

thm\_2Ellist\_2ELUNFOLD\_\_THM  
(TMdsL4tyhy3GKL4oXxCeHARVFB9DXp5kyQY)

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**Definition 1** We define `c_2Emin_2E_3D_3D_3E` to be  $\lambda P \in 2.\lambda Q \in 2.inj\_o (p P \Rightarrow p Q)$  of type  $\iota$ .

**Definition 2** We define `c_2Emin_2E_3D` to be  $\lambda A.\lambda x \in A.\lambda y \in A.inj\_o (x = y)$  of type  $\iota \Rightarrow \iota$ .

**Definition 3** We define `c_2Ebool_2ET` to be  $(ap (ap (c_2Emin_2E_3D (2^2)) (\lambda V0x \in 2.V0x)) (\lambda V1x \in 2.V1x))$

**Definition 4** We define `c_2Ebool_2E_21` to be  $\lambda A.27a : \iota.(\lambda V0P \in (2^{A-27a}).(ap (ap (c_2Emin_2E_3D (2^{A-27a}))$

**Definition 5** We define `c_2Ebool_2EF` to be  $(ap (c_2Ebool_2E_21 2) (\lambda V0t \in 2.V0t))$ .

**Definition 6** We define `c_2Ebool_2EBOUNDED` to be  $(\lambda V0v \in 2.c_2Ebool_2ET)$ .

Let `c_2Enum_2EZERO__REP` :  $\iota$  be given. Assume the following.

$$c_2Enum_2EZERO__REP \in \omega \tag{1}$$

Let `ty_2Enum_2Enum` :  $\iota$  be given. Assume the following.

$$\text{nonempty } ty_2Enum_2Enum \tag{2}$$

Let `c_2Enum_2EABS__num` :  $\iota$  be given. Assume the following.

$$c_2Enum_2EABS__num \in (ty_2Enum_2Enum^{\omega}) \tag{3}$$

**Definition 7** We define `c_2Enum_2E0` to be  $(ap c_2Enum_2EABS__num c_2Enum_2EZERO__REP)$ .

**Definition 8** We define `c_2Earithmic_2EZERO` to be `c_2Enum_2E0`.

Let `c_2Enum_2EREP__num` :  $\iota$  be given. Assume the following.

$$c_2Enum_2EREP__num \in (\omega^{ty_2Enum_2Enum}) \tag{4}$$

Let `c_2Enum_2ESUC__REP` :  $\iota$  be given. Assume the following.

$$c_2Enum_2ESUC__REP \in (\omega^{\omega}) \tag{5}$$

**Definition 9** We define  $c\_2Enum\_2ESUC$  to be  $\lambda V0m \in ty\_2Enum\_2Enum.(ap\ c\_2Enum\_2EABS\_num$

Let  $c\_2Earithmetic\_2E\_2B : \iota$  be given. Assume the following.

$$c\_2Earithmetic\_2E\_2B \in ((ty\_2Enum\_2Enum^{ty\_2Enum\_2Enum})^{ty\_2Enum\_2Enum}) \quad (6)$$

**Definition 10** We define  $c\_2Earithmetic\_2EBIT1$  to be  $\lambda V0n \in ty\_2Enum\_2Enum.(ap\ (ap\ c\_2Earithmetic$

**Definition 11** We define  $c\_2Earithmetic\_2ENUMERAL$  to be  $\lambda V0x \in ty\_2Enum\_2Enum.V0x$ .

Let  $c\_2Earithmetic\_2E\_2D : \iota$  be given. Assume the following.

$$c\_2Earithmetic\_2E\_2D \in ((ty\_2Enum\_2Enum^{ty\_2Enum\_2Enum})^{ty\_2Enum\_2Enum}) \quad (7)$$

Let  $ty\_2Eoption\_2Eoption : \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A0.nonempty\ A0 \Rightarrow nonempty\ (ty\_2Eoption\_2Eoption\ A0) \quad (8)$$

Let  $ty\_2Ellist\_2Ellist : \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A0.nonempty\ A0 \Rightarrow nonempty\ (ty\_2Ellist\_2Ellist\ A0) \quad (9)$$

Let  $c\_2Ellist\_2Ellist\_rep : \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A\_27a.nonempty\ A\_27a \Rightarrow c\_2Ellist\_2Ellist\_rep\ A\_27a \in \\ (((ty\_2Eoption\_2Eoption\ A\_27a)^{ty\_2Enum\_2Enum})^{(ty\_2Ellist\_2Ellist\ A\_27a)}) \quad (10)$$

Let  $ty\_2Eone\_2Eone : \iota$  be given. Assume the following.

$$nonempty\ ty\_2Eone\_2Eone \quad (11)$$

**Definition 12** We define  $c\_2Ebool\_2E\_2F\_5C$  to be  $(\lambda V0t1 \in 2.(\lambda V1t2 \in 2.(ap\ (c\_2Ebool\_2E\_21\ 2)\ (\lambda V2t \in$

Let  $ty\_2Esum\_2Esum : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A0.nonempty\ A0 \Rightarrow \forall A1.nonempty\ A1 \Rightarrow nonempty\ (ty\_2Esum\_2Esum\ A0\ A1) \quad (12)$$

Let  $c\_2Esum\_2EABS\_sum : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow c\_2Esum\_2EABS\_sum\ A\_27a\ A\_27b \in ((ty\_2Esum\_2Esum\ A\_27a\ A\_27b)^{((2^{A\_27b})^{A\_27a})^2}) \quad (13)$$

**Definition 13** We define  $c\_2Esum\_2EINL$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda V0e \in A\_27a.(ap\ (c\_2Esum\_2EABS$

Let  $c\_2Eoption\_2Eoption\_ABS : \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A\_27a.nonempty\ A\_27a \Rightarrow c\_2Eoption\_2Eoption\_ABS\ A\_27a \in \\ ((ty\_2Eoption\_2Eoption\ A\_27a)^{(ty\_2Esum\_2Esum\ A\_27a\ ty\_2Eone\_2Eone)}) \quad (14)$$

**Definition 14** We define  $c\_2Eoption\_2ESOME$  to be  $\lambda A\_27a : \iota.\lambda V0x \in A\_27a.(ap (c\_2Eoption\_2Eoption\_2ESOME A\_27a) x)$

**Definition 15** We define  $c\_2Emin\_2E\_40$  to be  $\lambda A.\lambda P \in 2^A.\text{if } (\exists x \in A.p (ap P x)) \text{ then } (the (\lambda x.x \in A.\lambda P x))$  of type  $\iota \Rightarrow \iota$ .

**Definition 16** We define  $c\_2Ebool\_2ECOND$  to be  $\lambda A\_27a : \iota.(\lambda V0t \in 2.(\lambda V1t1 \in A\_27a.(\lambda V2t2 \in A\_27a.(ap (c\_2Ebool\_2ECOND A\_27a) t1 t2))))$

Let  $c\_2Ellist\_2Ellist\_abs : \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A\_27a.nonempty A\_27a \Rightarrow c\_2Ellist\_2Ellist\_abs A\_27a \in ((ty\_2Ellist\_2Ellist A\_27a)^{(ty\_2Eoption\_2Eoption A\_27a)^{ty\_2Enum\_2Enum}}) \quad (15)$$

**Definition 17** We define  $c\_2Ellist\_2ELCONS$  to be  $\lambda A\_27a : \iota.\lambda V0h \in A\_27a.\lambda V1t \in (ty\_2Ellist\_2Ellist A\_27a) (ap (c\_2Ellist\_2ELCONS A\_27a) h t)$

**Definition 18** We define  $c\_2Eone\_2Eone$  to be  $(ap (c\_2Emin\_2E\_40 ty\_2Eone\_2Eone) (\lambda V0x \in ty\_2Eone\_2Eone. x))$

**Definition 19** We define  $c\_2Ebool\_2E\_7E$  to be  $(\lambda V0t \in 2.(ap (ap c\_2Emin\_2E\_3D\_3D\_3E V0t) c\_2Ebool\_2E\_7E t))$

**Definition 20** We define  $c\_2Esum\_2EINR$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda V0e \in A\_27b.(ap (c\_2Esum\_2EABS A\_27a A\_27b) e)$

**Definition 21** We define  $c\_2Eoption\_2ENONE$  to be  $\lambda A\_27a : \iota.(ap (c\_2Eoption\_2Eoption\_2ABS A\_27a) (c\_2ENONE A\_27a))$

**Definition 22** We define  $c\_2Ellist\_2ELNIL$  to be  $\lambda A\_27a : \iota.(ap (c\_2Ellist\_2Ellist\_abs A\_27a) (\lambda V0n \in ty\_2Ellist\_2Ellist A\_27a. n))$

Let  $ty\_2Epair\_2Eprod : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A0.nonempty A0 \Rightarrow \forall A1.nonempty A1 \Rightarrow nonempty (ty\_2Epair\_2Eprod A0 A1) \quad (16)$$

**Definition 23** We define  $c\_2Ecombin\_2EK$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.(\lambda V0x \in A\_27a.(\lambda V1y \in A\_27b.V0x))$

**Definition 24** We define  $c\_2Ecombin\_2Eo$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda A\_27c : \iota.\lambda V0f \in (A\_27b^{A\_27c}).\lambda V1x \in A\_27a. f x$

Let  $c\_2Epair\_2ESND : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A\_27a.nonempty A\_27a \Rightarrow \forall A\_27b.nonempty A\_27b \Rightarrow c\_2Epair\_2ESND A\_27a A\_27b \in (A\_27b^{(ty\_2Epair\_2Eprod A\_27a A\_27b)}) \quad (17)$$

Let  $c\_2Epair\_2EFST : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\forall A\_27a.nonempty A\_27a \Rightarrow \forall A\_27b.nonempty A\_27b \Rightarrow c\_2Epair\_2EFST A\_27a A\_27b \in (A\_27a^{(ty\_2Epair\_2Eprod A\_27a A\_27b)}) \quad (18)$$

**Definition 25** We define  $c\_2Epair\_2EUNCURRY$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda A\_27c : \iota.\lambda V0f \in ((A\_27c^{A\_27b})^{A\_27a})$

Let  $c\_2Eoption\_2EOPTION\_BIND : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow c\_2Eoption\_2EOPTION\_BIND \\ & A\_27a\ A\_27b \in (((ty\_2Eoption\_2Eoption\ A\_27a)^{(ty\_2Eoption\_2Eoption\ A\_27a)^{A\_27b}})^{(ty\_2Eoption\_2Eoption\ A\_27b)^{A\_27a}}) \end{aligned} \quad (19)$$

Let  $c\_2Earithmetic\_2EFUNPOW : \iota \Rightarrow \iota$  be given. Assume the following.

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow c\_2Earithmetic\_2EFUNPOW\ A\_27a \in \\ & (((A\_27a^{A\_27a})^{ty\_2Enum\_2Enum})^{(A\_27a)^{A\_27a}}) \end{aligned} \quad (20)$$

Let  $c\_2Eoption\_2EOPTION\_MAP : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow c\_2Eoption\_2EOPTION\_MAP \\ & A\_27a\ A\_27b \in (((ty\_2Eoption\_2Eoption\ A\_27b)^{(ty\_2Eoption\_2Eoption\ A\_27a)^{A\_27b}})^{(A\_27b)^{A\_27a}}) \end{aligned} \quad (21)$$

**Definition 26** We define  $c\_2Ellist\_2ELUNFOLD$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda V0f \in ((ty\_2Eoption\_2Eoption$

$c\_2Eoption\_2Eoption\_CASE : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow c\_2Eoption\_2Eoption\_CASE \\ & A\_27a\ A\_27b \in (((A\_27b)^{(A\_27b)^{A\_27a}})^{(A\_27b)^{(ty\_2Eoption\_2Eoption\ A\_27a)}}) \end{aligned} \quad (22)$$

Let  $c\_2Epair\_2EABS\_prod : \iota \Rightarrow \iota \Rightarrow \iota$  be given. Assume the following.

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow c\_2Epair\_2EABS\_prod \\ & A\_27a\ A\_27b \in ((ty\_2Epair\_2Eprod\ A\_27a\ A\_27b)^{(2^{A\_27b})^{A\_27a}}) \end{aligned} \quad (23)$$

**Definition 27** We define  $c\_2Epair\_2E\_2C$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda V0x \in A\_27a.\lambda V1y \in A\_27b.(ap\ (c\_2$

**Definition 28** We define  $c\_2Epair\_2Epair\_CASE$  to be  $\lambda A\_27a : \iota.\lambda A\_27b : \iota.\lambda A\_27c : \iota.\lambda V0p \in (ty\_2Epair$

Assume the following.

$$True \quad (24)$$

Assume the following.

$$\begin{aligned} & (\forall V0t \in 2.(((True \wedge (p\ V0t)) \Leftrightarrow (p\ V0t)) \wedge (((p\ V0t) \wedge True) \Leftrightarrow \\ & (p\ V0t)) \wedge (((False \wedge (p\ V0t)) \Leftrightarrow False) \wedge (((p\ V0t) \wedge False) \Leftrightarrow False) \wedge \\ & (((p\ V0t) \wedge (p\ V0t)) \Leftrightarrow (p\ V0t)))))) \end{aligned} \quad (25)$$

Assume the following.

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow (\forall V0x \in A\_27a.((V0x = V0x) \Leftrightarrow \\ & True)) \end{aligned} \quad (26)$$

Assume the following.

$$(\forall V0v \in 2.((p\ (ap\ c\_2Ebool\_2EBOUNDED\ V0v)) \Leftrightarrow True)) \quad (27)$$

Assume the following.

$$\begin{aligned}
& \forall A\_27a.nonempty\ A\_27a \Rightarrow (\forall V0h1 \in A\_27a. (\forall V1t1 \in \\
& \quad (ty\_2Ellist\_2Ellist\ A\_27a). (\forall V2h2 \in A\_27a. (\forall V3t2 \in \\
& \quad (ty\_2Ellist\_2Ellist\ A\_27a). (((ap\ (ap\ (c\_2Ellist\_2ELCONS\ A\_27a) \\
& \quad V0h1)\ V1t1) = (ap\ (ap\ (c\_2Ellist\_2ELCONS\ A\_27a)\ V2h2)\ V3t2))) \Leftrightarrow (( \\
& \quad V0h1 = V2h2) \wedge (V1t1 = V3t2))))))
\end{aligned} \tag{28}$$

Assume the following.

$$\begin{aligned}
& \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow ( \\
& \quad \forall V0f \in ((ty\_2Eoption\_2Eoption\ (ty\_2Epair\_2Eprod\ A\_27a \\
& \quad A\_27b))^{A\_27a}). (\forall V1x \in A\_27a. ((ap\ (ap\ (c\_2Ellist\_2ELUNFOLD \\
& \quad A\_27b\ A\_27a)\ V0f)\ V1x) = (ap\ (ap\ (ap\ (c\_2Eoption\_2Eoption\_CASE \\
& \quad (ty\_2Epair\_2Eprod\ A\_27a\ A\_27b)\ (ty\_2Ellist\_2Ellist\ A\_27b))\ ( \\
& \quad ap\ V0f\ V1x))\ (c\_2Ellist\_2ELNIL\ A\_27b))\ (\lambda V2v \in (ty\_2Epair\_2Eprod \\
& \quad A\_27a\ A\_27b). (ap\ (ap\ (c\_2Epair\_2Epair\_CASE\ (ty\_2Ellist\_2Ellist \\
& \quad A\_27b)\ A\_27a\ A\_27b)\ V2v)\ (\lambda V3v1 \in A\_27a. (\lambda V4v2 \in A\_27b. (ap \\
& \quad (ap\ (c\_2Ellist\_2ELCONS\ A\_27b)\ V4v2)\ (ap\ (ap\ (c\_2Ellist\_2ELUNFOLD \\
& \quad A\_27b\ A\_27a)\ V0f)\ V3v1)))))))))
\end{aligned} \tag{29}$$

Assume the following.

$$\begin{aligned}
& \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow ( \\
& \quad (\forall V0v \in A\_27b. (\forall V1f \in (A\_27b^{A\_27a}). ((ap\ (ap\ (ap\ (c\_2Eoption\_2Eoption\_CASE \\
& \quad A\_27a\ A\_27b)\ (c\_2Eoption\_2ENONE\ A\_27a))\ V0v)\ V1f) = V0v))) \wedge (\forall V2x \in \\
& \quad A\_27a. (\forall V3v \in A\_27b. (\forall V4f \in (A\_27b^{A\_27a}). ((ap\ (ap \\
& \quad (ap\ (c\_2Eoption\_2Eoption\_CASE\ A\_27a\ A\_27b)\ (ap\ (c\_2Eoption\_2ESOME \\
& \quad A\_27a)\ V2x))\ V3v)\ V4f) = (ap\ V4f\ V2x))))))
\end{aligned} \tag{30}$$

Assume the following.

$$\begin{aligned}
& \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow \forall A\_27c. \\
& \quad nonempty\ A\_27c \Rightarrow (\forall V0x \in A\_27b. (\forall V1y \in A\_27c. (\forall V2f \in \\
& \quad ((A\_27a^{A\_27c})^{A\_27b}). ((ap\ (ap\ (c\_2Epair\_2Epair\_CASE\ A\_27a\ A\_27b \\
& \quad A\_27c)\ (ap\ (ap\ (c\_2Epair\_2E\_2C\ A\_27b\ A\_27c)\ V0x)\ V1y))\ V2f) = (ap \\
& \quad (ap\ V2f\ V0x)\ V1y))))
\end{aligned} \tag{31}$$

**Theorem 1**

$$\begin{aligned} & \forall A\_27a.nonempty\ A\_27a \Rightarrow \forall A\_27b.nonempty\ A\_27b \Rightarrow ( \\ & \forall V0f \in ((ty\_2Eoption\_2Eoption\ (ty\_2Epair\_2Eprod\ A\_27a \\ & A\_27b))^{A\_27a}).(\forall V1x \in A\_27a.(\forall V2v1 \in A\_27a.(\forall V3v2 \in \\ & A\_27b.(((ap\ V0f\ V1x) = (c\_2Eoption\_2ENONE\ (ty\_2Epair\_2Eprod \\ & A\_27a\ A\_27b))) \Rightarrow ((ap\ (ap\ (c\_2Elist\_2ELUNFOLD\ A\_27b\ A\_27a)\ V0f) \\ & V1x) = (c\_2Elist\_2ELNIL\ A\_27b))) \wedge (((ap\ V0f\ V1x) = (ap\ (c\_2Eoption\_2ESOME \\ & (ty\_2Epair\_2Eprod\ A\_27a\ A\_27b))\ (ap\ (ap\ (c\_2Epair\_2E\_2C\ A\_27a \\ & A\_27b)\ V2v1)\ V3v2))) \Rightarrow ((ap\ (ap\ (c\_2Elist\_2ELUNFOLD\ A\_27b\ A\_27a) \\ & V0f)\ V1x) = (ap\ (ap\ (c\_2Elist\_2ELCONS\ A\_27b)\ V3v2)\ (ap\ (ap\ (c\_2Elist\_2ELUNFOLD \\ & A\_27b\ A\_27a)\ V0f)\ V2v1)))))))))) \end{aligned}$$