalian cell cultures
- Mice
Cre-lox Successfully Engineered in Other Organisms

Organisms

- Yeast
- Plants
- Mammalian cell cultures
- Mice

Allows

- Alteration & deletion of DNA
- Regulation of location and timing of gene recombination
A Simple, Two Component System

**Cre recombinase**
- Site-specific enzyme, catalyzes recombination between two *LoxP* sites

***LoxP* site**
- 34 base pair DNA sequence
- Location and orientation determines recombination result:
  - Deletion
  - Inversion
  - Translocation

*Abundant possibilities for genome manipulation!*

**Mechanism: Cre-lox Deletion**

- Floxed target gene
- Cre excision
- Knockout allele
Mechanism: Cre-lox Inversion

![Mechanism Diagram]

- **LoxP** sites
- **GeneX** gene
- **Cre** enzyme

Diagram shows the Cre-lox recombination process, where the **LoxP** sites are inverted by the action of the **Cre** enzyme, effectively removing the **GeneX** gene.
Mechanism: Cre-lox Translocation

Reciprocal Translocation (3;6)
Cre-lox Tissue-Specific Knockout

Homozygous “floxed” mouse

Liver-specific cre transgene
Ex: B6.Cg-Tg(Alb-Cre)21Mgn/J (003574)
Cre-lox Tissue-Specific Knockout

Homozygous “floxed” mouse

Liver-specific cre transgene
Ex: B6.Cg-Tg(Alb-Cre)21Mgn/J (003574)

Cre-Lox mouse:
Heterozygous for gene X conditional knockout after 1 generation
Cre-lox Tissue-Specific Knockout
Cre-lox Tissue-Specific Knockout (continued)

Homozygous “floxed” mouse

X

Hemizygous Alb-cre heterozygous “floxed” gene

25% homozygous for gene X conditional knockout (2nd generation)
**Cre-lox Tissue-Specific Knockout**

(continued)

<table>
<thead>
<tr>
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<th>loxP</th>
<th>+</th>
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<td>loxP</td>
<td>+</td>
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<td>loxP</td>
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</table>

**Hemizygous**

cre
Cre-lox Tissue-Specific Knockout (continued)

25% homozygous for gene X conditional knockout (2\textsuperscript{nd} generation)
Improving Conditional Knockout Efficiency

Homozygous “floxed” mouse

Hemizygous Alb-cre heterozygous “floxed” gene
Improving Conditional Knockout Efficiency

Heterozygous null mouse (traditional knockout) x Hemizygous Alb-cre heterozygous “floxed” gene

12.5% conditional gene X knockouts
Cre-lox Tissue-Specific Knockout (continued)

<table>
<thead>
<tr>
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<td><em>loxP</em></td>
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<tr>
<td>+</td>
<td></td>
</tr>
<tr>
<td>-</td>
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</tbody>
</table>

Hemizygous cre

![Diagram](image)
Cre-lox Tissue-Specific Knockout (continued)

12.5% conditional gene X knockouts

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<thead>
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<tbody>
<tr>
<td>loxP</td>
<td>+</td>
<td>loxP</td>
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<tr>
<td>+</td>
<td>Alb-cre</td>
<td>Alb-cre</td>
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<tr>
<td></td>
<td>loxP / +</td>
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<td>Alb-cre</td>
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<tr>
<td></td>
<td>loxP / -</td>
<td>+ / -</td>
</tr>
</tbody>
</table>

Hemizygous cre
Improving Conditional Knockout Efficiency

Homozygous “floxed” mouse

Hemizygous Alb-cre heterozygous null mouse

25% conditional gene X knockouts
Cre-lox Germline Knockouts

Homozygous “floxed” mouse

Oocyte-specific cre expression
Ex: C57BL/6-Tg(Zp3-cre)93Knw/J
(003651)

2 more generations to produce homozygote null mouse
Cre-lox Knockout Breeding Scheme

Cre mouse – *cre* transgene (Tg) early, widespread expression promoter B6.Cg-(Sox2-cre)1Amc/J (008454)

Homozygous *LoxP* mouse

Offspring: 50% heterozygous knockout after 1 generation
Cre-lox Knockout Breeding Scheme
(continued)

Offspring 2\textsuperscript{nd} generation: 25% homozygous knockout
Cre-lox Summary

**Tissue-specific deletion**

- 2 generations of breeding
- Cre *required* to maintain line for future generations
- Genotype of whole mouse: homozygous *flox*; Cre
- Tissue-specific genotype: homozygous *flox*-deleted; Cre

**Germline/Embryonic deletion**

- 2-3 generations of breeding
- Cre *not required* after germline deletion (can breed it out)
- Genotype of whole mouse, germplasm, organs & tissues: homozygous *flox*-deleted (knockout) for gene of interest
Inducible Cre Mouse Models

Inducible Cre mouse – tamoxifen dependent Cre function
Ex: B6.Cg-Tg(CAG-cre/Esr1*)5Amc/J (004682)

Homozygous LoxP mouse

2 Generations

Induce homozygous knockout of gene X with tamoxifen
The FLP-FRT System

- Analogous to the Cre-lox system
- Derived from the yeast *Saccharomyces cerevisiae*
- Becoming more popular in mouse-based research
- Flipase recombinase (FLP) recognizes a pair of target sequences (FRT) that flank a genomic region of interest
Using FLP-FRT with Cre-lox
Cre Considerations

Mosaicism

- Some target cells may not express Cre, or *LoxP* sites may not recombine
- May be integration site specific; evaluate multiple cre transgenic founders

Expression in unexpected tissues (including germline)

- Use Cre-positive males for breeding
- Test expression using reporter

*LoxP* site recombination efficiency

- Affected by position and distance

Cre Considerations (continued)

Breeding efficiency

- If possible, have cre transgene on a different chromosome than the floxed allele
- Often good idea to breed out cre transgene after germline deletion

Cre may produce a phenotype by itself

- Insertion site effects; changes in gene expression
- “Cre toxicity”

Target gene may be expressed prior to Cre recombination

Consider that genetic background may affect phenotype

Heffner et al. 2012. *Nat Commun* 3:1218. PMID: [23169059](https://doi.org/10.1038/ncomms1218)

Schmidt-Supprian and Rajewsky. 2007. *Nat Immunol* 8(7):665-8. PMID: [17579640](https://doi.org/10.1038/ni0707-665)
Cre Reporter Strains

- “Lox-Stop-Lox” (LSL)
- Used to assess Cre activity in tissue(s) of interest
- Only one generation of breeding needed
- Ex: B6.129S4Gt(ROSA)26Sor^{tm1Sor/J} (003474)
Cre Reporter Data

LacZ expression following widespread Cre recombination

B6.129S4Gt(ROSA)26Sor\textsuperscript{tm1Sor}/J (003474)

Cre Reporter Breeding Scheme

**Cre reporter strain**

B6.129S4Gt(ROSA)26Sor^tm1Sor/J (003474)

**Could be any Cre recombinase strain**

B6.Cg-Tg(Nes-cre)1kln/J (003771)

Ex: nervous system-specific cre

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1 Generation

Nestin  Cre

LoxP  LoxP  LoxP  LacZ

LacZ stain confirms Cre activity in expected tissues
Cre-lox Disease Model

**B6.129S4-Kras<sup>tm4Tyj</sup>/J (008179)**

Cre-lox Disease Model

B6.129S4-\textit{Kras}^{tm4Tyj/J} (008179)

Ex: STOCK Tg(MMTV-cre)4Mam/J (003553)

Only one round of breeding needed

Mice develop mammary neoplasms
JAX Cre Repository*

Largest collection of Cre-lox strains

- 580+ cre-expressing
- 200+ inducible Cre strains
- 1000+ floxed genes
- 210+ floxed-stop (LSL) Cre reporters
- > 200 neuronal specific Cre strains

http://cre.jax.org/NeuroCres.html

*as of Dec 2015

http://cre.jax.org
Our Research Focus

The JAX Cre Repository’s aim is to provide the scientific community with a centralized, comprehensive set of well-characterized Cre Driver lines and related information resources. Available strains include Cre expressing strains, inducible Cre strains, Cre reporter strains, and IoxP-flanked (floxed) strains.

Our extensive characterization data is available through www.creportal.org.

How to cite this resource

The Cre Repository is supported by the Office of Research Infrastructure Programs/Office of the Director grant number OD011190 of the National Institutes of Health (NIH). Please reference this grant in citations acknowledging use of the resource.

Characterization protocols

The JAX Cre Repository uses a lacZ Cre-reporter strain, B6.129S4-Gt(ROSA26Sortm1(cre)J) to assess cre activity. β-Galactosidase staining of 10.5 dpc embryos is done in whole mount. Because of tissue size, 15.5 dpc embryos, postnatal day 7 pups, and 8 week old adult mice are cryo-sectioned prior to staining of frozen sections.

Available cre lines and cre reporters
Available cre lines and cre reporters

The Jackson Laboratory offers over 300 cre tool strains. Listed by promoter, including site of expression:

Cre Recombinase Expression

Cre-Recombinase Expression: Germline/Embryonic Expression

Cre-Recombinase Expression: Inducible

Cre Reporter Strains

Cre Reporter strains allow the user to assess the function (degree of excision) of an individual Cre line. These strains are engineered to express a reporter gene (such as lacZ or GFP) following the removal of a loxP-flanked STOP cassette, thus marking cell lineages that can be targeted with a given Cre line. Some lines also express a distinct reporter prior to Cre-mediated excision. The JAX repository provides a wide selection of cre reporter lines that incorporate distinct reporter molecules.

View a list of all cre reporter strains:

Comparison of Selected Cre Reporter Strains
Searching for Cre Strains

JAX® MICE SEARCH

NSG™: THE MOST INNOVATIVE IMMUNODEFICIENT MODEL. READILY AVAILABLE.

Search by Stock #
Keyword Search

muscle

RESULTS FOR
- Research Tools
- Cre-lox System
- Cre Recombinase Expression

REFINE BY:

Popularity
- Most Popular Strains (16)
- Cre - Expressing (571)

Availability
- Live (247)
- New (45)
- Cryopreserved (201)

Stock Type
- Targeted Mutation (230)
- Transgenic (345)
- Congenic (240)

SHOWING 1-50 OF 587 RESULTS

B6.129-Gt(Rosa)26Sor tm1(cre/ERT2)Tjrj
Stock No: 008463
Congenic, Targeted Mutation
This strain enables temporal control of floxed gene expression by tamoxifen induction in vivo

B6.129P2(C)-Cd19 im1(cre)/gaj
Stock No: 006785 | Cd19cre
Congenic, Targeted Mutation
The CD19-Cre knock-in/knock-out allele has a Cre recombinase gene inserted into the first coding exon of the CD19 antigen gene, both abolishing endogenous Cd19 gene function and placing cre expression under the control of the endogenous Cd19 promoter/enhancer elements. Cre recombinase expression is directed at the earliest stages and throughout B-lymphocyte development and differentiation. Homozygous mice are also useful for studying B cell-deficiency.

https://www.jax.org/research-and-faculty/tools/cre-repository
Searching for Cre Strains

JAX® MICE SEARCH

Enter Search Term

RESULTS FOR: Research Tools × Cre-lox System × Cre Recombinase Expression × muscle ×

REFINE BY:

Popularity
- Cre-Expressing (61)

Availability
- Live (31)
- New (6)
- Cryopreserved (21)

Stock Type
- Targeted Mutation (32)
- Transgenic (29)
- Congenic (25)
- Collegenic (7)

Generation Method
- Targeted (32)
- Transgenic (29)

Attribute

B6.129S6-Tg(In)e(cre)Fec1/J

Stock No: 006878 | SM22α-CreK0

Congenic, Targeted Mutation

Mice homozygous for the transgelin knock-in allele (Tagln tm2(cre)flac) or commonly referred to as SM22alpha-CreK0 exhibit Cre recombinase activity in adult smooth muscle cells and cardiac myocytes. These mice may be useful for Cre-lox technology applications in studying smooth muscle and cardiac gene function, as well as cardiovascular disease.

B6.Cg-Tg(Acta1-cre)79Jme/J

Stock No: 006149 | HSA-Cre99

Congenic, Transgenic

These transgenic mice have the cre recombinase gene driven by the human alpha-skeletal actin (HSA or ACTA1) promoter. When bred with mice containing a loxP-flanked sequence of interest, Cre-mediated recombination will result in striated muscle-specific deletion of the flanked genome. These mice are useful in study of spinal muscular atrophy (SMA).

B6.Cg-Tg(Myh11-cre,-EGFP)2Mik/J

Stock No: 007742 | smMHC::Cre/eGFP

Congenic, Transgenic

These smMHC/Myh11/Cret/eGFP transgenic mice may be useful in studies utilizing Cre-lox
**JAX Cre Repository**

https://www.jax.org/research-and-faculty/tools/cre-repository

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**OUR RESEARCH FOCUS**

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## JAX Cre Repository

[https://www.jax.org/research-and-faculty/tools/cre-repository](https://www.jax.org/research-and-faculty/tools/cre-repository)

### CHARACTERIZED CRE LINES

<table>
<thead>
<tr>
<th>Stock number (links to data sheet)</th>
<th>Strain name (links to expression data)</th>
<th>Promoter (species)</th>
<th>Expected site of expression</th>
<th>Expression data thumbnail</th>
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</thead>
<tbody>
<tr>
<td>000149</td>
<td>B6.Cg-Tg(ACTA1-cre)1Jmje/J</td>
<td>ACTA1 (human)</td>
<td>Cre activity is restricted to adult striated muscle fibers and embryonic striated muscle cells of the somites and heart.</td>
<td><img src="image1" alt="Expression data thumbnail" /></td>
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<tr>
<td>010803</td>
<td>B6.FVB-Tg(Adipoq-cre)1Evdr/J</td>
<td>Adipoq, adiponectin, C1Q and collagen domain containing (mouse)</td>
<td>Cre recombinase activity is expected in white adipose tissue (WAT) and brown adipose tissue (BAT).</td>
<td><img src="image2" alt="Expression data thumbnail" /></td>
</tr>
<tr>
<td>012099</td>
<td>STOCK.Agfp-cre;tm1(cre);tm1(Lw)J</td>
<td>Agfp (mouse)</td>
<td>ArGP neurons in the hypothalamus</td>
<td><img src="image3" alt="Expression data thumbnail" /></td>
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</tbody>
</table>
JAX Repository:
Cre Expression Data

- B6.129S4-Gt(ROSA)26Sor<sup>tm1Sor</sup>/J (003474)
- Bred to LacZ reporter Strain
JAX Repository: Cre Expression Data

- Evaluated @ four time points: E10.5, E15.5, P7 and P56 (adult)
  - whole-mount or fresh frozen sections
  - full necropsy (P7 & P56) – 11 organ systems, 30 organs/structures, 89 substructures
- NanoZoomer slide scanner to capture data at 20X
- Data shared with MGI Cre portal database
Cre Portal @ MGI

Recombinase (cre) Activity
MGI collects and annotates expression and activity data for recombinase-containing transgenes and knock-in alleles.

Access Data

**FIND RECOMBINASE-CARRYING ALLELES**

Search for alleles assayed for specificity/activity in an anatomical structure.

- Recombinase activity in: muscle

Search for alleles by promoter/driver activity.

- Recombinase driven by: (choose one) 

Retrieve all alleles

Retrieve a list of all recombinase-containing transgenes and knock-in alleles.

Recombinase Allele Data Include

- "380 Recombinase-containing knock-in alleles"
- "1,411 Recombinase-containing transgenes"
- "1,991 Total recombinase transgenes and alleles"
- "563 Drivers in recombinase transgenes"
- "335 Drivers in recombinase knock-in alleles"
- "2,963 Tissues in recombinase specificity assays"

FAQs

How do I...

- find existing recombinase-expressing transgenes and knock-ins that have a given promoter (driver)? FAQ
- find the promoter (driver) that I'm looking for if it is not on the selection list? FAQ
- find a recombinase-containing transgene or knock-in that is expressed in a specific tissue? FAQ
- get a full list of all transgenes and knock-ins that express recombinase? FAQ
- order mice with a desired recombinase construct? FAQ

More FAQs
Cre Portal Tutorial

Search by Site of Expression or Promoter

www.creportal.org
## Cre Portal Search Results

<table>
<thead>
<tr>
<th>Driver</th>
<th>Allele Symbol</th>
<th>Recombinase Activity Detected</th>
<th>Recombinase Activity Not Detected</th>
<th>Allele Synonym</th>
<th>Inducible</th>
<th>Find Mice (IMSR)</th>
<th>Refs</th>
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<td>ACTA1</td>
<td>Tg(Acta1-T調べ)1MII</td>
<td>limbs, muscle</td>
<td>adipose tissue, alimentary system, branched arterial, cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, reproductive system, respiratory system, sensory organs, skeletal system, tail</td>
<td>HSA-cre</td>
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<tr>
<td>ACTA1</td>
<td>Tg(Acta1-T調べ)7Jo3mc</td>
<td>limbs</td>
<td>adipose tissue, alimentary system, branched arterial, cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, reproductive system, respiratory system, sensory organs, skeletal system, tail</td>
<td>HSA-Cre, HSA-Cre79, HSA-cre</td>
<td>2 43</td>
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<tr>
<td>ACTA1</td>
<td>Tg(Acta1-T調べ)7Jo3mc</td>
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<td>adipose tissue, alimentary system, branched arterial, cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, reproductive system, respiratory system, sensory organs, skeletal system, tail</td>
<td>HSA-Cre, HSA-Cre79, HSA-cre</td>
<td>2 43</td>
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<td>Acta2</td>
<td>Tg(Acta2-cre)12Bcn</td>
<td>limbs, mesenchyme, muscle</td>
<td>cardiovascular system, renal and urinary system</td>
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<td>Acta2</td>
<td>Tg(Acta2-cre)12Bcn</td>
<td>limbs, mesenchyme, muscle</td>
<td>cardiovascular system, renal and urinary system</td>
<td>HSA-rtTA/CRE-cre</td>
<td>Yes 9</td>
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<td>Tg(Acctc1-cre)1Mwa</td>
<td>limbs</td>
<td>adipose tissue, alimentary system, branched arterial, cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, reproductive system, respiratory system, sensory organs, skeletal system, tail</td>
<td>hCaalpha-A-Cre</td>
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<tr>
<td>Acdf1</td>
<td>Tg(Acdf1-cre)L15po</td>
<td>limbs</td>
<td>adipose tissue, alimentary system, branched arterial, cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, respiratory system, sensory organs, skeletal system, tail</td>
<td>L1cre, Tg(Acfl1-cre)1L1</td>
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<td>Adipoq</td>
<td>Tg(Adipoq-cre)1Bvd</td>
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<td>cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, reproductive system, respiratory system, sensory organs, skeletal system, tail</td>
<td>Adipoq-Cre</td>
<td>1 16</td>
<td></td>
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<tr>
<td>Agpp</td>
<td>Agpp(tml-cre)</td>
<td>adipose tissue, cardiovascular system, branched arterial, cardiovascular system, cavities and their linings, endocrine system, extraembryonic component, hemolymphoid system, integumental system, limbs, liver and biliary system, mesenchyme, muscle, nervous system, renal and urinary system, reproductive system, respiratory system, skeletal system, tail</td>
<td>Agpp-Cre, Agpp-tms-cre</td>
<td>1 17</td>
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</table>
## Cre Portal Search Results

### Link to Phenotypic Data, Images, & References

### Tg(ACTA1-cre)79Jme

#### Transgene Detail

<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Symbol: Tg(ACTA1-cre)79Jme</th>
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</thead>
<tbody>
<tr>
<td>Name:</td>
<td>transgene insertion 79, Judith Melli</td>
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<tr>
<td>MGI ID:</td>
<td>MGI:2447635</td>
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<tr>
<td>Synonyms:</td>
<td>HSA::cre, HSA-Cre, HSA-Cre79</td>
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<tr>
<td>Transgene:</td>
<td>Tg(ACTA1-cre)79Jme Location: unknown</td>
</tr>
</tbody>
</table>

#### Transgene origin

- Strain of Origin: (C57BL/6J x SJL)F1

#### Transgene description

- Transgene Type: Transgenic (Cre/Ip)
- Mutation: Insertion
  - Mutation details

#### Recombinase activity

<table>
<thead>
<tr>
<th>Activity:</th>
<th>adipose tissue</th>
<th>alimentary system</th>
<th>branchial arches</th>
<th>cardiovascular system</th>
<th>cavities and their linings</th>
<th>endocrine system</th>
<th>extrembryonic component</th>
<th>hemolymphoid system</th>
<th>integumental system</th>
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<th>liver and biliary system</th>
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Cre Portal Search Results
Link to Phenotypic Data, Images, & References

**Tg(ACTA1-cre)79Jme - Muscle**

### Allele Information
- **Allele:** Tg(ACTA1-cre)79Jme
- **Synonym:** HSA-Cre, HSA-Cre79
- **Molecular description:** This transgene expresses Cre recombinase under the control of a human α-skeletal actin promoter, active in striated muscle, heart, and skeletal muscle.
- **Find mice (IMSIR):** 2 lines available
- **Cell Lines:** 0 lines available
- **Additional Tissues:** Tg(ACTA1-cre)79Jme activity also observed in: adipose tissue, alimentary system, branchial arches, cardiovascular system...

### Tissue Information
- **Muscle**
- **Other recombinase alleles with activity in Muscle tissues:**
  - Cdh23tm1(MukosagumoS) Cre
  - Cdh23tm1(MukosagumoS) Cre

### Images
- Drag images to compare to others or to data in the table below. Drag mouse to resize images for more detail.

### Recombinase Activity

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<th>Pattern</th>
<th>Reference, Source</th>
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<th>Reporter Gen</th>
<th>Detection Method</th>
<th>Assay Note</th>
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**References:** All for this allele: 43 reference(s)
### International Mouse Strain Resource (IMSR)

**Summary**

Search for:

**You searched for:**
Strain States: [embryo, live, ovaries, sperm]
2 strains(s) match your unfiltered search.

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<th>Repository</th>
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<td>Acta1:6</td>
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