ANSC/FSTC 607
Physiology and Biochemistry of Muscle as a Food
Myoblast *trans*-differentiation

I. Satellite cells

A. Satellite cells are necessary for muscle growth and repair.

B. As animals grow, the number of satellite cells decreases.

1. Muscle growth and/or regeneration is rapid in young animals.
2. The ability of muscle to grow is greatly depressed in older humans and animals.
3. Where do satellite cells go?

II. Satellite cells and marbling

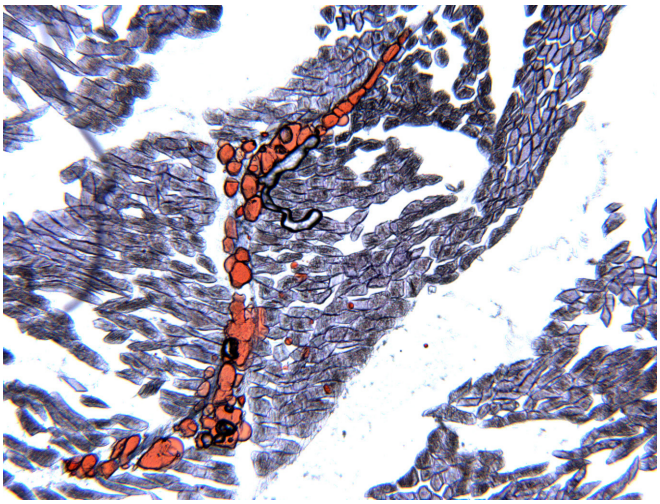
A. Marbling = intramuscular (interfascicular) adipocytes

B. Marbling usually occurs between muscle fiber bundles (fascicules).

C. Some breed types have a huge capacity to marble. This process involves both preadipocyte hyperplasia and hypertrophy.

D. In typical U.S. cattle, adipocytes are located between muscle fasciculi.

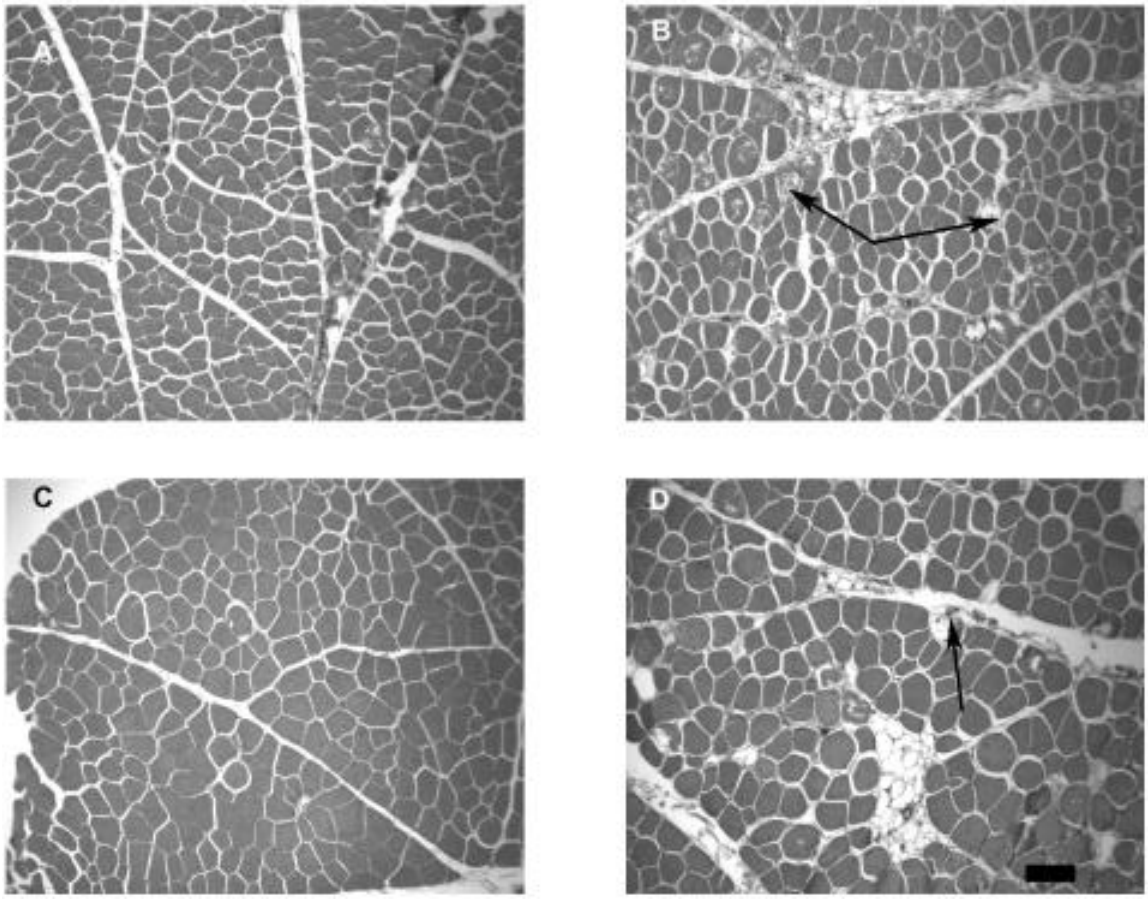
E. Fibroblasts (preadipoyctes?) differentiate into marbling adipocytes when animals are fed high-energy diets.



F. In Japanese Black cattle, marbling adipocytes have invaded muscle fasciculi.
G. This indicates that a preadipocyte precursor cell exists within the muscle fasciculus of Japanese Black cattle.

H. Infiltration of poultry pectoralis muscle with marbling adipocytes. Intramuscular adipocytes form spontaneously in young, feed-restricted broilers.

A & C, normal muscle. B & D, muscle from feed-restricted broilers. Arrows point the marbling adipocytes within perimyseal connective tissue and within muscle fasciculi. Courtesy of Dr. Sandra Velleman, Ohio Statea University.

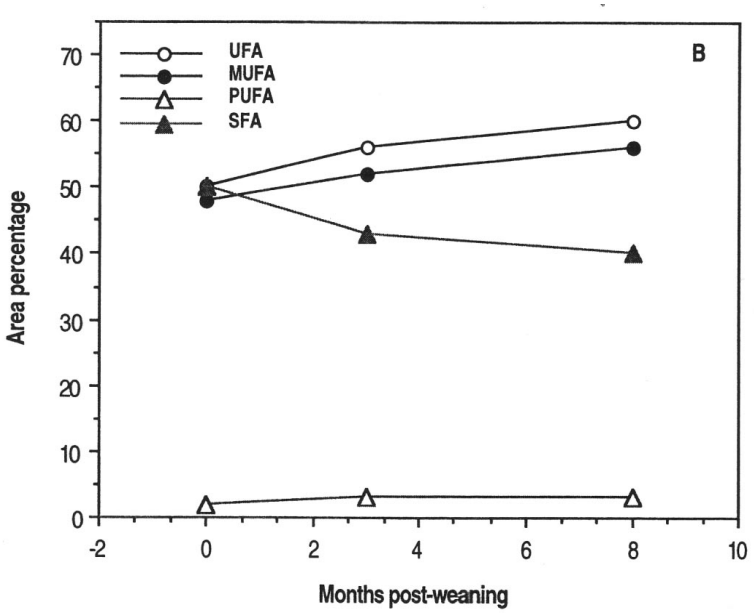


III. Change in fat composition with age

A. Adipose tissue lipids become more unsaturated with increasing age.

B. The primary unsaturated fatty acid in beef in oleic acid (a monounsaturated fatty acid).

C. In U.S. cattle, oleic acid increases in muscle and fat as the cattle get older.



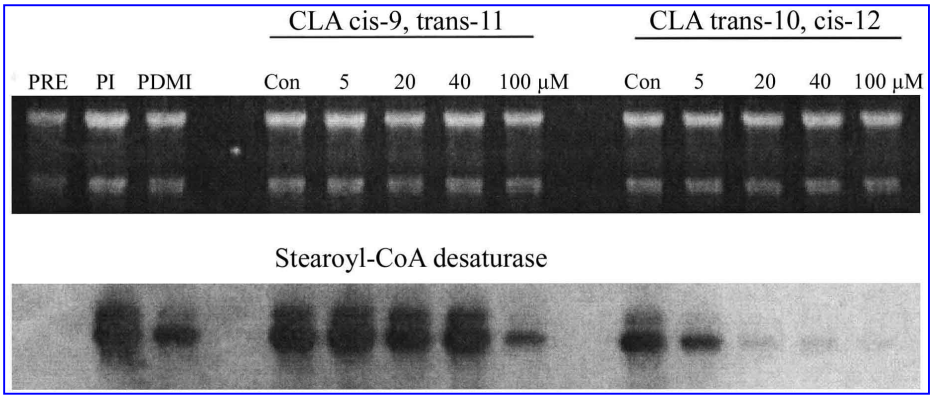
Changes in fatty acid composition of subcutaneous adipose tissue in postweaning calves. UFA = total unsaturated fatty acids; MUFA = monounsaturated fatty acids (16:1 + 18:1); PUFA = polyunsaturated fatty acids (18:2 + 18:3); SFA = saturated fatty acids (14:0 + 16:0 + 18:0).

IV. Monunsaturated fatty acids and adipocyte differentiation

A. When adipocytes fill with lipid, they express the stearoyl-CoA desaturase (*SCD*) gene.

B. The higher the SCD gene expression, the more oleic acid that is produced.

C. The elevated oleic acid may cause muscle satellite cells to convert to marbling adipocytes.

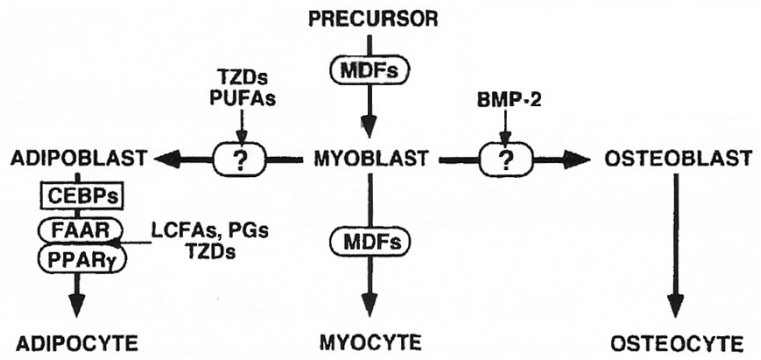


Stearoyl-CoA desaturase (*SCD*) gene expression up-regulates during differentiation.

t10,c12 CLA depresses *SCD* gene expression.

V. *trans*-Differentiation of myoblasts to marbling adipocytes

A. Myoblasts can be changed to adipocytes → *trans*-differentiation



B. Treatment of myoblasts with linoleic acid and a TZD causes them to become rounded and fill will lipid.

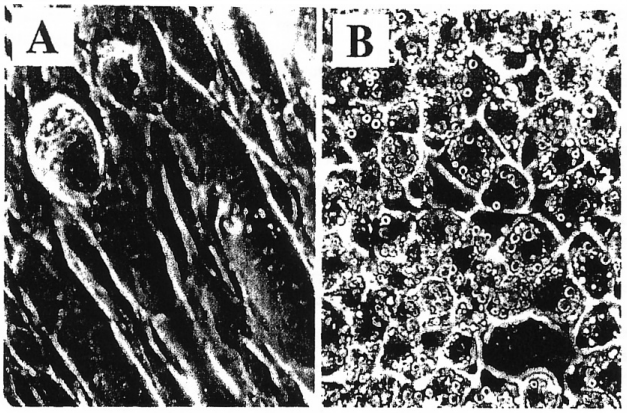
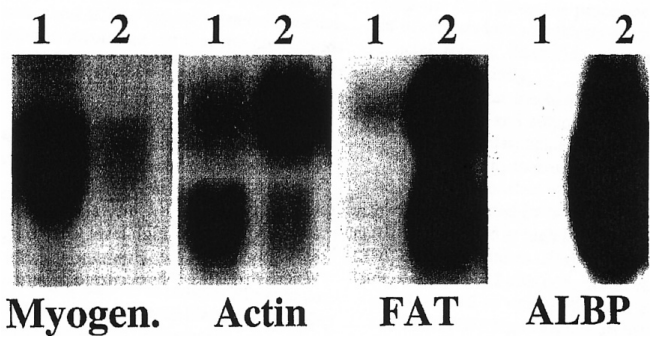


Fig. 1 Conversion of C2C12 myoblasts into adipose-like cells. Cells were maintained to day 5 post-confluence in standard medium without addition (A) or in the presence of 10 μM pioglitazone (B).

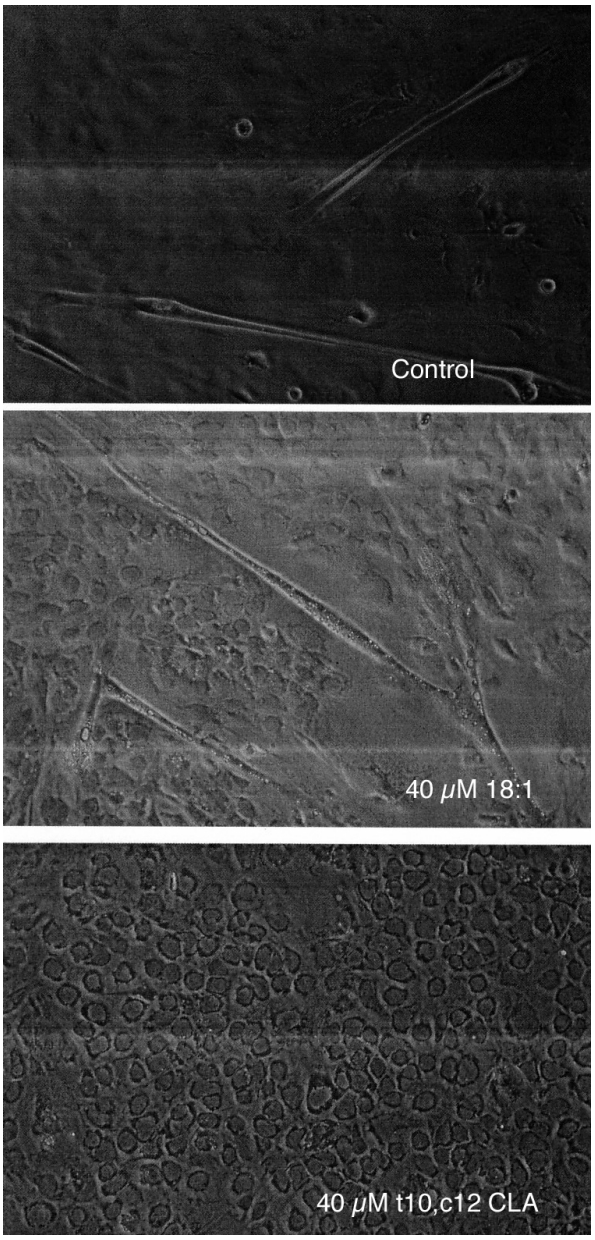
C. The myoblasts express much less muscle-specific genes (mygenenin) and over-expression adipose tissue-specific genes (FAT and ALBP).

D. Do endogenously synthesized fatty acids such as oleic acid promote *tran*-differentitation?



C. Treatment of bovine myoblasts with oleic acid causes conversion to adipocytes.

1. Myoblasts fill with lipid and become rounded.
2. Myogenic gene expression is depressed.



D. In older animals, some satellite cells may convert to marbling adipoctyes

1. This would explain the loss of satellite cells in older animals.
2. This also could be the basis for steatosis (invasion of muscle with fat cells).

E. There truly can be conversion of muscle to fat.

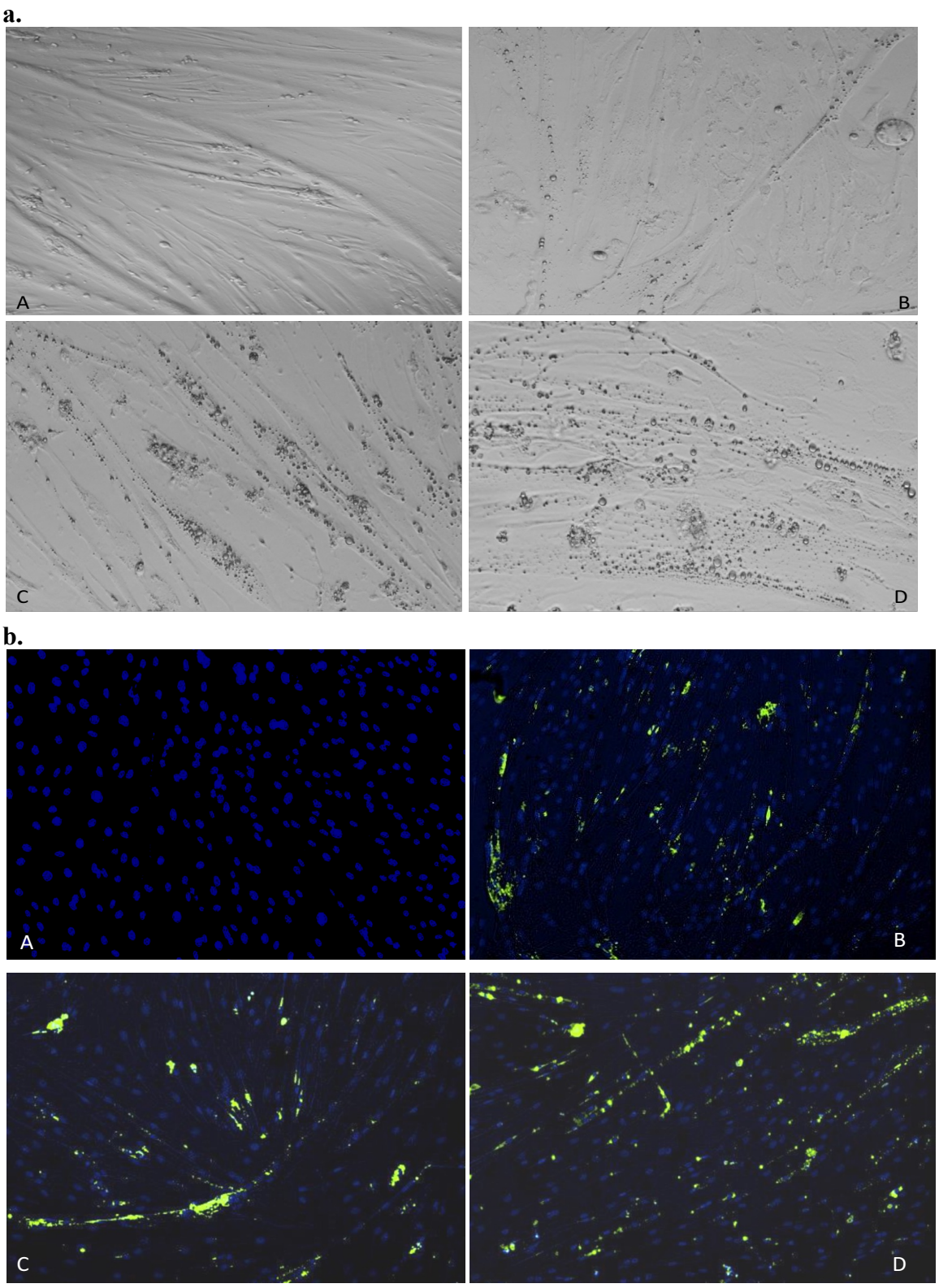


Figure 1. (a) Lipid droplet of BSC was informed during differentiation. (b) Lipid droplet of BSC was visualized using BODIPY 493/503, nuclei was counterstained using 4′, 6-diamidino-2-phenylindole, dihydrochloride (DAPI). A: CON (DMEM + 2% horse serum); B: OA50 (CON + 50 μM oleic acid); C: OA100 (CON + 100 μM oleic acid); D: OA200 (CON + 200 μM oleic acid).