



Cloning Technology: Myths and Facts

Emerging Issues in Global Meat Trade

Cloning and Country of Origin Labeling (COOL)

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Cloning: Science and Mythology

What I'm going to talk about

- Some basic definitions & cell biology
- How we make clones
- Demythification

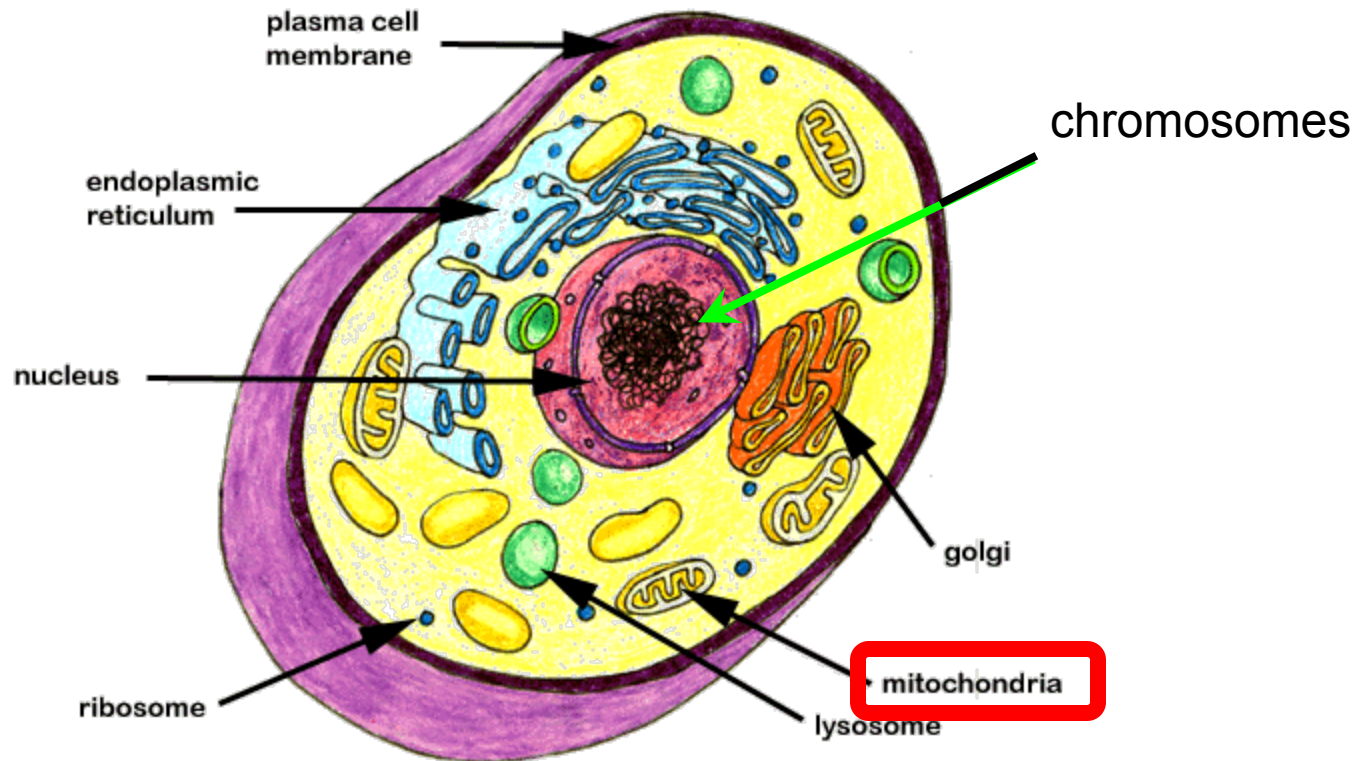
Background definitions

What is a Gene?

- Basic unit of heredity
- Made of DNA molecules (deoxyribose nucleic acid)
- Arranged on chromosomes
- Chromosomes come in pairs (maternal + paternal)
- Chromosomes reside in cell's nucleus

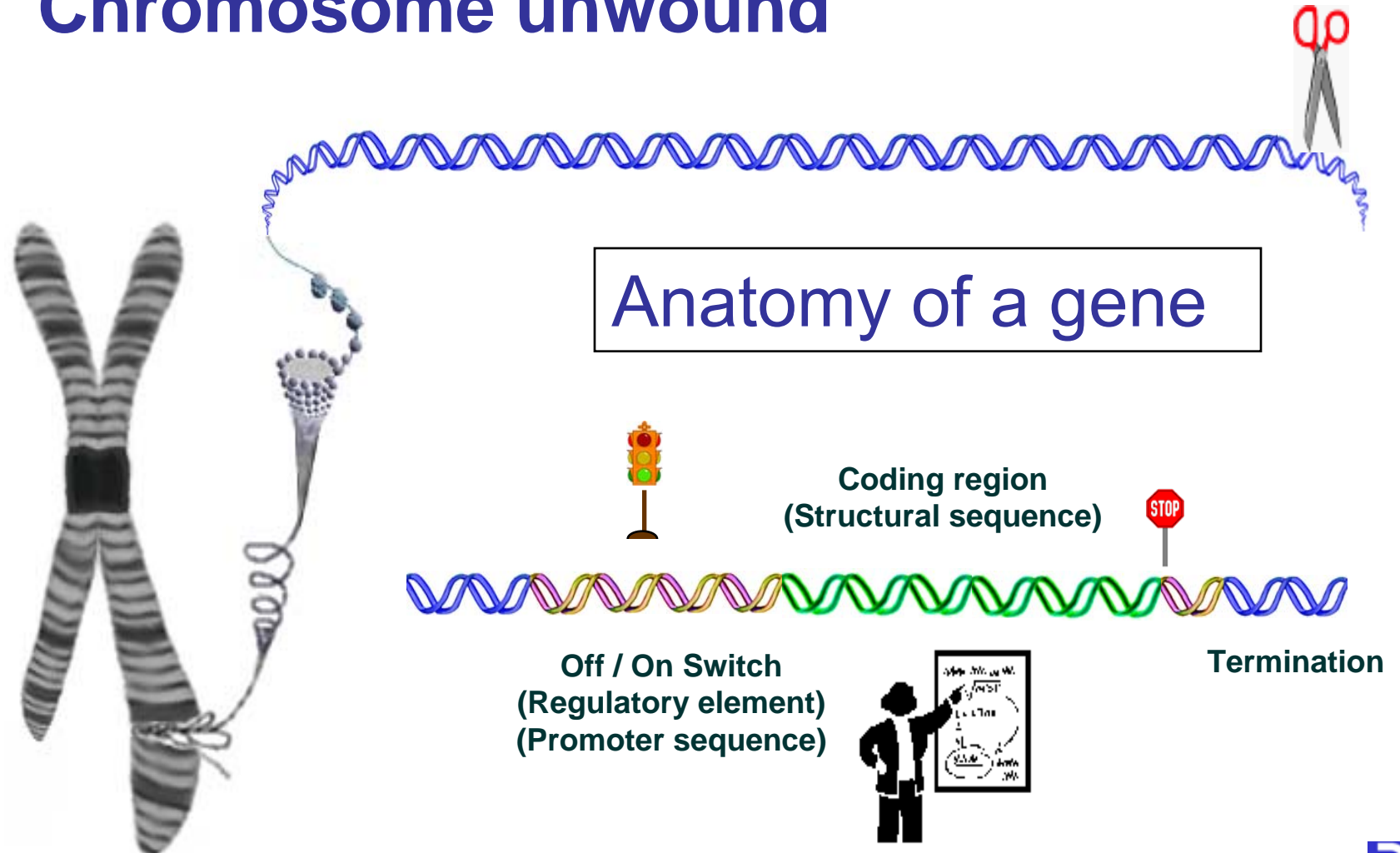
Background definitions

A eukaryotic cell



Background definitions

Chromosome unwound



Background definitions

What is a Cloned Animal ?

A copy of an animal produced asexually

Maternal (identical) twins – a natural example

Just another selective breeding tool

Two kinds of man made clones

- Embryonic clones
- Somatic cell clones

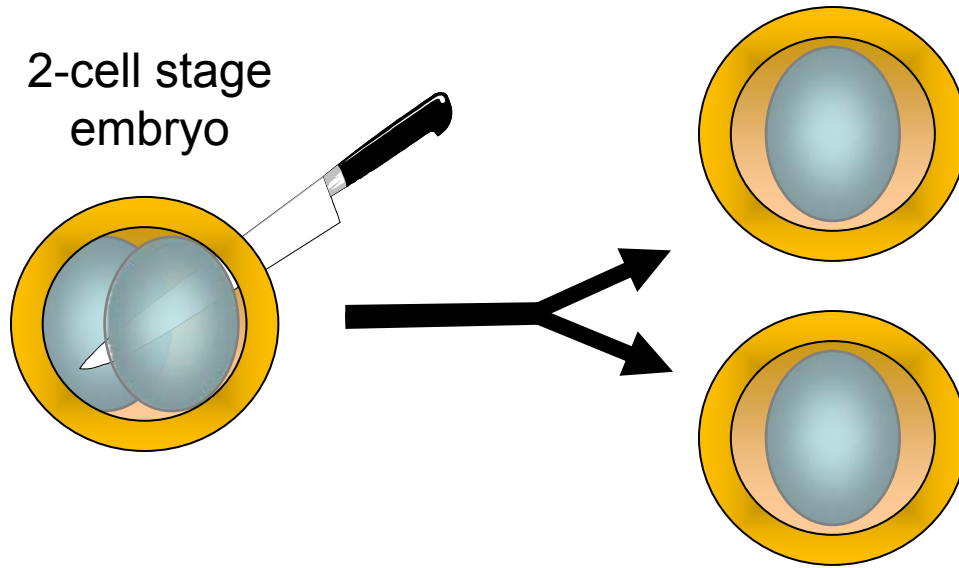
Fact or Fiction # 1

Man made cloning is new technology

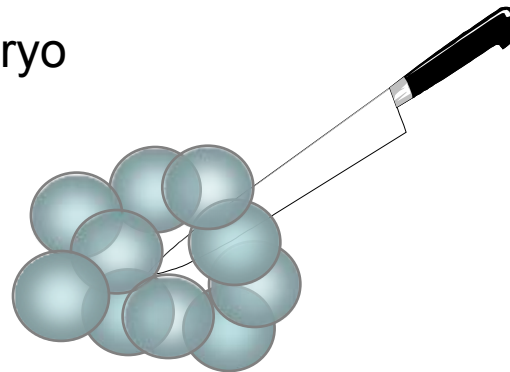
Fiction

- ✓ Embryo “twinning” has been done since the 80’s
- ✓ Vegetative propagation (plant cloning) has been done for over 200 years – grapes, potatoes, bananas

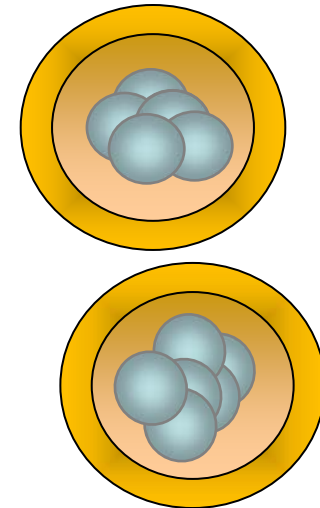
How are animals cloned ?



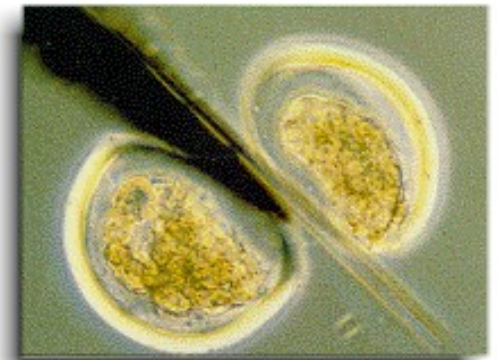
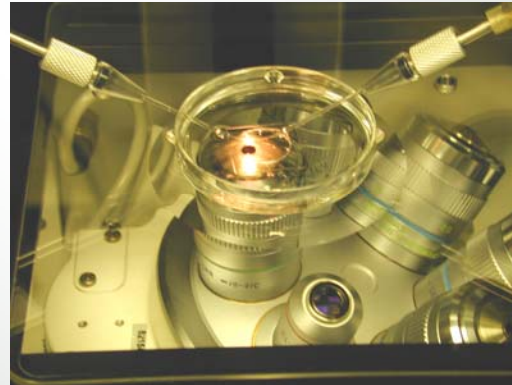
Morula stage embryo
(8 - 32 cells)



Embryonic cloning



How are clones made?



Clones, circa 1980

Seven calves from a single embryo



Background definitions

More facts

Sheep and cattle have been cloned since 1980

Clones produced in the 80s were

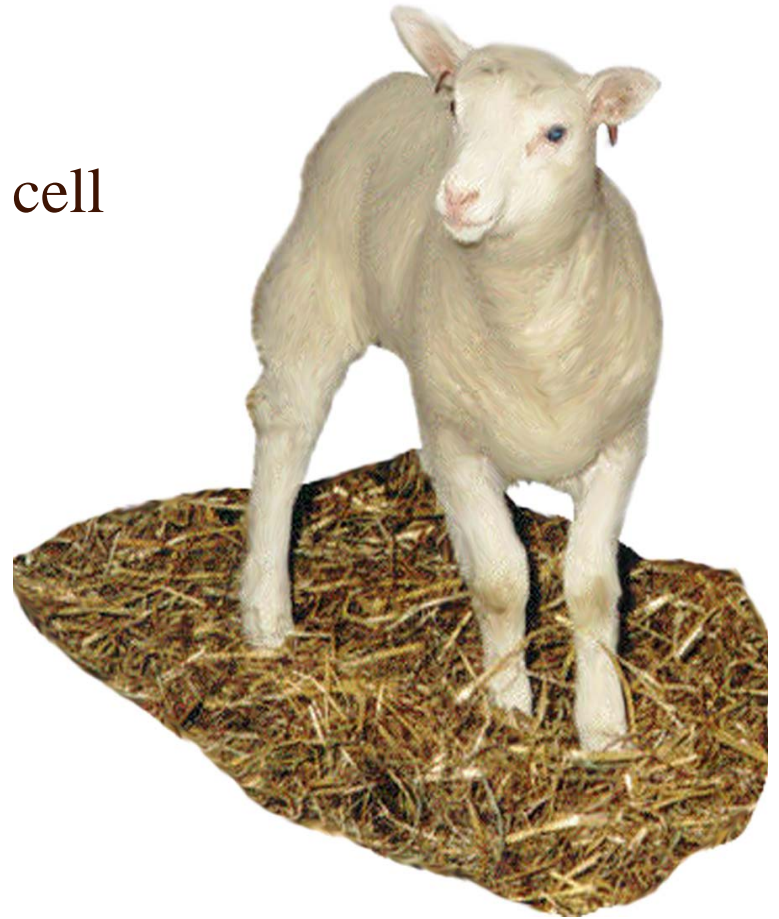
So why is there such a fuss about clones now?

Well Hello, Dolly...

Dolly was cloned from a SOMATIC cell

Significance

- Can “reproduce” a known entity



Well Hello, Dolly...

Dolly was cloned from an **ADULT cell**

Significance

- Can “reproduce” a known entity



Cloning doesn't make biological sense

Textbooks said

- Embryonic cell's potential limitless
- Differentiated cell's potential finite
- Differentiated cells utilize only a subset of genome
- De-differentiation not possible

Cloning doesn't make biological sense

Textbooks need revision

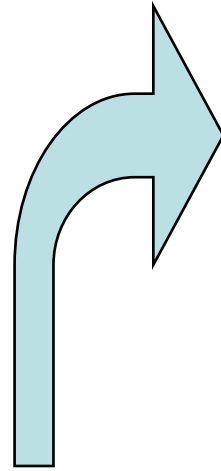
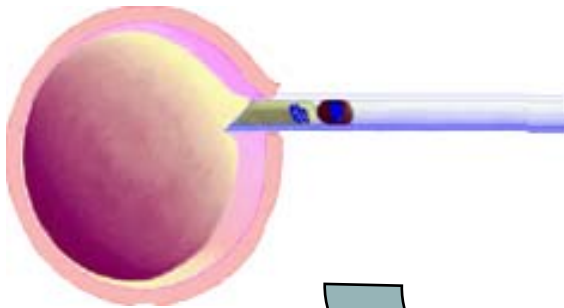
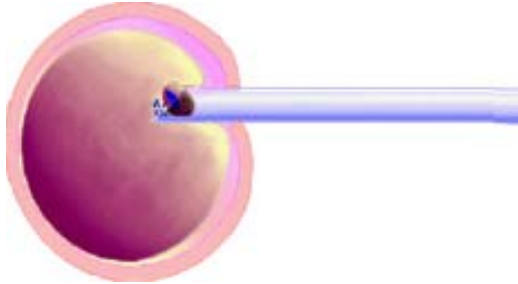
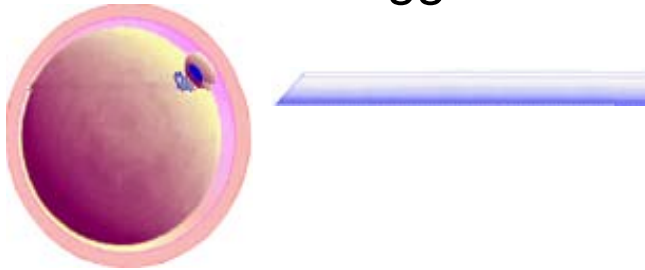
- Embryonic cell's potential limitless
- ~~✘ Differentiated cell's potential finite~~
- Differentiated cells utilize only a subset of genome
- ~~✘ De-differentiation not possible~~

How are somatic cell clones made ?

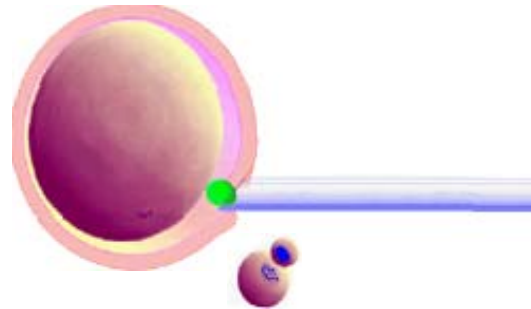
- Build a transgene (optional)
- Harvest oocytes (unfertilized eggs)
- Fabricate cloned embryos
- Transfer clones to surrogate mothers
- WAIT !

Somatic-Cell Cloning (Somatic Cell Nuclear Transfer)

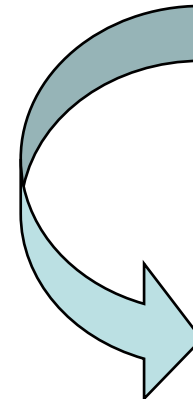
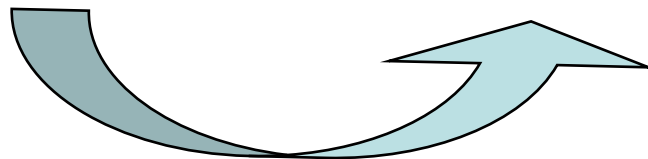
Remove chromosomes
from egg



Embryo
culture



Add cell with desired
genetic information

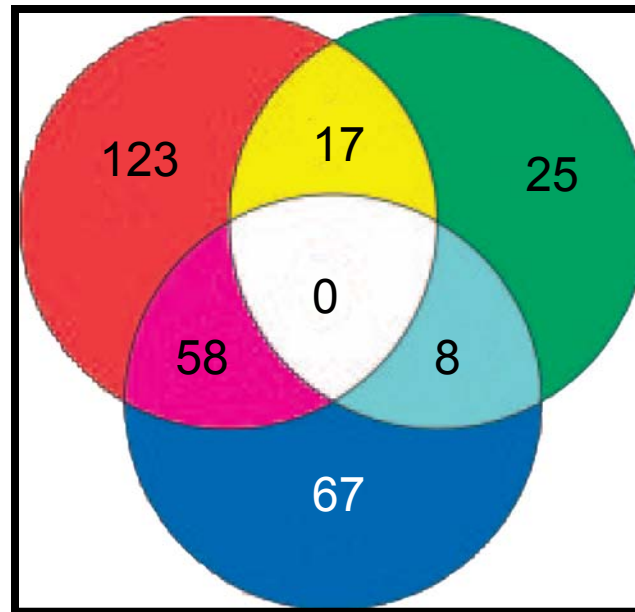


Transfer to
surrogate
mom

Are cloned embryos normal ?

Differentially expressed genes (out of 5,174) in normal & ART embryos

Normal (In vivo)
vs.
In Vitro Fertilized
(198)



Normal
vs.
Clone
(50)

Clone vs. In Vitro Fertilized (133)

How efficient is Nuclear Transfer?

- Enucleation – 85%
- Couplet formation – 20 to 60%
- In vitro development – 40% (blastocyst/couplet)
- In vivo development – 15% (calves born/embryo)

- Overall efficiency 6% (calves / somatic cells)

Heyman, *Reprod. Nutr. Dev.* 45:353, 2005

How efficient is Nuclear Transfer?

In Context

- NT (academic) \approx 90% embryonic / fetal loss
- NT (commercial) = ?
- Normal livestock repro. \approx 20 – 30% fetal loss
- Women \geq 50% embryonic / fetal loss

Fact or Fiction # 2

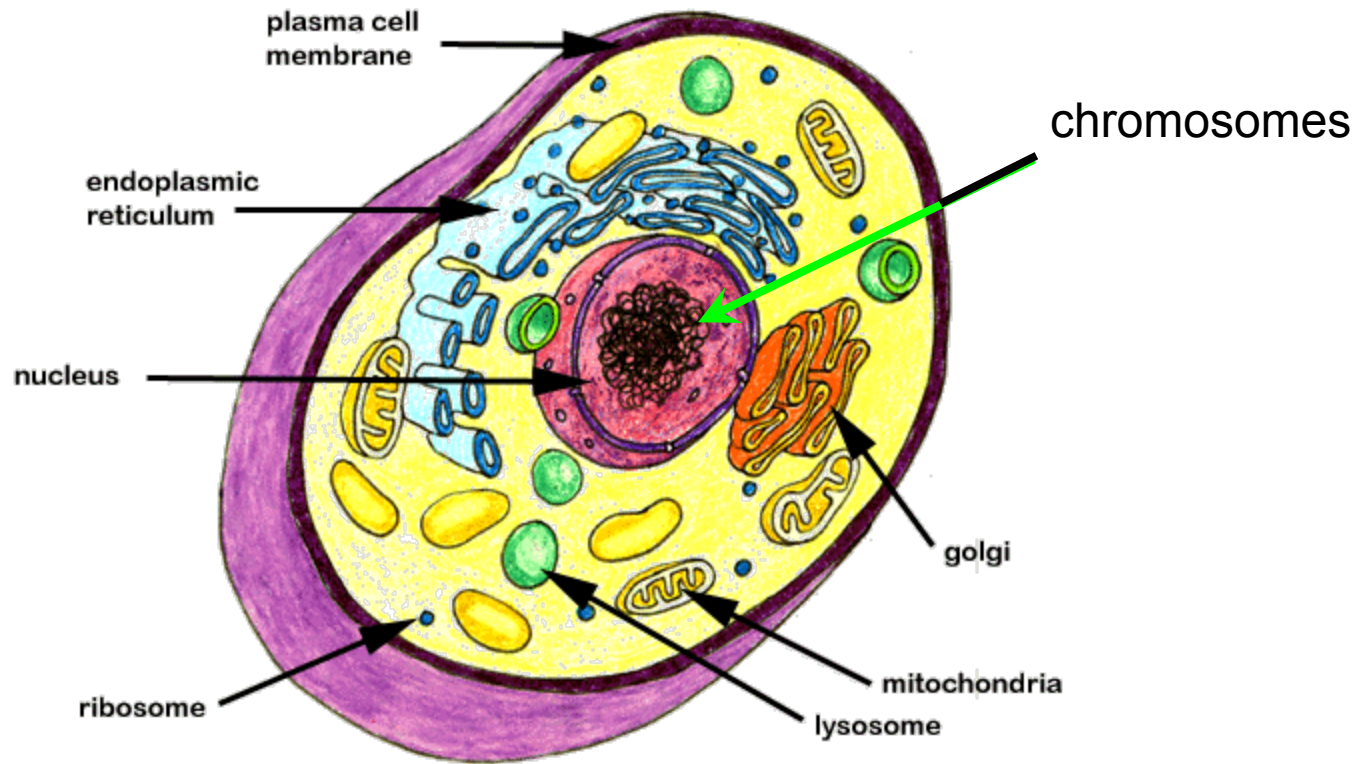
Clones are genetically identical

Fact and Fiction

- ✓ Split embryos are identical
- ✓ Nuclear transfer embryos are not identical

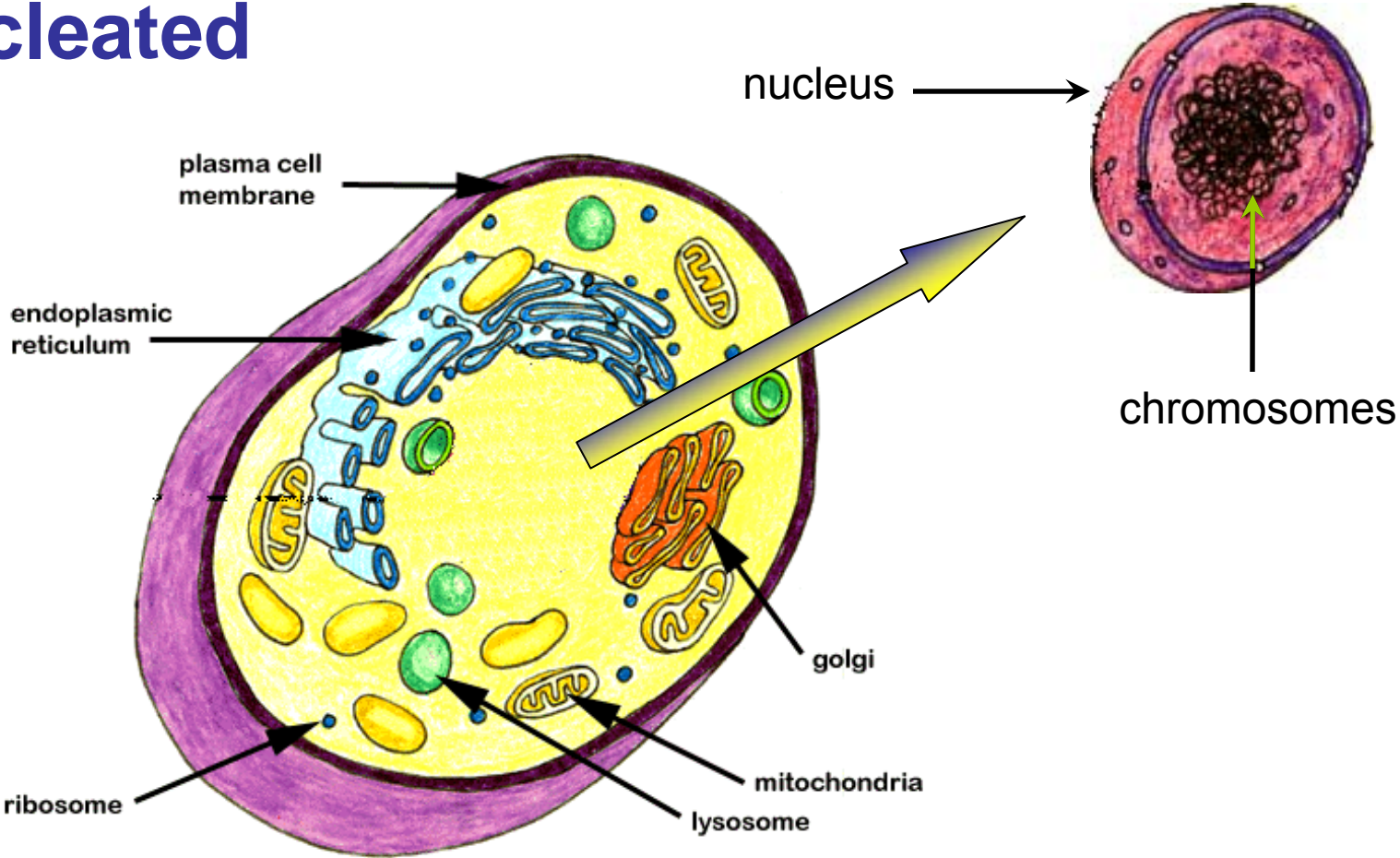
Background definitions

A eukaryotic cell



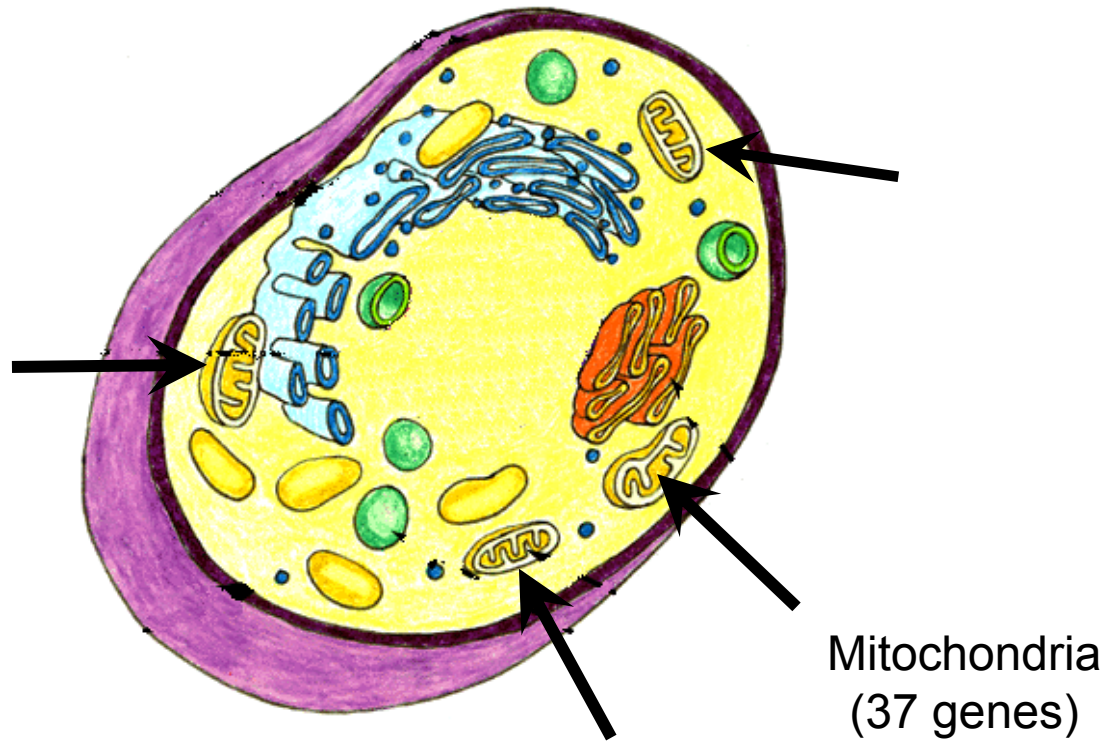
Background definitions

Enucleated



Background definitions

Enucleated – but still some genes left



Fact or Fiction # 3

Clones don't look and act the same as the clonee

Fact – even for split embryos

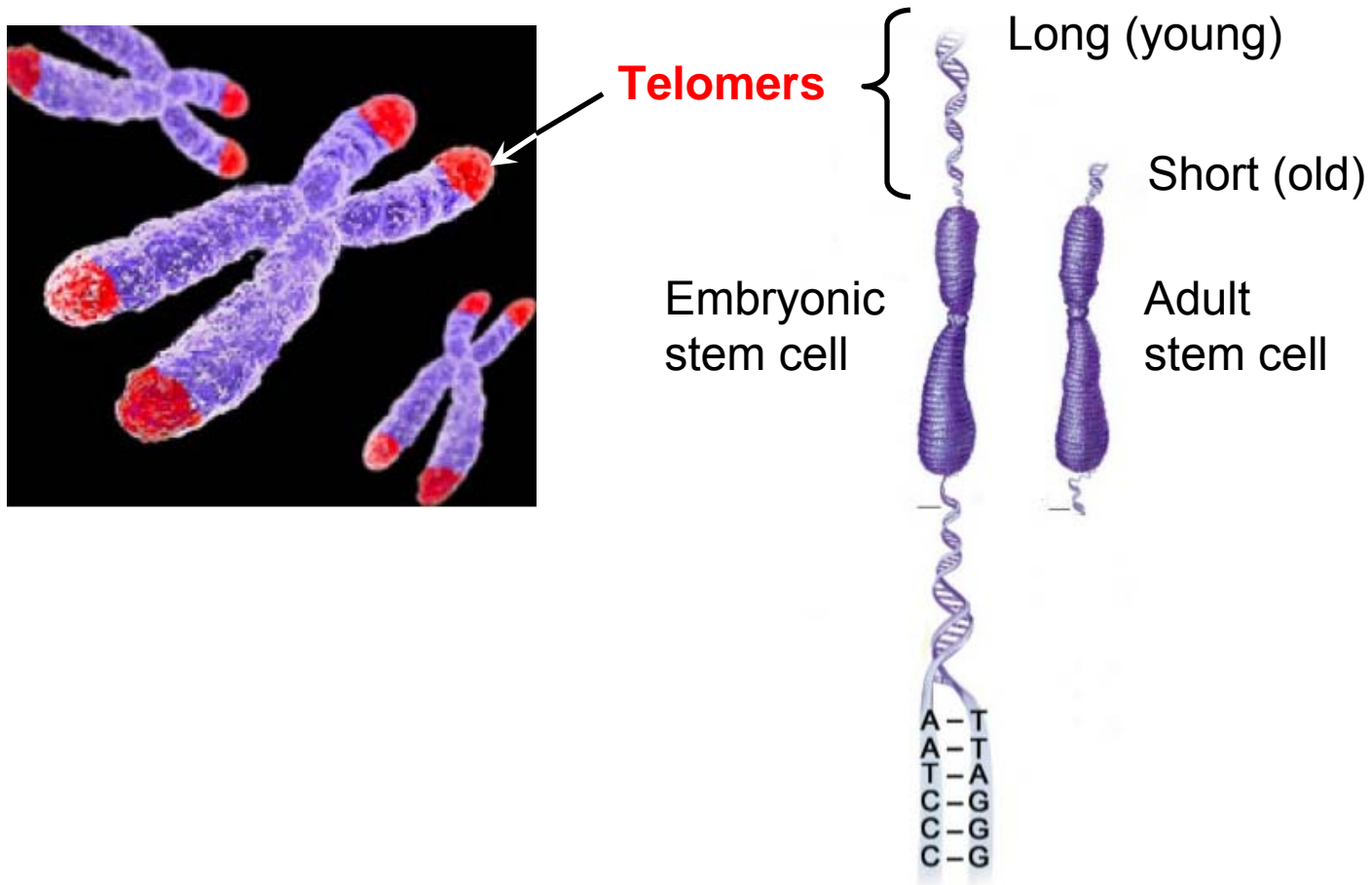
- ✓ Looks – spots, bands, coat patterns are mostly developmentally determined
- ✓ Behavior – a quantitative traits

Phenotype = Genetics X Environment

Fact or Fiction # 4

Clones are born old – same age as clonee

Clones are born old – same age as donor



Fact or Fiction # 5

Offspring of Clones are Clones of Clones

Fiction

- ✓ Offspring are produced by sexual reproduction
- ✓ Genome a mix of maternal & paternal genes
- ✓ Offspring not necessarily the same sex
- ✓ Offspring are no more alike than offspring

Family resemblance

Fact or Fiction # 5

Clones are safe to eat ?

Fact – but question is probably irrelevant

Fact or Fiction # 5

Clones are safe to eat ?

Fact



U.S. Food and Drug Administration

Meat and Milk from Clones of Cattle, Swine, and Goats, and the Offspring of All Clones, are as Safe to Eat as Food from Conventionally Bred Animals

FDA News

January 15, 2008



Fact or Fiction # 5

Clones are safe to eat

Question is probably irrelevant

Doesn't make economic sense

A clone costs – (Tens ? of) thousands

Carcass value – < \$1,000 / steer, dressed

Take home lessons

- ✓ Clones are genetically identical copies – almost
- ✓ Cloning is less efficient than normal reproduction
- ✓ Phenotype = Genetics by Environment interaction
- ✓ Offspring of clones are not clones
- ✓ Clones & offspring are as safe to eat as any animal
- ✓ Clones are too expensive to eat
- ✓ Greatest long term impact: Biology to be learned

Just the beginning

