

# Chapter 8

## Electroporation-Mediated Gene Transfer to the Developing Mouse Inner Ear

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### Abstract

Electroporation-mediated gene transfer to the developing mouse inner ear was used to study the role of the inner ear in the development of the brain. The inner ear is a complex organ that is essential for hearing and balance. It is located in the temporal bone of the skull and is composed of the cochlea and the vestibular system. The cochlea is the part of the ear that is responsible for hearing, and the vestibular system is responsible for balance. The inner ear is a highly specialized organ that is essential for the development of the brain. The inner ear is a complex organ that is essential for hearing and balance. It is located in the temporal bone of the skull and is composed of the cochlea and the vestibular system. The cochlea is the part of the ear that is responsible for hearing, and the vestibular system is responsible for balance. The inner ear is a highly specialized organ that is essential for the development of the brain.

**Key words:** Electroporation, gene transfer, inner ear, mouse, developing, brain, hearing, balance, cochlea, vestibular system, temporal bone, skull, specialized organ, essential, development.

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### 1. Introduction

The inner ear is a complex organ that is essential for hearing and balance. It is located in the temporal bone of the skull and is composed of the cochlea and the vestibular system. The cochlea is the part of the ear that is responsible for hearing, and the vestibular system is responsible for balance. The inner ear is a highly specialized organ that is essential for the development of the brain. The inner ear is a complex organ that is essential for hearing and balance. It is located in the temporal bone of the skull and is composed of the cochlea and the vestibular system. The cochlea is the part of the ear that is responsible for hearing, and the vestibular system is responsible for balance. The inner ear is a highly specialized organ that is essential for the development of the brain.

(1)

(2)

(3)

(4)

(5)

(6, 7)

The image displays a complex musical score consisting of approximately 12 staves. The notation is dense, featuring a variety of note values, rests, and dynamic markings. The letters 'm' and 'mh' are prominently used as dynamic or articulation markings throughout the score. The notation includes stems, beams, and dots, suggesting a rhythmic structure. The score is divided into two main sections, with the first section ending at a double bar line and the second section beginning below it. The first section is labeled with a circled '8' at its end, and the second section is labeled with a circled '1' at its end. The overall appearance is that of a highly detailed and intricate musical composition.

**2.2. Ventral Laparotomy**

1. ... (12502-12), ... (1410-0), ... (11106-0) (see Note 2).
2. ... 6-0 (0. ... m<sup>-11</sup>, ... -1, 30 (5. ... m<sup>-11</sup>).
3. ...
4. ... 0% ... 10% ... (10% ... m<sup>-11</sup>).
5. ... (2 2323, ... 500 m<sup>-11</sup> ... 033 -011 .

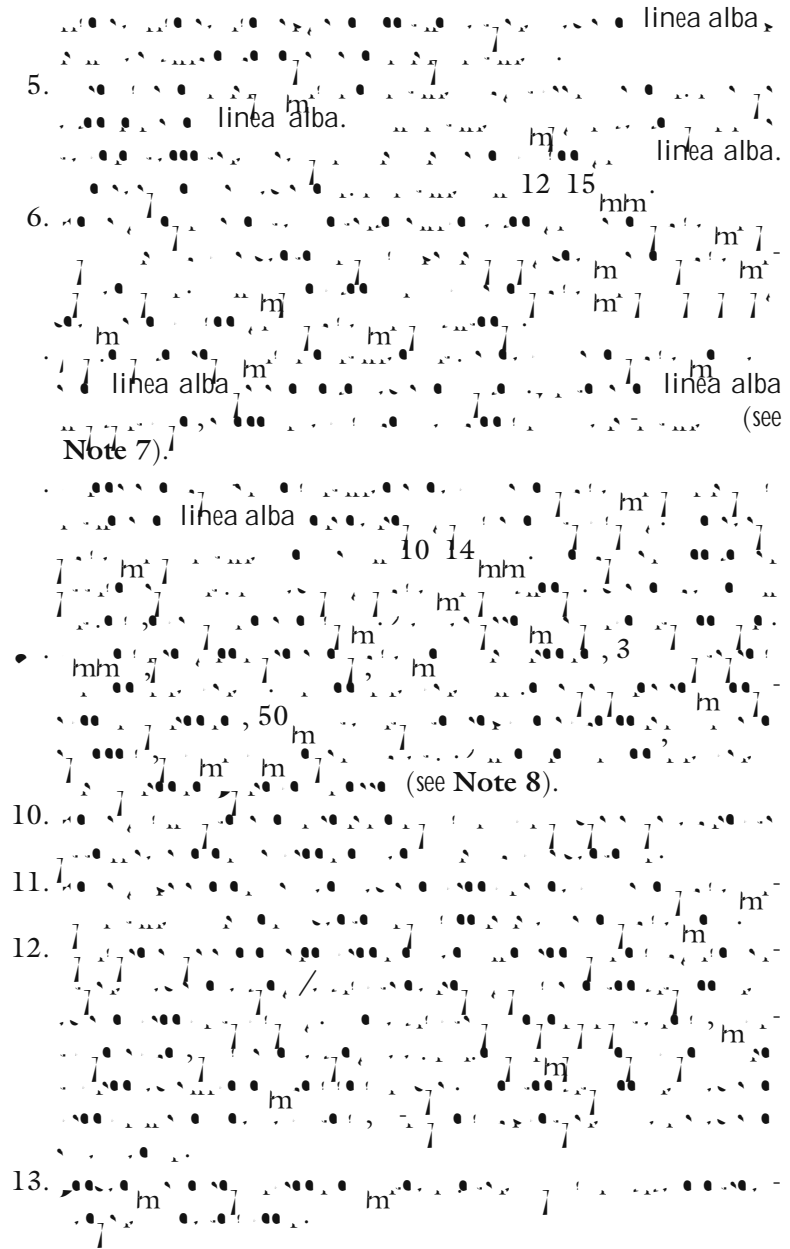
12.  $\frac{1}{m} \left( \frac{1}{m} \right)$ .
13.  $\frac{1}{m} \left( \frac{1}{m} \right)$ .

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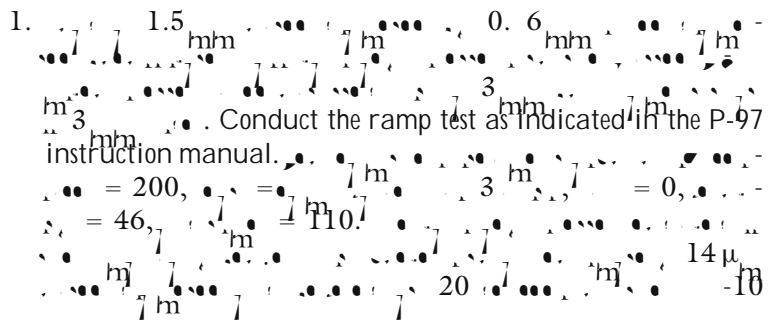
### 3. Methods

#### 3.1. General Anesthesia for Mouse Ventral Laparotomy

1.  $\frac{1}{m} \left( \frac{1}{m} \right)$ .



**3.3. Transuterine Microinjection and In Vivo Electroporation**



Conduct the ramp test as indicated in the P-97 instruction manual.

= 200, = 0,  
= 46, = 10, = 14, = 20

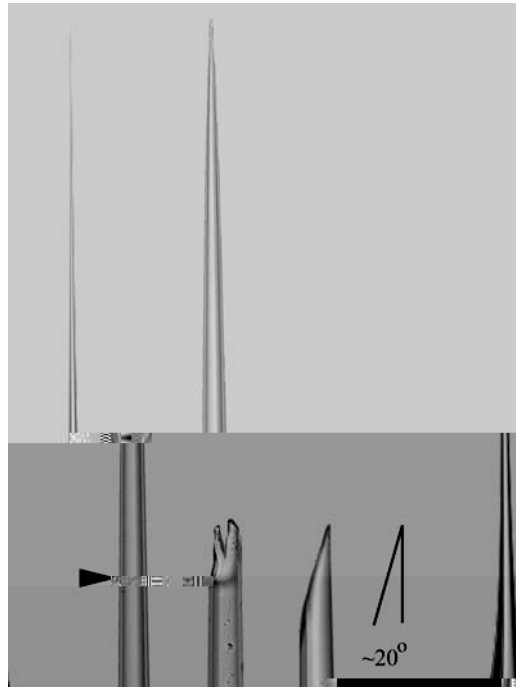


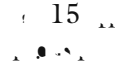


Fig. 8.1. Fabrication of a transuterine microinjection pipette. A pipette was pulled with the P-97 micropipette puller using the pressure:heat:pull:velocity:time settings indicated in **Section 3.3, step 1**. **(A)** The outer diameter of the unpulled shaft is 1.5 mm and the length of the tapered part is 12 mm. The tip of this pipette was imaged in three successive stages of preparation **(B–D)**. **(B)** The approximate location of the manual

4.  20  15 

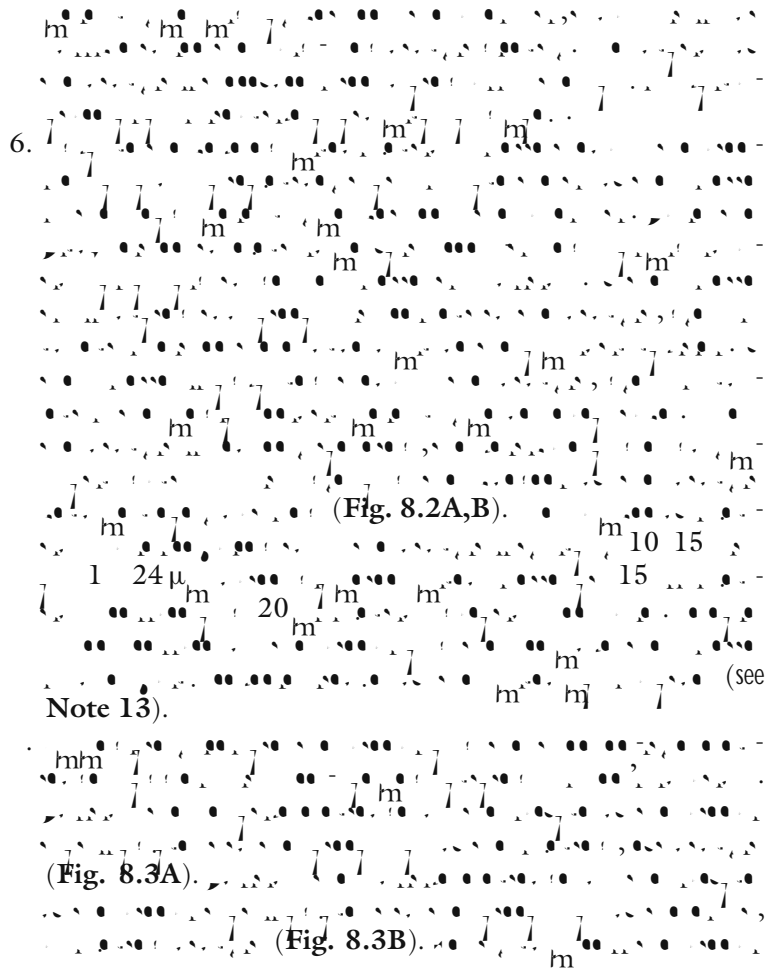
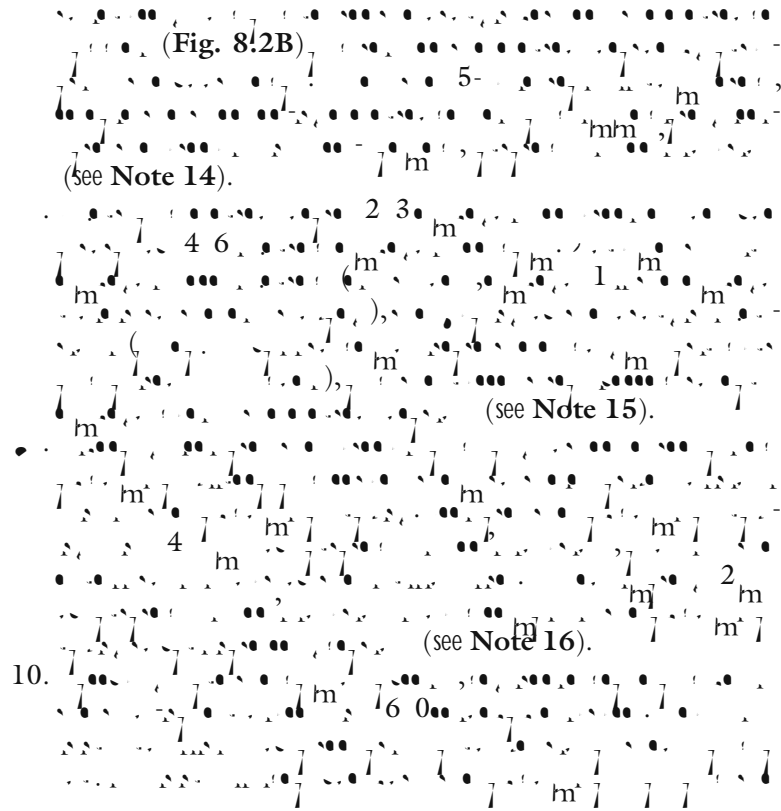


Fig. 8.3. In vivo electroporation of the embryonic day 11.5 mouse otocyst. (A) The uterus was transilluminated with light from a fiber optic cable whose output end (fo) was directly in contact with the irrigated uterus. The left otocyst (o) of the E11.5 mouse embryo was injected with fast green solution, and its gross morphology is discernable beneath the nascent 4th ventricle (4th) in the caudal hindbrain. The insulated surface of the cathode (c) and the reflective, platinum surface of the anode (a) were grossly positioned around the uterus to flank the embryo. (B) Gentle compression of the uterus with the tweezer-style electrodes forced a counter-clockwise rotation of the embryo, placing the injected otocyst toward the center of the 5 mm cathode–anode field. The goal is to drive negatively charged DNA into ventral progenitors within the otic vesicle. (C) Bubbles (b) on the surface of the uterus after execution of the 5-pulse train appear as graininess in the





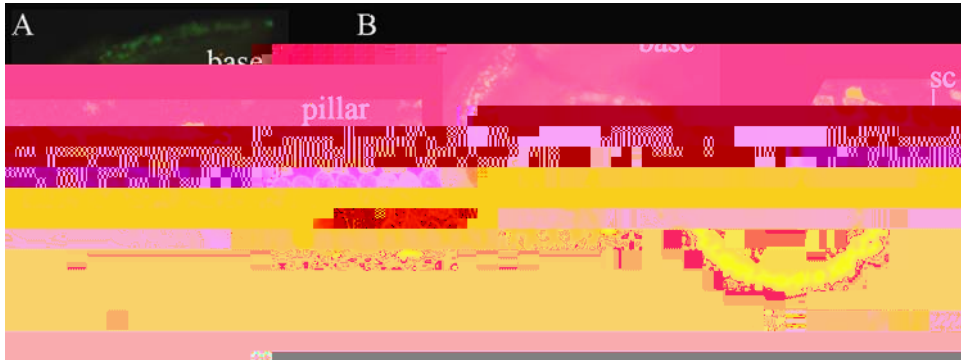


Fig. 8.4. Electroporation-mediated transfer of an expression plasmid encoding green fluorescent protein transfects progenitors that give rise to the organ of Corti. An expression plasmid encoding green fluorescent protein (GFP) driven by the human elongation factor 1- $\alpha$  promoter (EF1- $\alpha$ ) was electroporated into the E11.5 mouse otocyst. The inner ear was harvested 6 days later at E17.5 and fixed in 4% paraformaldehyde in PBS for 12 h. The cartilaginous otic capsule and the cochlear lateral wall were removed, and the whole mount preparation was imaged in panel **A**. GFP expression is detectable in the base, midbase, and proximal apex of the cochlea. **(B)** Laser confocal microscopy of a representative  $100\ \mu\text{m}$  section of the EF1- $\alpha$ /GFP-transfected cochlea immunostained with an antibody against myosin 7a (red) to identify the single row of inner hair cells and three rows of outer hair cells. Several supporting cells (sc), pillar cells (pillar), and outer hair cells (ohc) express GFP. These data indicate that progenitors giving rise to supporting cells and hair cells of the organ of Corti were transfected and expression of the transgene was maintained in differentiated cell types of the maturing cochlea. Scale bar in **A** =  $100\ \mu\text{m}$  and in **B** =  $10\ \mu\text{m}$ .

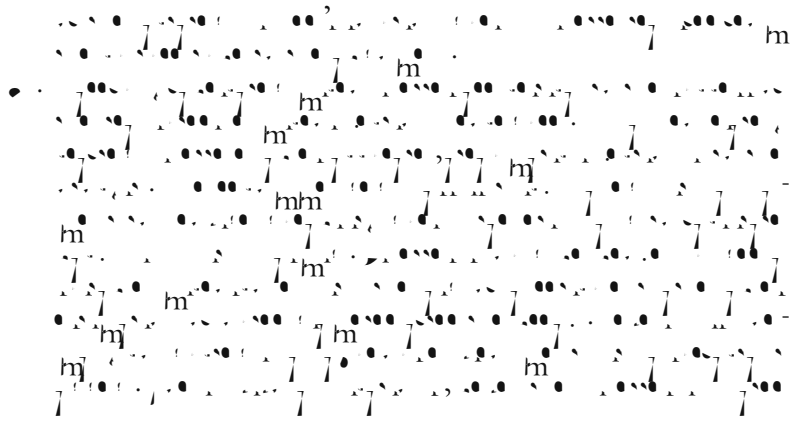


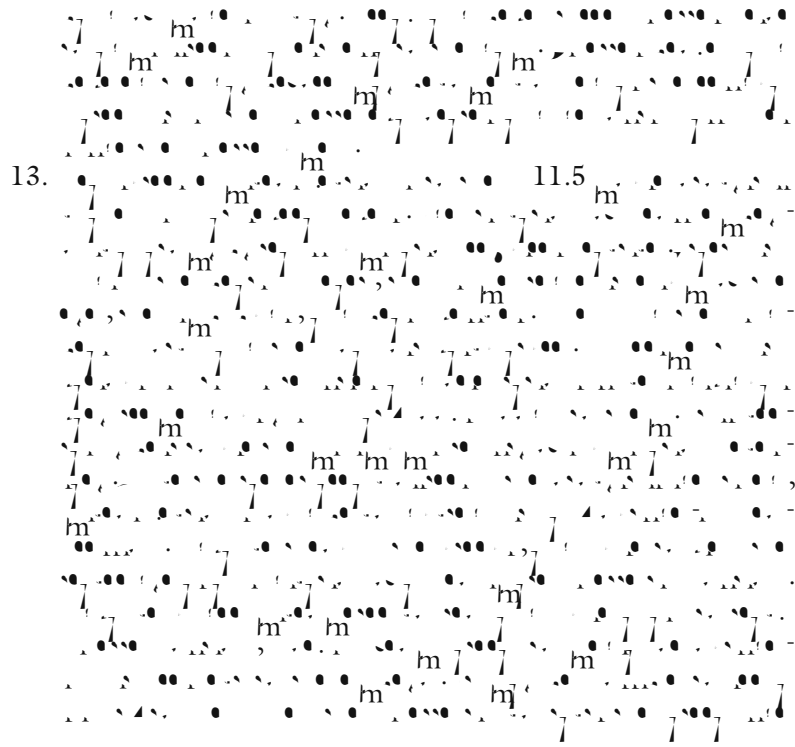
#### 4. Notes

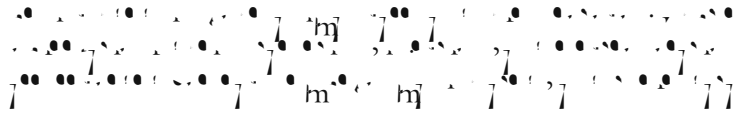


- 1.
- 2.
- 3.











**References**

1. ... (2001) ... Nat. Rev. Neurosci. 2, 631-1.
2. ... (2000) ... Int. J. Dev. Neurosci. 18, 121-131.
3. ... (2001) ... Int. J. Dev. Biol. 43, 13-3.
4. ... (1995) ... J. Neurophysiol. 8, 15-21.
5. ... (1993) ... J. Exp. Zool. 80, 34-3.
6. ... (1994) ... Dev. Biol. 41, 162-14.
7. ... (1993) ... Dev. Biol. 30, 21-222.
8. ... (2006) ... Nat. Rev. Neurosci. 7, 3-4.