WHY STUDY THE MAMMARY GLAND AND MILK SECRETION?

1. **Greater knowledge allows us to alter environment, nutrition, milking procedures, or general management to maximize production**

WHY STUDY THE MAMMARY GLAND AND MILK SECRETION?

2. **Understanding function aids in the control of some diseases**

- **e.g. mastitis or cancer, or conditions such as edema**

WHY STUDY THE MAMMARY GLAND AND MILK SECRETION?

3. **Mammary tissue is ideal for studying physiological functions of cells or organ systems**
   - **Growth occurs after animal reaches maturity**
     - **Under hormonal control**
     - **Can study function in tissue culture**

WHY STUDY THE MAMMARY GLAND AND MILK SECRETION?

4. **Can study cell differentiation**
    - **i.e. to develop into specialized organs or develop differences in function by alteration or modification**

WHY STUDY THE MAMMARY GLAND AND MILK SECRETION?

5. **Study protective mechanisms and disease process**

WHY STUDY THE MAMMARY GLAND AND MILK SECRETION?

6. **Study process of synthesis and secretion**

- **Mammary gland has high metabolic activity and responds to hormonal and neural stimuli**
  - **Thus it is an ideal "model" system to study mechanisms of biochemical control**

INTRODUCTION TO LACTATIONAL PHYSIOLOGY

- **Class Mammalia - Animals having hair and mammary glands**
- **<u>Mammal</u>**
  - **Comes from Latin *mamma*: breast milk or milk gland.**
  - **Present in male but usually rudimentary and nonfunctional**
  - **> 4200 species**

INTRODUCTION TO PHYSIOLOGY OF LACTATION

a. Importance of Milk
b. Variation in composition and Yield
c. Ontogeny and Phylogeny

INTRODUCTION TO PHYSIOLOGY OF LACTATION

Importance of Milk

(Chapter 1)

IMPORTANCE OF MILK

1. **Provide nourishment for young**
   - **Milk is described as nature's most nearly perfect food**
   - **Rather high caloric value (70-75 kcal/100g), balance of nutrients, easily digested**
     - **Satisfies nutritional needs of the young during early critical period of development**
     - **Provides adequate growth until newborn can consume solid food**

IMPORTANCE OF MILK

2. **Provide protection for neonate against disease**

- **Primarily in the form of immunoglobulins**

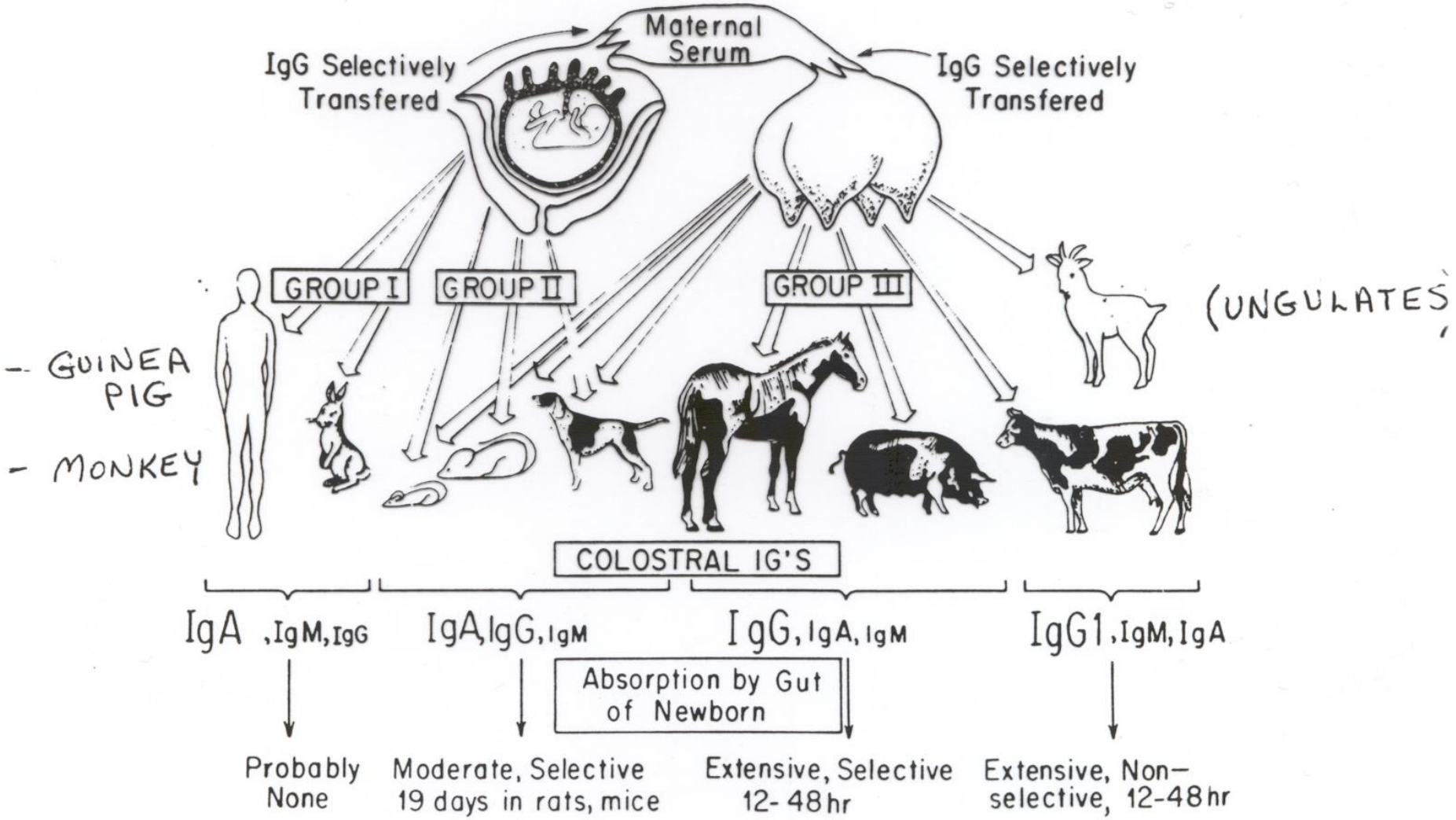
  - **Especially important in <u>ungulates</u> (hoofed animals)**

- ***Maternal Ig is the universal carrier of passive immunity in all species***

Ig TYPES

Antibody Type	Found	Purpose
IgG	All body fluids Universal in passive transfer	Very important in fighting bacterial and viral infections
IgA	Nose, breathing passages, digestive tract, ears, eyes, vagina, saliva, tears, blood	Protect body surfaces that are exposed to outside foreign substances
IgM	Blood and lymph fluid	First type of antibody made in response to an infection; also cause other immune system cells to destroy foreign substances

TRANSFER OF Ig TO FETUS OR NEONATE



IMPORTANCE OF MILK

2. Con't

<u>Groups of mammals by maternal IG transfer</u>

I. Transplacental transfer, no gut absorption

- *human, monkey, guinea pig, rabbit*

- **In humans, colostral protection may be mainly in the gut lumen**

II. Both transplacental transfer and gut absorption

- *rat, mouse, dog*

IMPORTANCE OF MILK

2. Con't.

<u>Groups of mammals by maternal IG transfer</u>

III. No transplacental, all gut absorption

- **critical in ungulates**
- ***cattle, goats, sheep, horses, pigs***

*****Likely that local protection by colostral Ig plays a role in all species***

Concentration and relative percentage of immunoglobulins in the serum and mammary secretions of three representative species.

Species	Immuno-Globulin	% Total Immunoglobulins		
		Serum	Colostrum	Milk
Human	IgG	**78**	2	3
	IgA	16	**90**	**87**
	IgM	6	8	10
Porcine	IgG	**89**	**80**	29
	IgA	7	14	**70**
	IgM	4	6	1
Bovine	IgG_1	50	**81**	73
	IgG_2	**36**	5	2.5
	IgA	2	7	**18**
	IgM	12	7	6.5

Source: Butler 1973

IMPORTANCE OF MILK

3. **Provide human food - dairy cow, goat, sheep, buffalo, etc.**
   - **Man has domesticated certain mammals, selected and bred them for milk production far in excess of that needed to nourish their young**
   - **This is the basis for dairy industry**

WHAT ARE THE MAJOR COMPONENTS OF MILK?

WHAT ARE THE MAJOR COMPONENTS OF MILK?

WHAT ARE THE MAJOR COMPONENTS OF MILK?

CLASSES OF MILK COMPONENTS

1. **Organ and species specific**
   - **e.g. caseins, α-lactalbumin, β-lactoglobulin**
2. **Organ specific, not species specific**
   - **e.g. lactose**
3. **Species specific, not organ specific**
   3. **e.g. serum albumin and immunoglobulins**
4. **Neither organ nor species specific**
   4. **e.g. water, carotenoids, cholesterol, vitamins, salts**

FACTORS AFFECTING MILK COMPOSITION AND YIELD

1. **Species**
   - * **requirements of neonate [growth rate, maintenance req. (environment)]**
   - * **availability of other nutrients (H_2O)**
2. **Breed and individuals within breed**
3. **Stage of lactation**

COMPOSITIONAL VARIATION OF MILK FROM VARIOUS SPECIES

SPECIES	TOTAL SOLIDS	FAT	PROTEIN	LACTOSE	ASH	WATER
Cow	12.6	3.7	3.4	4.8	0.7	**87.4**
Human	12.6	4.5	1.1	6.8	0.2	**87.4**
Zebra & rhino	8.1					**91.9**
Gray seal	**67.7**	**53.3**				32.3
Polar bear		**31.0**				
Whale		**34.8**				
Zebra		0.8	1.1	5.8	0.4	
Human & Chimp			1.0-1.1			
Jackrabbit			**23.7**	1.7	1.5	
Mouse (Minnie)			**13-14.0**			

Milk Composition and Growth Rates of Selected Mammals

Mammal	Milk composition, in %					Time, in days, for the newborn to double its weight
	Protein	Lactose	Fat	Ash	Solids	
Woman	1.6	7.0	3.7	0.2	12.5	180
Mare	2.2	5.9	1.3	0.4	9.8	60
Cow	3.3	5.0	4.0	0.7	13.0	47
Goat	3.7	4.2	4.1	0.8	12.8	19
Sow	4.9	5.3	5.3	0.9	16.4	18
Dog	7.1	3.7	8.3	1.3	20.4	8

Source: J. R. Campbell and J. F. Lasley, *The Science of Animals That Serve Mankind*, McGraw-Hill, New York, 1969, pp. 38, 288.

Composition of Milk From Different Species

Species	Fat %	Protein %	Lactose %	Ash %	Total Solids %
Antelope	13.0	6.9	4.0	1.30	25.2
Ass (donkey)	1.2	1.7	6.9	0.45	10.2
Bear, polar	31.0	10.2	0.5	1.2	42.9
Bison	1.7	4.8	5.7	0.96	13.2
Buffalo, Philippine	10.4	5.9	4.3	0.8	21.5
Camel	4.9	3.7	5.1	0.7	14.4
Cat	10.9	11.1	3.4	--	--

Composition of Milk From Different Species (con't)

Species	Fat %	Protein %	Lactose %	Ash %	Total Solids %
Deer	19.7	10.4	2.6	1.4	34.1
Dog	8.3	9.5	3.7	1.20	20.7
Dolphin	14.1	10.4	5.9	--	--
Elephant	15.1	4.9	3.4	0.76	26.9
Goat	3.5	3.1	4.6	0.79	12.0
Guinea Pig	3.9	8.1	3.0	0.82	15.8
Horse	1.6	2.7	6.1	0.51	11.0

Composition of Milk From Different Species (con't)

Species	Fat %	Protein %	Lactose %	Ash %	Total Solids %
Human	4.5	1.1	6.8	0.20	12.5
Kangaroo	2.1	6.2	Trace	1.20	9.5
Mink	8.0	7.0	6.9	0.7	22.6
Monkey	3.9	2.1	5.9	2.60	14.5
Opossum	6.1	9.2	3.2	1.60	24.5
Pig	8.2	5.8	4.8	0.63	19.9
Rabbit	12.2	10.4	1.8	2.0	26.4

Composition of Milk From Different Species (con't)

Species	Fat %	Protein %	Lactose %	Ash %	Total Solids %
Rat	14.8	11.3	2.9	1.5	31.7
Reindeer	22.5	10.3	2.5	1.40	36.7
Seal, grey	53.2	11.2	2.6	0.70	67.7
Sheep	5.3	5.5	4.6	1.90	16.3
Whale	34.8	13.6	1.8	1.60	51.2

FACTORS AFFECTING MILK COMPOSITION AND YIELD

1. Species
2. Breed and individuals within breed
3. Stage of lactation

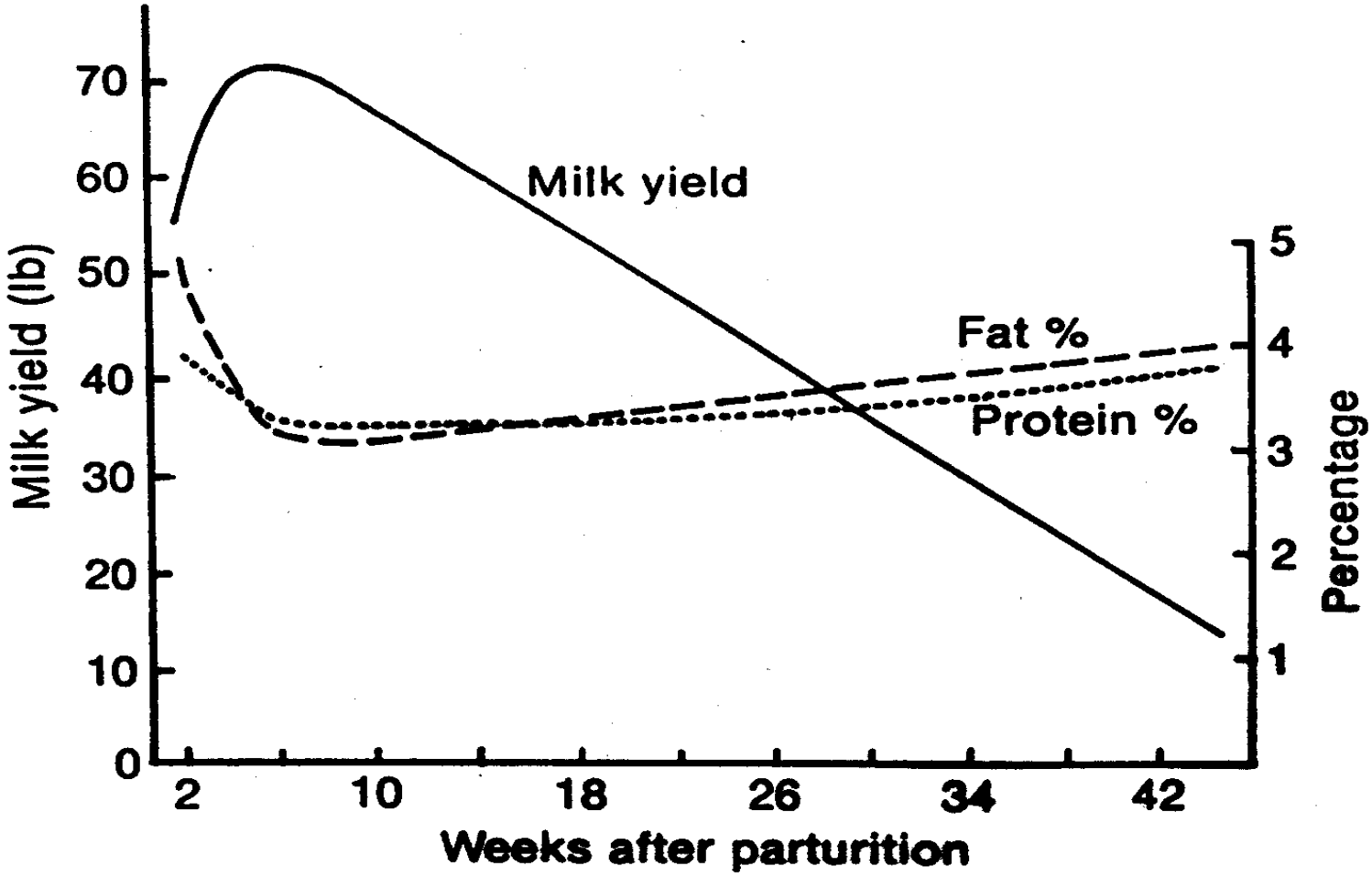
Composition of Milk From Different Breeds

Species	Fat %	Protein %	Lactose %	Ash %	Total Solids %
Cow					
Ayrshire	4.1	3.6	4.7	0.7	13.1
Brown Swiss	4.0	3.6	5.0	0.7	13.3
Guernsey	5.0	3.8	4.9	0.7	14.4
Holstein	3.5	3.1	4.9	0.7	12.2
Jersey	5.5	3.9	4.9	0.7	15.0
Zebu	4.9	3.9	5.1	0.8	14.7

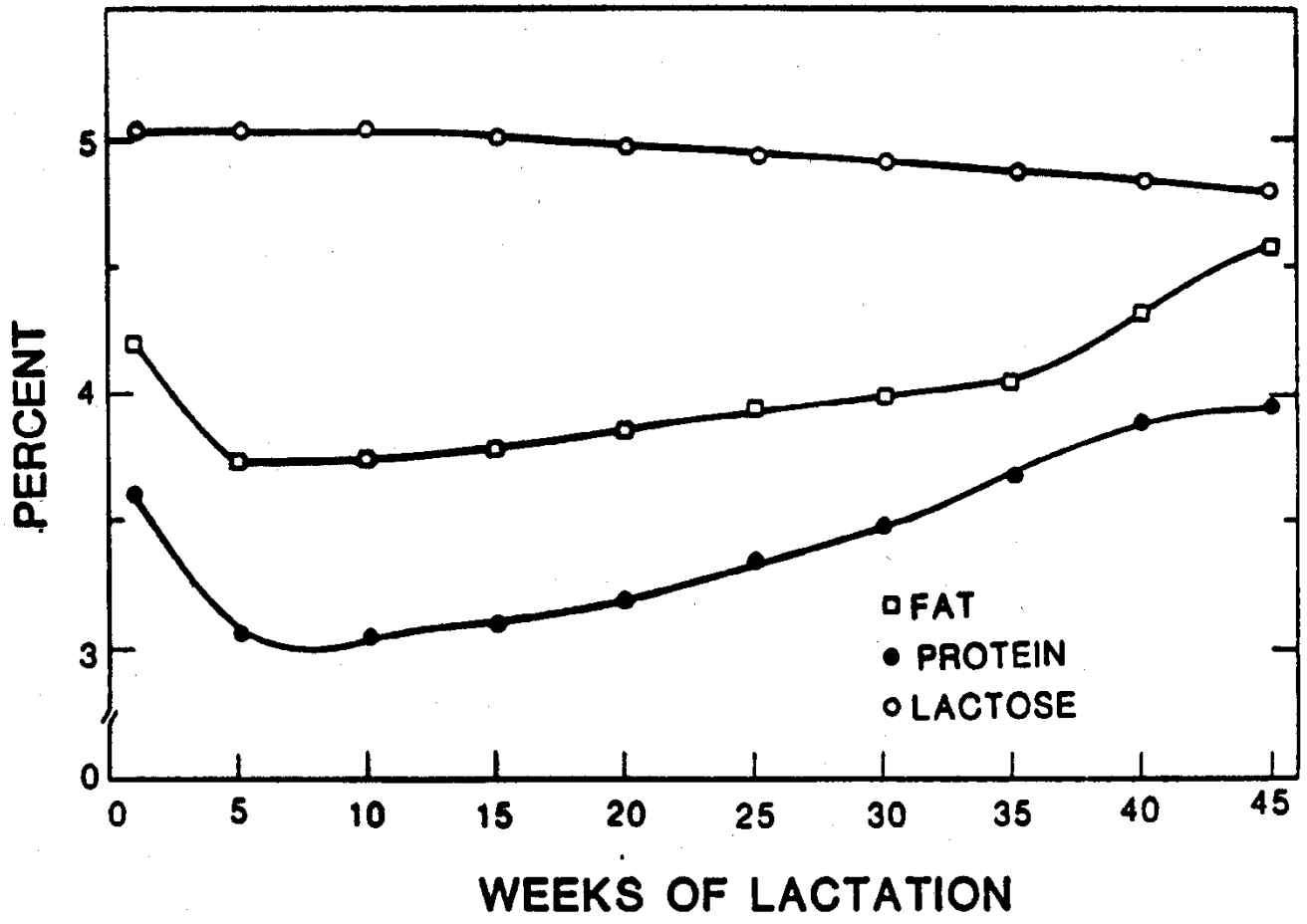
FACTORS AFFECTING MILK COMPOSITION AND YIELD

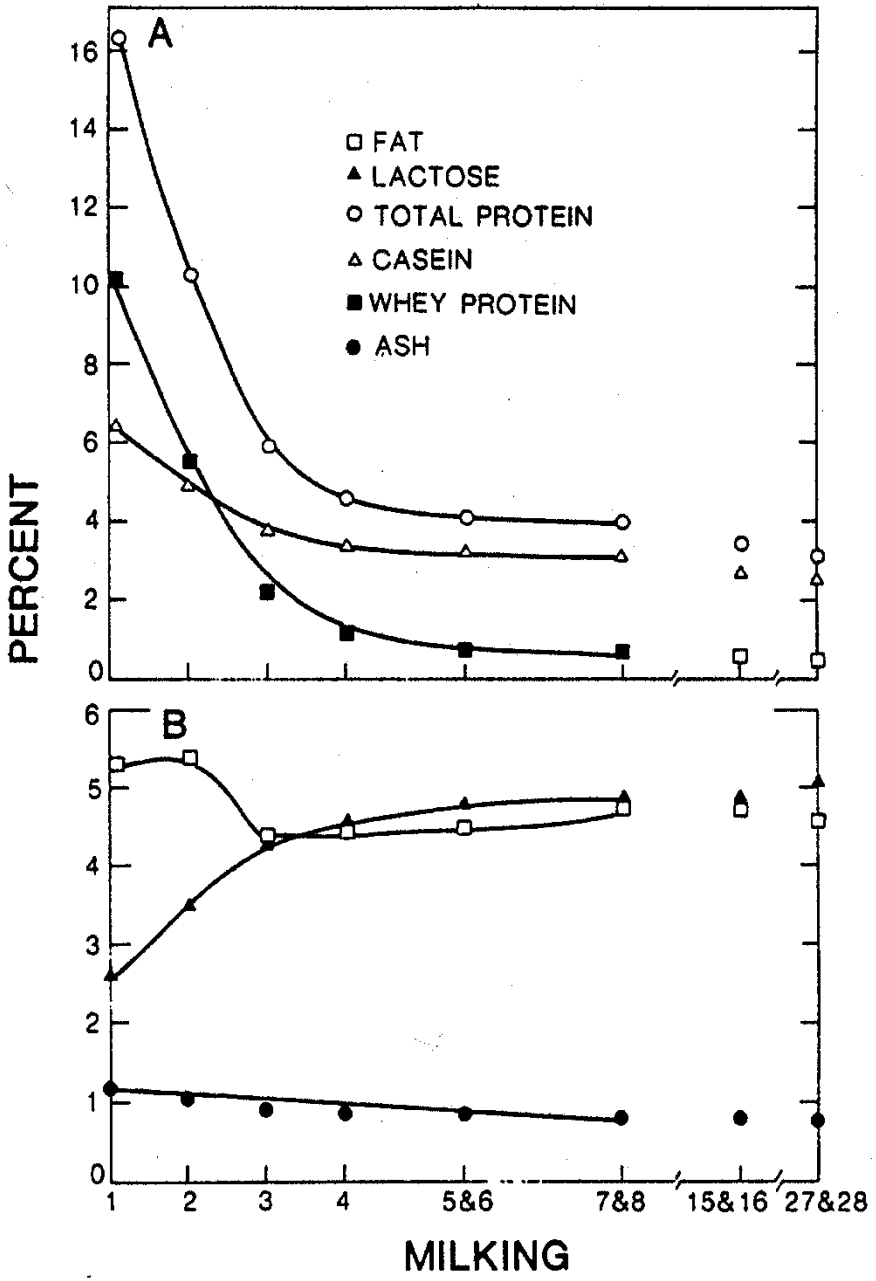
1. Species
2. Breed and individuals within breed
3. Stage of lactation

Lactation Curves of Milk Yield and Milk Fat & Protein Percentages of Holstein Cows



STAGE OF LACTATION EFFECTS ON MILK COMPOSITION





STAGE OF LACTATION EFFECTS ON COMPOSITION

**

EARLY LACTATION

FACTORS AFFECTING MILK COMPOSITION AND YIELD

4. **Milk removal**
    - * **frequency & persistency**
    - * **interval**
    - * **milk fraction**
5. **Nutrition**
6. **Udder health - mastitis**
7. **Environmental**

Relationship Between Rate of Milk Secretion and Milk Pressure Within the Udder

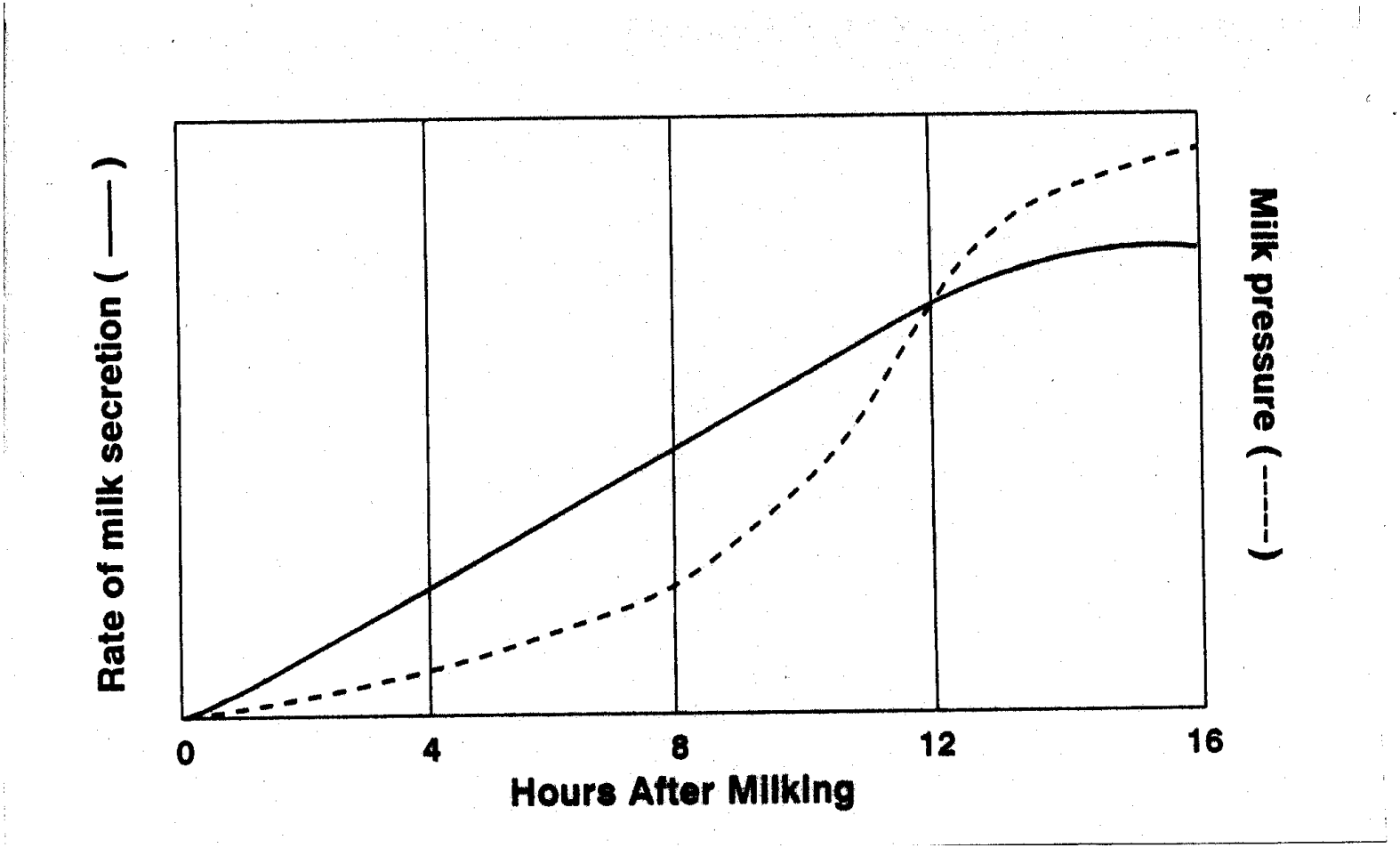
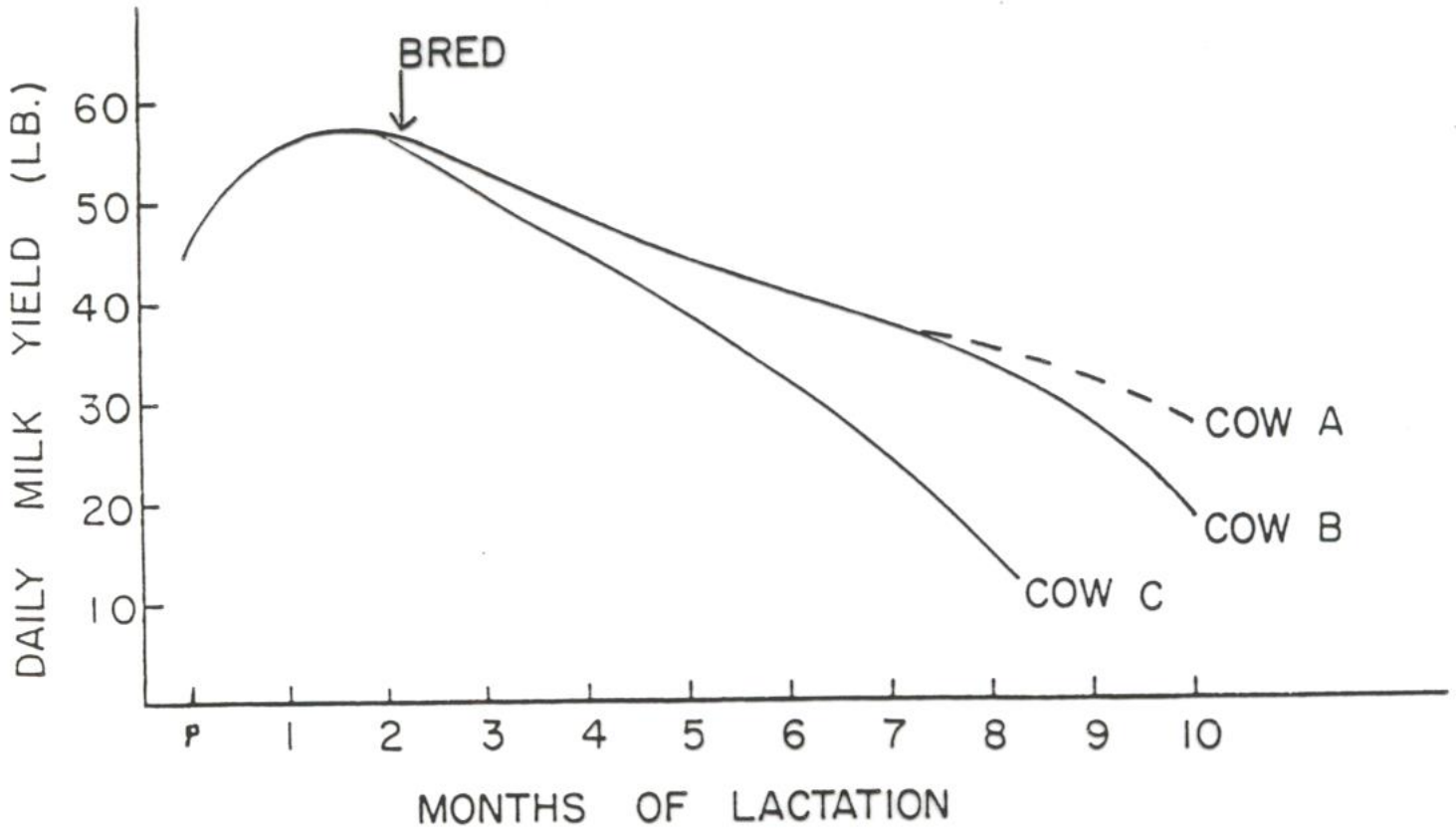
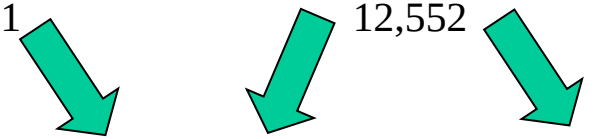


Diagram of the lactation curve of a dairy cow



Effect of Persistency on Lactation Production

Month	Cow A: persistency = 90% Production		Cow B: persistency = 85% Production		Cow C: persistency = 80% Produciton	
	Daily	**Monthly**	**Dialy**	**Monthly**	**Daily**	**Monthly**
1	60.0	1,800	60.0	1,800	60.0	1,800
2	70.0	2,100	70.0	2,100	70.0	2,100
3	63.0	1,890	59.5	1,785	56.0	1,680
4	56.7	1,701	50.6	1,518	44.8	1,344
5	51.0	1,530	43.0	1,290	35.8	1,074
6	45.9	1,377	36.5	1,095	28.6	858
7	41.3	1,239	31.0	930	22.9	687
8	37.2	1,116	26.4	792	18.3	549
9	33.5	1,005	22.4	672	14.6	438
10	30.1	903	19.0	570	11.7	351
10-month total		14,661		12,552		10,881



14.4% Less Milk

13.3% Less Milk

Composition Varies With Fraction

Fraction	Fat	SCC
Foremilk	low (2.0%)	true (150,000)
Composite or bucket	true (3.5%)	true (150,000)
Strippings or residual	hi (7-9%)	hi (450,000) (3-5X higher)

FACTORS AFFECTING MILK COMPOSITION AND YIELD

4. **Milk removal**
5. **Nutrition**
6. **Udder health - mastitis**
7. **Environmental**

FACTORS AFFECTING MILK COMPOSITION AND YIELD

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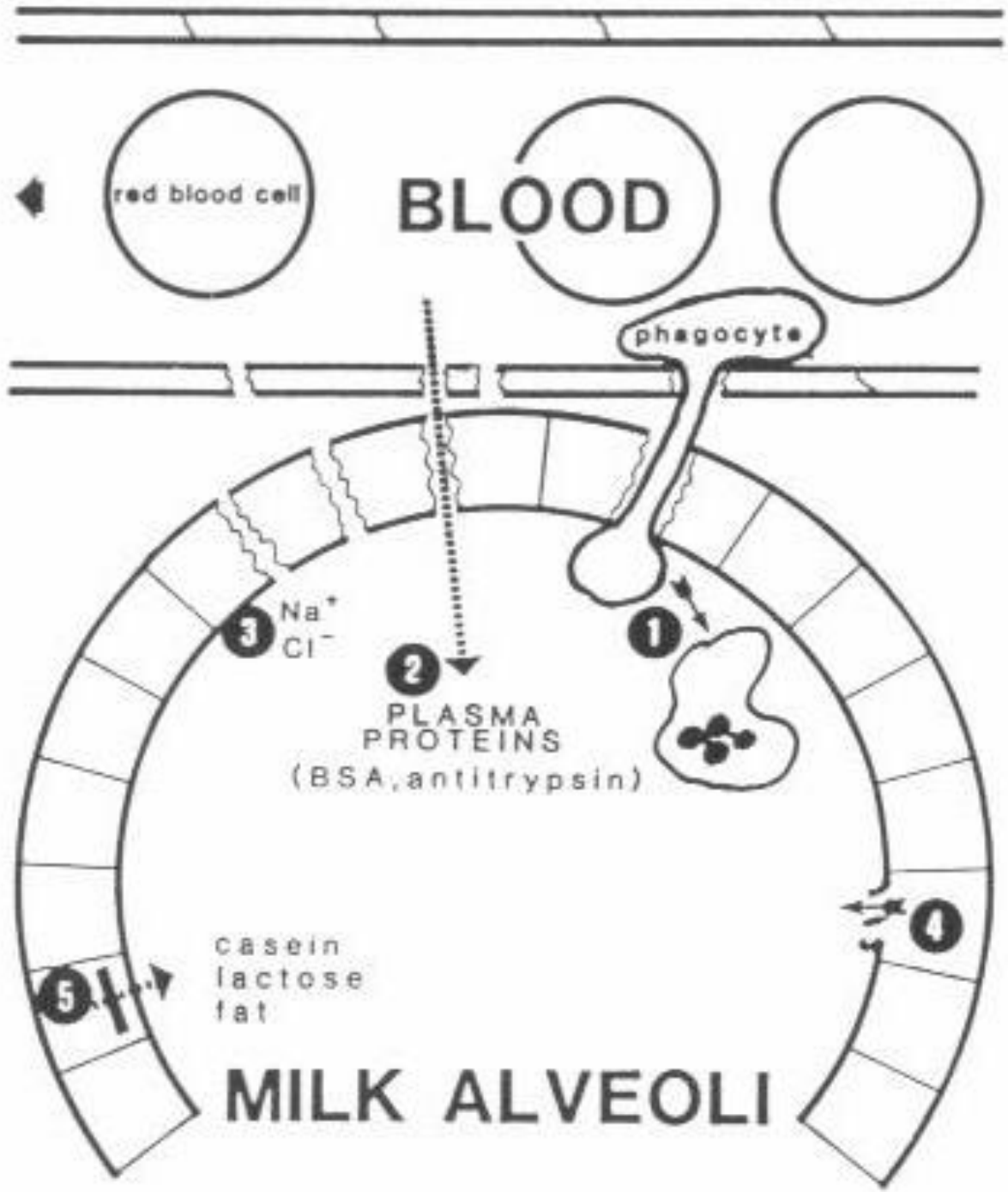


Chemotactic agents: *attract* PMN into tissues & milk!

Altered Composition During Mastitis

↑ Somatic cell counts (SCC)

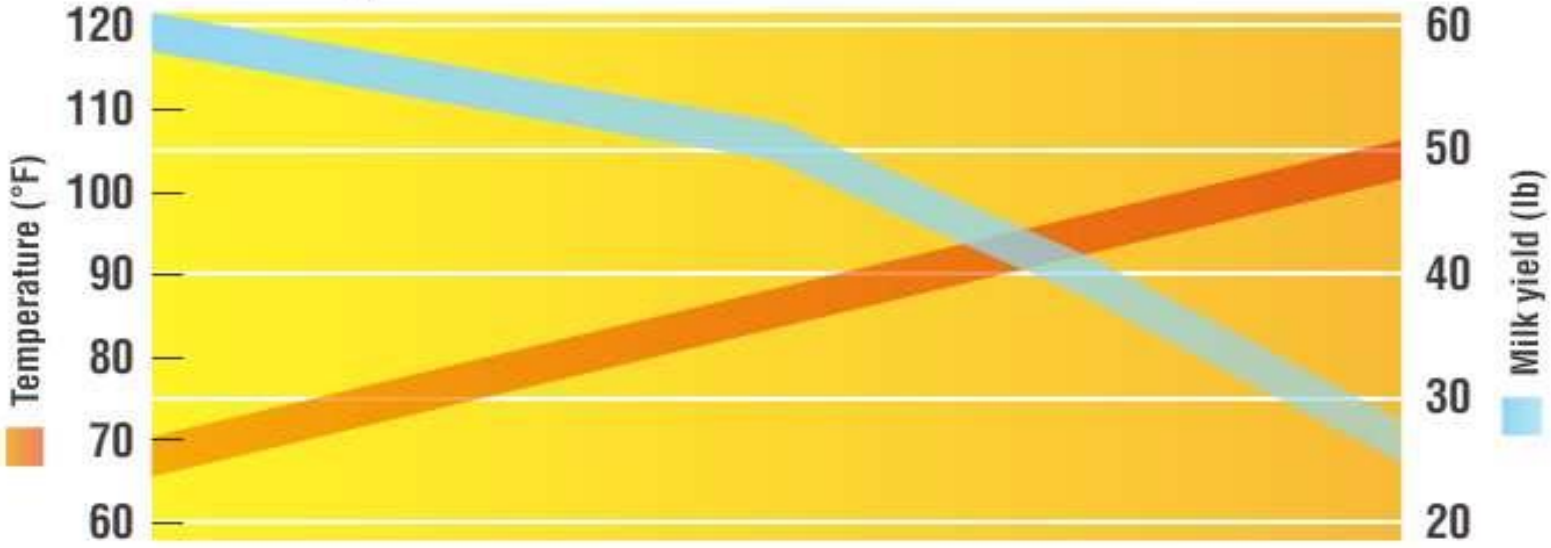
↑ Na, Cl, whey protein (e.g., serum albumin, Ig)

↓ lactose, casein, K, α-lactalbumin

FACTORS AFFECTING MILK COMPOSITION AND YIELD

4. **Milk removal**
    - ∗ **frequency & persistency**
    - ∗ **interval**
    - ∗ **milk fraction**
5. **Nutrition**
6. **Udder health - mastitis**
7. **Environmental**

When heat and humidity rise, milk production falls



ANY QUESTIONS?