DIVISION B · STUDY DECK

2026-2027 Season

Food Science

A complete study guide to the dairy chemistry event — composition, preservation, cooking chemistry, nutrition labeling, and the three hands-on lab tasks — built from the official 2027 Event Rules.

Team Size	Time	Eye Protection	Focus
Up to 2	**~50 minutes**	**Level C**	**Dairy Chemistry**

ABOUT THIS PACK

How to Use This Pack

Pack Contents

Slides move from milk composition and chemistry through preservation and testing, cooking chemistry, nutrition labeling, and end with the three hands-on lab tasks and test-prep review.

Work Through in Order

Chemistry concepts build on each other — composition before preservation, preservation before the lab tasks. Save the Lab Tasks section for once the underlying chemistry is solid.

Rules-First

Every page in this pack is built from Section 2 (Event Parameters) and Section 3 (The Competition) of the official 2027 Food Science B rules — nothing here is carried over from an older event format.

EVENT OVERVIEW

Event Snapshot

Teams study the science behind milk products and experiment with ingredients and variables to produce and analyze the best dairy products they can — ice cream, curds, and butter.

The event has two graded parts every tournament: a pre-tournament **Notebook** of experiments, and a same-day combination of hands-on **Lab Tasks** plus a **written test** on dairy food science.

Team of	**Up to 2 students**
Approximate time	**50 minutes**
Eye protection	**Level C · goggles**
Calculator	**Class III · up to 2**

EVENT PARAMETERS

Materials & Setup

Teams bring

- Writing utensils and up to two Class III calculators
- One 8.5″×11″ reference sheet per participant, both sides, any source, no added annotations — may be laminated or in a sealed sheet protector
- Any items from the Division B Chemistry Events Lab Equipment List (posted on soinc.org)

Required for THIS event

Beyond the general Chemistry equipment list, bring these four items — supervisors will not provide them:

- 1 pint-size plastic bag
- 1 gallon-size plastic bag
- 500–600 mL container with lid
- Cheesecloth, ~30 cm square

Supervisors provide the milk products (125–150 mL depending on the lab), salts, lemon juice, vinegar, ice, thermometers, and other reagents/equipment needed.

EVENT PARAMETERS

Safety Requirements

Goggles & Coverage

Chemical splash goggles (Level C), plus an apron or lab coat, required for the entire event. Skin must be covered neck to wrist and toes.

Hair & Clothing

Shoulder-length or longer hair must be tied back. Pants should be loose-fitting. Gloves are optional unless the host specifies otherwise.

Penalties

Removing safety gear or unsafely handling materials/equipment is penalized — up to and including disqualification.

THE COMPETITION · BEFORE THE TOURNAMENT

The Notebook: Pre-Tournament Experiments

Before the tournament, teams must perform **3 or more experiments** related to **each** of the three Lab Tasks — 9 experiments minimum in total.

Every experiment is recorded on the official **Food Science Experiment Form** and placed together in the Notebook.

Each entry needs exactly **one independent variable**.

The Notebook is impounded before competition begins and returned at the end.

18
points max — up to 2 points per complete experiment. Incomplete experiments score lower. Only the first 3 experiments per task are graded.

Study tip: doing extra experiments beyond the required 3-per-task is encouraged for learning, but does not add extra points.

SCORING

Scoring Formula

Notebook Score
≤ 18
2 pts / complete exp.

+

Lab Task(s) Score
≤ 10 each
1–3 tasks by level

+

Test Score
≤ 50
% correct ÷ 2

−

Penalties
≤ 10%
cleanup failures

Lab Task detail — Ice cream: 0.1 pt per mm of height. Curd Mass & Milk Fat Mass: (Team mass ÷ Supervisor mass) × 10, capped at 10 pts each. High score wins; ties break on preselected Test questions.

SCORING

Scoring Worked Example

Component	Value
Notebook Score	18
Ice cream height: 125 mm × 0.1	12.5
Curd mass score	9.6
Test score: 90% ÷ 2	45.0
Penalties	0

Final Score

85.1

18 + 12.5 + 9.6 + 45.0 − 0

This is a Regional/Invitational example with 1 lab task. At State (1–2 tasks) and Nationals (2–3 tasks), add each additional task's score the same way.

Section One

Milk Composition & Chemistry

Lipids, carbohydrates, proteins, vitamins and minerals — the building blocks tested on every written exam.

MILK COMPOSITION

What's In Milk?

Whole cow's milk is roughly 87% water by mass. The rest — the milk solids — carry almost all of the chemistry tested in this event.



Approximate mass composition of whole cow's milk · minerals/ash and trace vitamins make up the final ~1.3%

Carbohydrate
Lactose — milk's primary sugar, a disaccharide

Lipid
Milkfat — carries fat-soluble vitamins A, D, E, K

Protein
Casein (~80%) and whey (~20%)

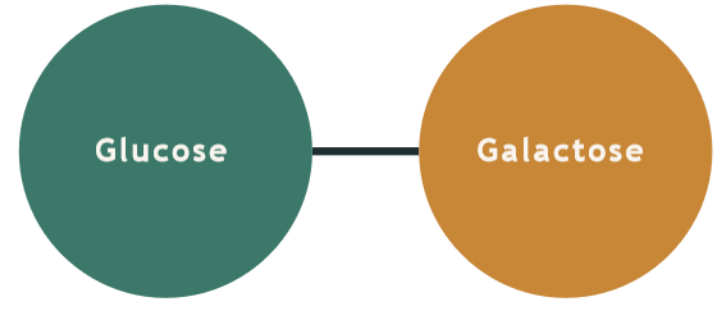
Minerals
Calcium, phosphorus, potassium and more

MILK COMPOSITION

Milk Carbohydrates: Lactose

Lactose is a **disaccharide** — one glucose unit joined to one galactose unit. It is the primary sugar found naturally in cow's milk.

Lactose is a **reducing sugar**: it has a free aldehyde/ketone group that can react in tests like Benedict's test. Sucrose (table sugar), by contrast, is non-reducing.



Lactose = Glucose + Galactose (β-1,4 glycosidic bond)

Monosaccharides
Glucose, fructose, galactose — single sugar units

Disaccharides
Lactose, sucrose, maltose — two joined units

Polysaccharides
Starch, cellulose — long sugar chains

MILK COMPOSITION

Lactose Intolerance vs. Milk Allergy

A very common exam distinction — these are different mechanisms entirely, and the test will expect you to tell them apart.

LACTOSE INTOLERANCE

A digestive shortage

The body lacks enough **lactase**, the enzyme that splits lactose into glucose and galactose. Undigested lactose ferments in the gut, causing bloating and discomfort.

Not immune-related. Often managed with lactase supplements or lactose-free products.

MILK PROTEIN ALLERGY

An immune response

The immune system reacts to milk **proteins** — typically casein or whey — as if they were a threat. This can trigger a broader, potentially serious reaction.

One of the nine major food allergens requiring label disclosure.

MILK COMPOSITION

Milk Proteins: Casein & Whey

Milk protein is built from long chains of amino acids and falls into two classes with very different behavior — the key to both the Curd Mass and Milk Fat lab tasks.

80%
of milk protein is Casein

Casein

Exists as **micelles** suspended in milk. Unstable at low pH — when acid (vinegar or lemon juice) is added, casein coagulates and precipitates out as **curds**. This is exactly what happens in the Curd Mass lab task.

20%
of milk protein is Whey

Whey

Stays dissolved in the liquid left behind after curds form. Whey proteins are heat-sensitive: when milk is heated, whey proteins **unfold and lose their 3-D structure** — denaturation.

MILK COMPOSITION

Milk Fats: Saturated & Unsaturated

Saturated Fatty Acids

Carbon chain has **no double bonds** — packs tightly, so it's **solid at room temperature**. Butterfat is largely saturated fat.



Straight chain — molecules stack closely

Unsaturated Fatty Acids

Contains **one or more double bonds**, creating a kink. Molecules can't pack tightly, so it's typically **liquid at room temperature**.

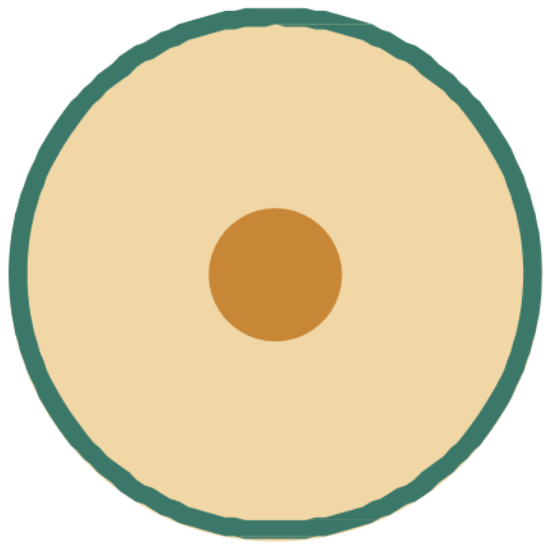


Kinked chain — molecules pack loosely

Also test topics: essential fatty acids the body can't synthesize, and **oxidative rancidity** — unsaturated fats reacting with oxygen to create off-flavors.

MILK COMPOSITION

The Milk Fat Globule & Emulsification



Milkfat globule: triglyceride core (gold) wrapped in the Milk Fat Globule Membrane (teal ring)

Each fat droplet in milk is coated by the **Milk Fat Globule Membrane (MFGM)**, made largely of **phospholipids** and proteins.

Phospholipids are unique: they have a **hydrophilic head** and a **hydrophobic tail**, letting them sit right at the fat–water interface.

This is **emulsification** — stabilizing fat droplets so they stay suspended in water instead of separating. Churning cream disrupts this membrane, letting fat globules coalesce into butter.

MILK COMPOSITION

Vitamins, Minerals & RDA

Dairy is one of the best dietary sources of several essential nutrients. Know the consequence of a deficiency for each — that's how short-answer questions test this topic.

Nutrient	Type	Why it matters / deficiency risk
Calcium	Mineral	Bone & teeth strength; deficiency risks weakened bones (osteoporosis)
Vitamin D	Fat-soluble vitamin	Needed to absorb calcium; dairy is often fortified with it
Phosphorus	Mineral	Works with calcium for bone structure
Potassium	Mineral	Fluid balance, nerve and muscle function
Vitamin A	Fat-soluble vitamin	Vision and immune function; carried by milkfat
Riboflavin (B2)	Water-soluble vitamin	Energy metabolism; milk is a major dietary source

Esterification & Fat Bonding

Esterification

A **glycerol** molecule bonds with **three fatty acid** chains, releasing water, to form a **triglyceride** — the storage form of milkfat.

Glycerol + 3 Fatty Acids → Triglyceride + Water

Why It's Tested

Ester bonds are exactly the bonds broken and formed as fat is churned into butter, whipped, or heated. This is the chemistry link between "fat" as a nutrient and "fat" as a triglyceride molecule.

Quick Definitions

Ester bond: linkage between an acid and alcohol group, releasing water.

Triglyceride: three fatty acids esterified to one glycerol backbone.

MILK COMPOSITION

How Cooking Changes Dairy

Denaturation

Heat unfolds whey proteins from their 3-D shape. This is why heated milk can form a skin and why whey-based sauces thicken.

Acid Coagulation

Adding acid lowers pH and destabilizes casein micelles, causing them to clump into curds — the basis of the Curd Mass lab task.

Freezing Point Depression

Dissolved sugar and salt lower milk's freezing point. Ice-and-salt mixtures reach temperatures below 0°C, which actually freezes the ice cream mixture.

Churning

Agitation breaks down the fat globule membrane in cream, letting fat globules coalesce and separate from the liquid (buttermilk) as butter.

Section Two

Processing, Preservation & Labeling

How dairy foods are kept safe, modified for different diets, and labeled for the consumer.

PROCESSING & PRESERVATION

Preserving Dairy Foods

The Notebook and written test both expect you to name and describe preservation methods — know at least two well enough to explain in a short-answer response.

Pasteurization

Brief heat treatment that kills pathogenic bacteria without fully cooking the milk. Extends shelf life while preserving most nutrients and flavor.

Refrigeration & Freezing

Slows microbial growth and enzymatic spoilage by lowering temperature; freezing halts it almost entirely but can alter texture on thawing.

Drying & Concentration

Removing water (powdered milk, evaporated/condensed milk) limits the moisture microbes need to grow, extending shelf life dramatically.

PROCESSING & PRESERVATION

Non-Dairy →Milk→ Alternatives

Plant-based beverages marketed as "milk" — almond, soy, oat, and others — are chemically very different from cow's milk and a common exam comparison point.

Product	Base	Key chemistry note
Almond milk	Ground almonds + water	Naturally lactose-free; low in protein vs. dairy
Soy milk	Soybeans + water	Closest protein content to dairy milk among plant milks
Oat milk	Oats + water	Higher in carbohydrates; often needs added emulsifiers
Coconut milk	Coconut flesh + water	High in saturated fat, but plant-derived (no cholesterol)

All plant "milks" are naturally lactose-free (lactose is dairy-specific) — but not automatically allergen-free: soy and tree nuts are allergens in their own right.

PROCESSING & PRESERVATION

Low-Fat, Fat-Free & Lactose-Free Milk

Low-Fat / Fat-Free

Made by mechanically skimming milkfat from whole milk. Removing fat also removes fat-soluble vitamins (A, D, E, K) unless the product is fortified to replace them.

Lactose-Free Milk

Regular dairy milk treated with the enzyme **lactase**, which pre-splits lactose into glucose and galactose — easier to digest, and noticeably sweeter-tasting as a result.

Both are still dairy milk chemically — they still contain casein/whey and lactose (unless treated). They are NOT the same as the plant-based alternatives on the previous page.

PROCESSING & PRESERVATION

Probiotics in Dairy

Probiotics are **live beneficial bacteria** — commonly *Lactobacillus* and *Bifidobacterium* strains — found in fermented dairy foods like yogurt and kefir.

These bacteria ferment lactose into **lactic acid**, which lowers pH, thickens the product, and gives fermented dairy its characteristic tangy flavor.

Lactose → Lactic Acid (fermentation)

Lower pH → protein coagulation & thickening

Some fermented dairy is naturally lower in lactose

PROCESSING & PRESERVATION

Organic Dairy Products

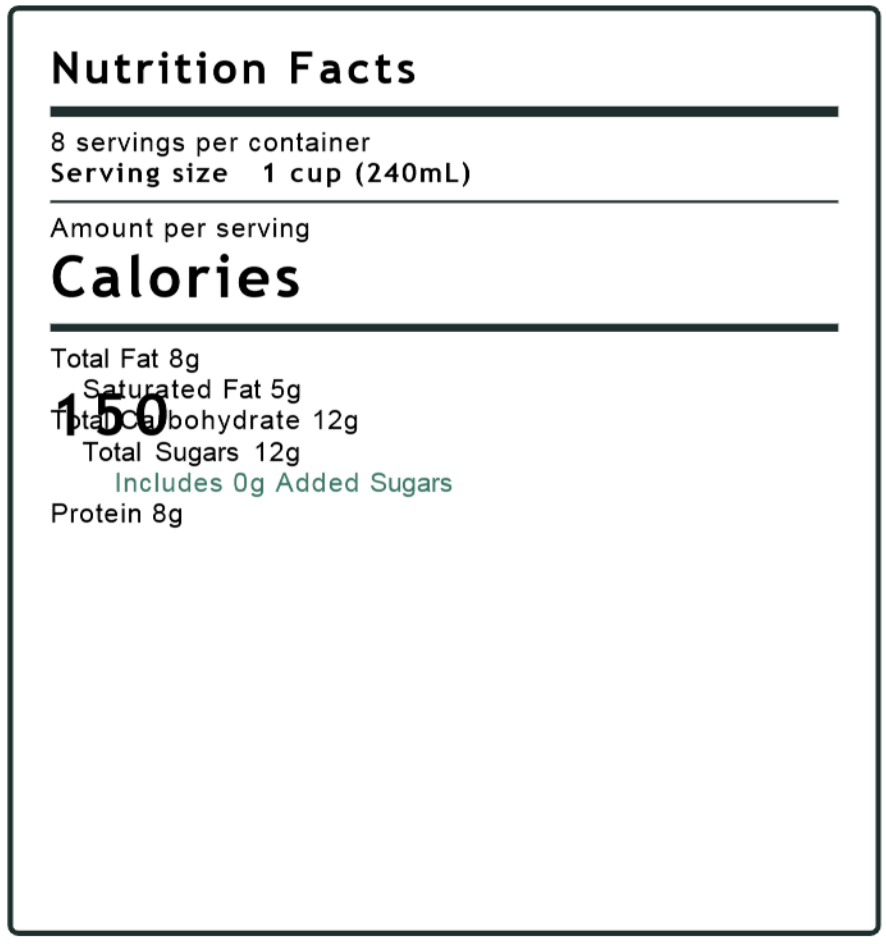
What "Organic" Means

Cows are fed organic (non-GMO, no synthetic pesticide/fertilizer) feed and raised without synthetic hormones or routine antibiotics, following USDA organic standards.

What It Doesn't Change

Organic milk has the **same basic chemistry** as conventional milk — same lactose, casein/whey, and fat structure. "Organic" is a farming-practice label, not a different macronutrient profile.

Reading the Nutrition Facts Label



- Nutrition Facts labels are **required**, not optional, on packaged dairy products sold in the U.S.
- Milk's 12g of sugar per cup is naturally-occurring **lactose** — the "Added Sugars" line should read 0g on plain milk.
- The agency responsible for regulating packaged food labeling is the **FDA**, not the USDA (which covers meat/poultry/eggs).

PROCESSING & PRESERVATION

Allergens: The Big Nine

The FASTER Act requires U.S. food labels to disclose nine major allergens. Milk is one of them — know all nine.

Milk	Eggs	Fish
Shellfish	Tree Nuts	Peanuts
Wheat	Soybeans	**Sesame***

*Sesame: the 9th allergen, added 2023

Section Three

The Lab Tasks

Three hands-on tasks — Ice Cream Formation, Determine Curd Mass, and Determine Milk Fat Mass from Cream.

THE LAB TASKS

Lab Tasks Overview

All three tasks use the same unknown milk product the Supervisor provides. The number of tasks run depends on tournament level.

01

Ice Cream Formation

Freeze a milk/cream mixture with an ice-and-salt bath; scored by height of the self-standing scoop.

02

Determine Curd Mass

Coagulate milk proteins with acid, drain through cheesecloth, and weigh the resulting curds.

03

Milk Fat from Cream

Churn cream to separate butterfat, drain the buttermilk, and weigh the butter formed.

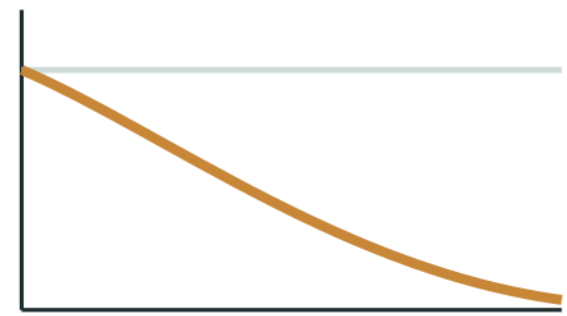
LAB TASK 1

Ice Cream: The Science

Plain water freezes at 0°C. Adding **salt to ice** lowers the freezing point of the ice bath well below 0°C — a colligative property called **freezing point depression**.

That colder-than-0°C brine can pull heat out of the milk/cream/sugar mixture fast enough to freeze it solid, forming ice cream.

Constant shaking keeps ice crystals small, giving ice cream its smooth texture instead of one solid ice block.



Plain ice (~0°C, top line)
Ice + salt (well below 0°C, falling curve)

LAB TASK 1

Ice Cream: Procedure & Scoring

Step 1
Combine up to 125 mL milk/cream/half-and-half with up to 15 mL sugar, up to 1.2 mL vanilla (optional)

Step 2
Fill a 1-gallon bag half-full with ice, add up to 90 mL salt, seal and shake to mix

Step 3
Place the mixture in a 1-pint bag, seal it

Step 4
Nest the small bag in the large bag; shake vigorously to cool and mix

Step 5
After 5–10 minutes, remove the ice cream from the small bag; hand-shape it

0.1 points per mm of height (rounded) — must self-stand for 5 seconds before it's measured

No cap on ingredient amounts up to the maximums listed — teams may use less.

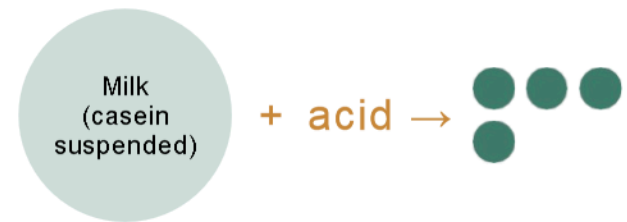
LAB TASK 2

Curd Mass: The Science

Casein proteins normally float as stable **micelles** in milk, kept apart by a slight negative charge and neutral-ish pH.

Adding an **acid** (vinegar or lemon juice) lowers the pH toward casein's isoelectric point. Casein loses its charge and can no longer repel itself — the micelles clump together and precipitate as **curds**.

Whey proteins stay dissolved and drain away in the whey, leaving curds on the cheesecloth.



Casein micelles clump together (curds) as pH drops

LAB TASK 2

Curd Mass: Procedure & Scoring

Step 1
Measure 120 mL of milk into a beaker and weigh it

Step 2
Milk temperature should be close to room temperature

Step 3
Add drops of vinegar or lemon juice, swirl 30 sec, let sit ~5 minutes

Step 4
Drain through cheesecloth over a beaker, collecting the curds

Step 5
Let drain 15 minutes, then determine the mass of the curds

Team mass ÷ Supervisor mass × 10

Example: Team gets 2.4g, Supervisor gets 2.5g → 0.96 × 10 = 9.6 pts. Max 10 pts.

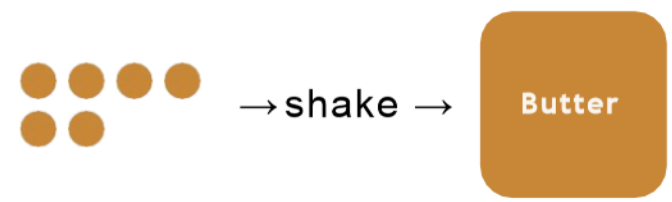
LAB TASK 3

Milk Fat from Cream: The Science

Cream is an **emulsion** — fat globules stabilized in water by the Milk Fat Globule Membrane.

Vigorous **agitation (churning)** physically damages that membrane. Once disrupted, fat globules are free to collide and **coalesce** into larger and larger fat clumps.

Eventually the fat separates completely from the liquid — the fat clumps become **butter**, and the leftover liquid is **buttermilk**.



Dispersed fat globules coalesce into a single solid mass once the membrane is disrupted

LAB TASK 3

Milk Fat from Cream: Procedure & Scoring

Step 1
Transfer 150 mL heavy cream into a 500–600 mL container and weigh it

Step 2
Cream temperature should be approximately 13°C

Step 3
Cap carefully and shake until a distinct separation of butter particles occurs

Step 4
Drain off the liquid (buttermilk) and discard it

Step 5
Determine the mass of the butter

Team mass ÷ Supervisor mass × 10 Same formula as Curd Mass scoring. Max 10 pts.

THE LAB TASKS

Tasks by Tournament Level

You won't know in advance which task(s) the Supervisor selects — be ready for any of the three at every level.

Regional / Invitational	State	Nationals
1	1 - 2	2 - 3
lab task	lab tasks	lab tasks

The written test time is shared with lab task time within the ~50-minute event — more tasks means less time free for the test, so practice for speed.

Section Four

Test Prep & Strategy

Topic map, glossary, and where teams typically lose points.

TEST PREP

Written Test: Topic Map

The rules state this test covers **ONLY** dairy food science topics — the same list at every tournament level.

Macronutrients
Lipids, carbs & proteins in dairy

Labeling
Standard nutrition labeling regulations

Reactions
Esterification, fat bonding

Fat Chemistry
Saturated vs. unsaturated fats

Sugars
Chemical structure of sugars/ starches

Essentials
Essential fats, vitamins, proteins

Cooking Chemistry
How cooking changes dairy foods

Allergens
Allergens in dairy foods

Preservation
Dairy food preservation methods

RDA
Essential minerals/vitamins & deficiency effects

Special Milks
Freezing pt. depression, non-dairy, lactose-free

Health & Biology
Lactose intolerance, emulsification, pasteurization, probiotics, casein/ whey

TEST PREP

Key Terms I

Casein
The majority (~80%) milk protein; coagulates when acidified, forming curds.

Whey
The remaining ~20% of milk protein; stays dissolved after curds form.

Lactose
Milk's disaccharide sugar (glucose + galactose); a reducing sugar.

Pasteurization
Brief heat treatment that kills pathogens without fully cooking the milk.

Emulsification
Stabilizing fat droplets in water using a membrane or emulsifier.

Esterification
Glycerol + 3 fatty acids → triglyceride + water.

Denaturation
Heat-driven unfolding of a protein's 3-D structure (e.g., whey when heated).

Freezing Point Depression
Dissolved solute (salt in ice, sugar in milk) lowers the freezing point.

TEST PREP

Key Terms II

Milk Fat Globule Membrane

Phospholipid/protein layer coating each fat droplet, keeping it suspended.

Coalescence

Fat globules merging into larger clumps once their membrane is disrupted.

Saturated Fat

No C=C double bonds; packs tightly; solid at room temperature.

Unsaturated Fat

Has C=C double bond(s), creating a kink; liquid at room temperature.

Rancidity (Oxidative)

Unsaturated fats reacting with oxygen, producing off-flavors.

Probiotics

Live beneficial bacteria in fermented dairy (yogurt, kefir).

Lactose Intolerance

Insufficient lactase enzyme; a digestive issue, not an immune response.

Milk Protein Allergy

Immune reaction to casein or whey; distinct from lactose intolerance.

TEST PREP

Where Points Slip

Missing required items

Forgetting the pint bag, gallon bag, 500–600 mL container, or cheesecloth. None are provided by the Supervisor.

Incomplete Notebook entries

Fewer than 3 recorded experiments per task, or more than one independent variable per entry.

Cleanup penalties

Up to 10% of the total possible score can be lost for failing to clean up as instructed — build cleanup into your practice runs.

Confusing intolerance & allergy

A frequent written-test trap. Intolerance = enzyme shortage; allergy = immune response to a protein.

Wrap-Up

You're Ready

- Know casein vs. whey cold — it drives both the Curd Mass task and half the written test.
- Log 3+ experiments per task in the Notebook well before impound — it's worth up to 18 points.
- Practice all three lab tasks for real, not just read about them — precision and timing are graded.
- Separate lactose intolerance from milk allergy, and don't confuse "organic" with a chemistry difference.

Food Science rewards teams who treat the kitchen like a lab — good luck!

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
Regional Exam

Team Name: _____ Team Number: _____

- This exam contains 30 questions: 21 multiple choice, 4 multiselect (select ALL correct answers), and 5 short answer.
- Five questions (Q4, Q6, Q17, Q28, Q29) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules. Content specific to State or National level events is not included.
- Total Time: 50 minutes (shared with lab tasks per event rules). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which macronutrient in milk is primarily responsible for supplying concentrated energy and carrying fat-soluble vitamins such as A and D?

A. Carbohydrates
B. Lipids (fats)
C. Minerals
D. Water

2. What is the primary carbohydrate found naturally in cow's milk?

A. Sucrose
B. Fructose
C. Lactose
D. Maltose

3. Which of the following correctly identifies the two main classes of protein found in milk?

A. Collagen and elastin
B. Casein and whey
C. Gluten and gliadin
D. Myosin and actin

4. Refer to Image 1 (an example U.S. Nutrition Facts label). Based on federal labeling regulations, which statement about the label is TRUE?

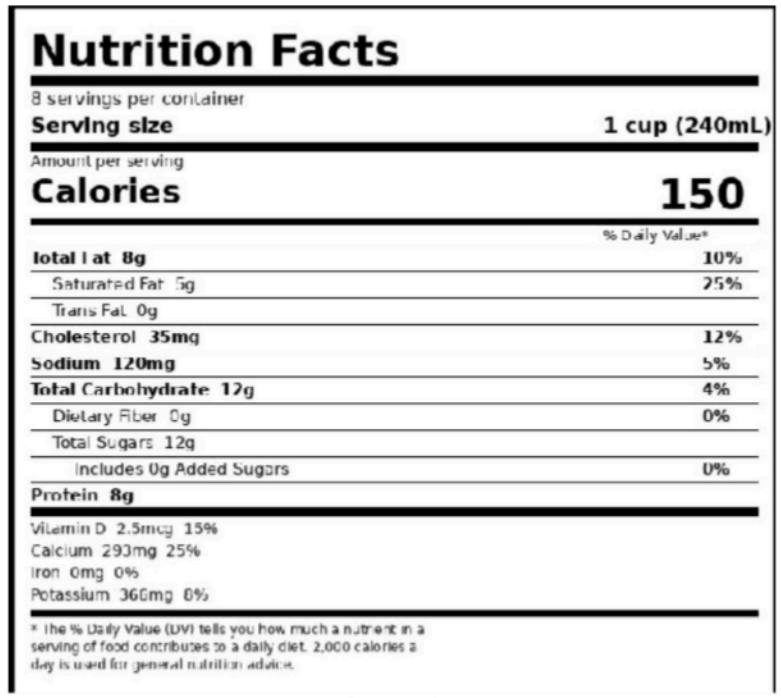


Image 1

A. Manufacturers may choose which nutrients to include on the label.

B. The label must list serving size, calories, and specific required nutrients in a standardized format.

C. Nutrition Facts labels are optional for packaged dairy products sold in the U.S.

D. The % Daily Value listed is always based on a 1,000-calorie diet.

5. Which U.S. federal agency is primarily responsible for regulating the labeling of most packaged dairy foods, including the Nutrition Facts panel?

A. Environmental Protection Agency (EPA)
B. Food and Drug Administration (FDA)
C. Department of Energy (DOE)
D. Federal Trade Commission (acting alone)

6. Refer to Image 2 (the general structural formula of a triglyceride). The bonds joining the glycerol backbone to the fatty acid chains are formed through which type of organic reaction?

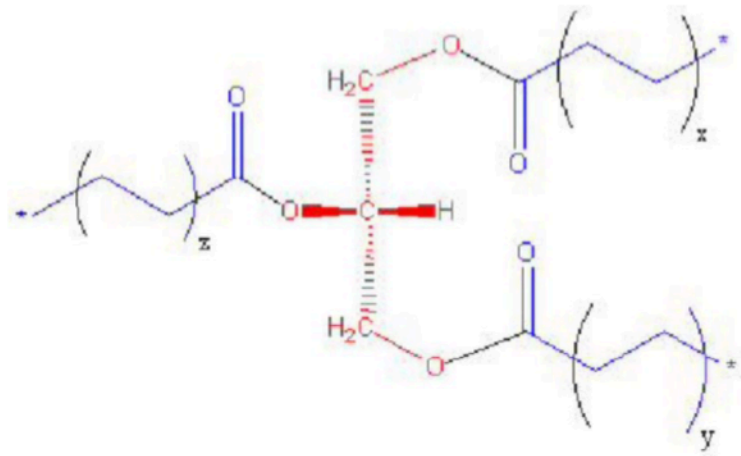


Image 2

A. Hydrolysis
B. Esterification
C. Saponification
D. Fermentation

7. Select ALL statements that correctly describe saturated and unsaturated fats. (Select ALL that apply.)

A. Saturated fats contain no carbon-carbon double bonds.
B. Unsaturated fats are typically liquid at room temperature.
C. Saturated fats are typically liquid at room temperature.
D. Unsaturated fatty acid chains contain one or more carbon-carbon double bonds.
E. Butterfat is composed entirely of unsaturated fat.

8. Lactose is a disaccharide made up of which two monosaccharides?

A. Glucose and fructose
B. Glucose and galactose
C. Fructose and galactose
D. Two glucose molecules

9. Starches are polysaccharides made of long, branched or unbranched chains of which monosaccharide?

A. Fructose
B. Galactose
C. Glucose
D. Ribose

10. Proteins such as casein and whey are built from long chains of which building block, linked together by peptide bonds?

A. Fatty acids
B. Amino acids
C. Nucleotides
D. Monosaccharides

11. Select ALL nutrients that are naturally found in significant amounts in cow's milk and are considered essential to the human diet. (Select ALL that apply.)

A. Vitamin A
B. Vitamin D
C. Vitamin C
D. Calcium
E. Complete (high-quality) protein

12. When milk is heated during cooking, whey proteins unfold and lose their original three-dimensional shape. This process is called:

A. Hydrolysis
B. Denaturation
C. Esterification
D. Fermentation

13. A true milk protein allergy is different from lactose intolerance because an allergy involves:

A. An inability to digest the sugar lactose
B. An immune system response to milk proteins such as casein or whey
C. A build-up of lactic acid in the muscles
D. A deficiency of vitamin D

14. Name and briefly describe TWO different methods used to preserve dairy foods and extend their shelf life.

15. Dairy foods are one of the best dietary sources of which essential mineral, needed for strong bones and teeth?

A. Iron
B. Calcium
C. Potassium
D. Sodium

16. Describe ONE health consequence that can result from a long-term deficiency of Vitamin D, and explain why dairy products are often fortified with this vitamin.

17. Refer to Image 3, a graph plotting the freezing point of a saltwater solution against salt (NaCl) concentration. Based on the trend shown, adding rock salt to the ice bath during a hands-on ice cream-making activity will:

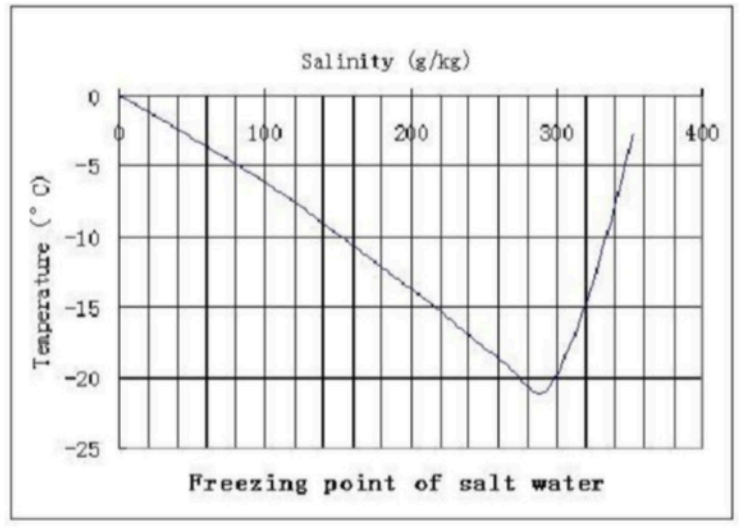


Image 3

A. Raise the freezing point of the ice bath, cooling the mixture faster
B. Have no effect on the freezing point of the ice bath
C. Lower the freezing point of the ice bath, allowing it to reach temperatures below 0°C
D. Cause the ice to melt at a higher temperature than pure water

18. Select ALL statements that are TRUE about non-dairy "milk" products such as almond, soy, or oat milk. (Select ALL that apply.)

A. They are produced by extracting liquid from a plant source rather than from an animal.
B. They naturally contain lactose unless specifically labeled lactose-free.
C. Many are fortified with added calcium and Vitamin D to resemble the nutrient profile of cow's milk.
D. Soy milk generally provides a protein content closer to cow's milk than almond or rice milk does.
E. All non-dairy milks are chemically identical to cow's milk.

19. Lactose-free milk is produced by adding which enzyme to regular milk to break lactose down into glucose and galactose?

A. Amylase
B. Lactase
C. Protease
D. Lipase

20. Identify TWO health benefits associated with regularly consuming dairy foods, and briefly explain why each benefit occurs.

21. Low-fat and fat-free milk are produced primarily by:

A. Adding water to whole milk
B. Mechanically or chemically removing (skimming) the milk fat/cream
C. Adding lactase enzyme
D. Heating the milk at very high temperatures

22. Explain, at the chemical/digestive level, why a person who is lactose intolerant experiences digestive discomfort after consuming dairy products.

23. Homogenization prevents cream from separating out of milk by:

A. Heating milk to kill bacteria
B. Breaking fat globules into smaller, evenly dispersed particles (an emulsification process)
C. Removing all fat from the milk
D. Adding artificial stabilizing salts

24. The HTST (High-Temperature-Short-Time) method of pasteurization typically heats milk to approximately:

A. 45°C for 1 hour

B. 72°C for 15 seconds
C. 100°C for 30 minutes
D. 4°C for 24 hours

25. To be labeled "organic" in the United States, dairy products must come from cows that meet requirements including:

A. Being fed only grain-based feed
B. Never having access to pasture
C. Not being treated with synthetic hormones or antibiotics, and having access to pasture
D. Being raised exclusively indoors on a corn-based diet

26. Select ALL statements that correctly describe casein protein, as compared to whey protein, in milk. (Select ALL that apply.)

A. Casein makes up the majority (about 80%) of the protein in cow's milk.
B. Casein remains dissolved in the liquid (does not coagulate) when milk is curdled with acid.
C. Casein coagulates into curds when milk is acidified or treated with rennet.
D. Whey protein is digested and absorbed by the body more quickly than casein.
E. Casein micelles are colloidal protein structures suspended in milk.

27. Probiotics found in yogurt and other fermented dairy products are best described as:

A. Synthetic preservatives added to extend shelf life
B. Live beneficial bacteria that can support digestive/gut health
C. A type of fat-soluble vitamin
D. An artificial sweetener used in low-fat yogurt

28. Refer to Image 4, a diagram of a casein micelle. Based on current scientific models, which statement best describes the overall structure shown?

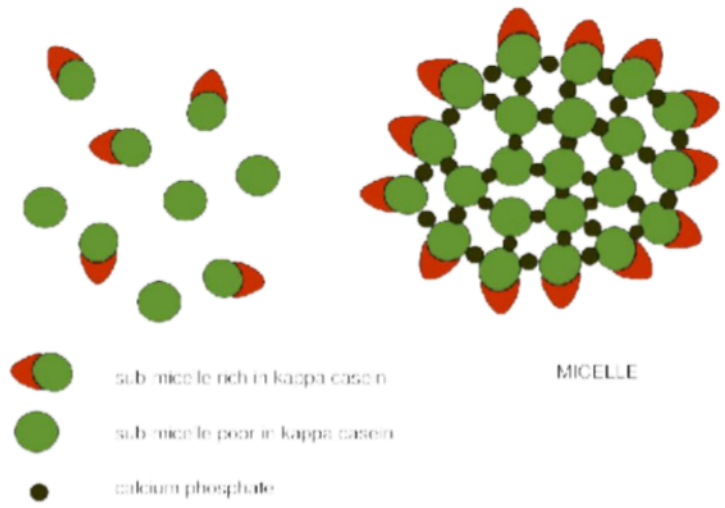


Image 4

A. A single long protein chain with no substructure
B. A colloidal cluster of casein sub-units held together in part by calcium-phosphate bridges
C. A crystal lattice made entirely of fat molecules
D. A simple ring-shaped monosaccharide structure

29. Refer to Image 5, a chart comparing average nutrient amounts in 2% cow's milk to several plant-based milk alternatives. According to the chart, which plant-based milk generally shows a protein content closest to cow's milk?

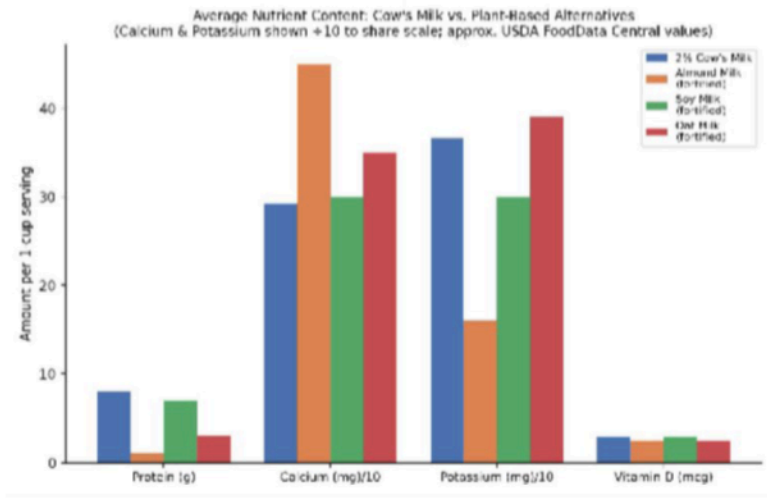


Image 5

A. Almond milk
B. Rice milk
C. Soy milk
D. Coconut milk

30. Compare cow's milk and a plant-based milk alternative (such as almond or oat milk) in terms of their natural macronutrient composition (proteins, fats, and carbohydrates), and explain ONE reason manufacturers often fortify plant-based milks.

ANSWER KEY

FOOD SCIENCE – DIVISION B – REGIONAL EXAM

1. **Correct Answer: B**
   Milk fat (lipids) provides concentrated energy (9 kcal/g) and serves as the carrier for fat-soluble vitamins A and D.

2. **Correct Answer: C**
   Lactose is the disaccharide sugar naturally present in milk.

3. **Correct Answer: B**
   Milk protein is made up mainly of casein (~80%) and whey (~20%) proteins.

4. **Correct Answer: B**
   Federal labeling regulations require a standardized format listing serving size, calories, and mandated nutrients; %DV is based on a 2,000-calorie reference diet, and the label is required, not optional.

5. **Correct Answer: B**
   The FDA regulates Nutrition Facts labeling requirements for most packaged foods, including dairy products.

6. **Correct Answer: B**
   Esterification is the condensation reaction between glycerol's hydroxyl groups and fatty acids' carboxyl groups, releasing water and forming ester bonds.

7. **Correct Answers: A, B, D**
   Saturated fats have no C=C double bonds and are usually solid at room temperature; unsaturated fats have one or more C=C double bonds and are usually liquid at room temperature. Butterfat is a mix of saturated and unsaturated fat, not entirely unsaturated.

8. **Correct Answer: B**
   Lactose is formed from one glucose molecule and one galactose molecule joined by a glycosidic bond.

9. **Correct Answer: C**
   Starch is a polysaccharide composed entirely of repeating glucose units.

10. **Correct Answer: B**
    Proteins are polymers of amino acids joined by peptide bonds.

11. **Correct Answers: A, B, D, E**
    Milk is a significant natural source of Vitamin A, Vitamin D, calcium, and complete protein. It is not a significant natural source of Vitamin C.

12. **Correct Answer: B**
    Heat causes proteins to denature (unfold), which changes their structure and functional properties, such as in scalded milk forming a skin.

13. **Correct Answer: B**
    A milk allergy is an immune reaction to milk proteins, while lactose intolerance is a digestive (enzyme deficiency) issue, not an immune response.

14. **Sample/Acceptable Answer:**
    Accept any two clearly described, correct methods, such as: Pasteurization (heating milk to destroy harmful bacteria and slow spoilage), Refrigeration/Freezing (slowing microbial growth and enzymatic activity), UHT (Ultra-High-Temperature) processing (allows shelf-stable, unrefrigerated storage), Drying/powdering milk (removes water needed for microbial growth), or Fermentation (converting milk into yogurt or cheese, lowering pH to inhibit spoilage organisms).

15. **Correct Answer: B**

Dairy is a leading dietary source of calcium, essential for bone and tooth mineralization.

16. **Sample/Acceptable Answer:**

A long-term Vitamin D deficiency can weaken and soften bones, causing rickets in children or osteomalacia/osteoporosis in adults, because Vitamin D is required for the body to properly absorb calcium from the digestive tract. Dairy products are commonly fortified with Vitamin D so that the calcium they provide can be effectively absorbed and used by the body, supporting bone health.

17. **Correct Answer: C**

As shown on the graph, increasing salt concentration lowers (depresses) the freezing point of the solution, allowing the ice-salt bath to reach temperatures well below 0°C, which is necessary to freeze the ice cream mixture.

18. **Correct Answers: A, C, D**

Plant-based milks are extracted from plant sources and naturally contain no lactose (lactose is only found in animal milk); many are fortified with calcium and Vitamin D, and soy milk's protein content is closest to cow's milk among common plant milks.

19. **Correct Answer: B**

Lactase is the enzyme added to break the glycosidic bond in lactose, producing free glucose and galactose.

20. **Sample/Acceptable Answer:**

Accept any two reasonable, correctly explained benefits, such as: supports bone and tooth health (calcium and Vitamin D support mineralization), supports muscle growth/repair (complete, high-quality protein provides all essential amino acids), or supports digestive/gut health (probiotics in fermented dairy such as yogurt support healthy gut bacteria).

21. **Correct Answer: B**

Low-fat and fat-free milk are made by separating (skimming) some or nearly all of the fat from whole milk.

22. **Sample/Acceptable Answer:**

A lactose-intolerant person does not produce enough of the enzyme lactase in the small intestine to break lactose down into glucose and galactose. The undigested lactose passes into the large intestine, where bacteria ferment it, producing gas, and the undigested sugar also draws water into the intestine osmotically, resulting in bloating, cramping, gas, and diarrhea.

23. **Correct Answer: B**

Homogenization mechanically breaks milk fat globules into smaller particles that stay evenly dispersed (emulsified) throughout the milk, preventing the cream layer from separating.

24. **Correct Answer: B**

HTST pasteurization is commonly performed at approximately 72°C (161°F) for about 15 seconds.

25. **Correct Answer: C**

USDA organic dairy standards require cows to be raised without synthetic hormones or antibiotics and to have access to pasture.

26. **Correct Answers: A, C, D, E**

Casein is the major milk protein (~80%) that coagulates into curds when acidified or treated with rennet, forming colloidal micelles; whey remains in the liquid and is digested more quickly than casein.

27. **Correct Answer: B**

Probiotics are live microorganisms (beneficial bacteria) that, when consumed, can support gut health.

28. **Correct Answer: B**

Casein micelles are colloidal particles composed of casein sub-units linked together in part by calcium-phosphate bridges, as illustrated in the sub-micelle model.

29. Correct Answer: C

Soy milk consistently provides a protein content closest to cow's milk among common plant-based alternatives, as shown in the chart.

30. Sample/Acceptable Answer:

Cow's milk naturally contains complete, high-quality protein (casein and whey), lactose as its carbohydrate, and milk fat that includes saturated fatty acids. Most plant-based milks naturally contain little protein, contain no lactose (their carbohydrates instead come from the starches/sugars of the plant source), and their fat content/type varies by plant source. Because many plant milks naturally lack the calcium, Vitamin D, and protein levels found in cow's milk, manufacturers often fortify them with added calcium, Vitamin D, and sometimes protein so their nutrition profile more closely resembles cow's milk.

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B Form 2
Regional Exam

Team Name: _____ Team Number: _____

- This exam contains 30 questions: 21 multiple choice, 4 multiselect (select ALL correct answers), and 5 short answer.
- Five questions (Q4, Q8, Q10, Q14, Q16) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules. Content specific to State or National level events is not included.
- Total Time: 50 minutes (shared with lab tasks per event rules). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which dairy processing method involves adding live lactic acid bacteria cultures to milk to produce a fermented product such as yogurt?

A. Pasteurization
B. Homogenization
C. Fermentation
D. Ultra-filtration

2. Compared to whole milk, skim (fat-free) milk has had which component removed?

A. Protein
B. Milk fat
C. Lactose
D. Calcium

3. Select ALL statements that are TRUE about milk proteins. (Select ALL that apply.)

A. Whey proteins remain dissolved in the liquid after acid coagulation.
B. Casein makes up the minority of the total protein in milk.
C. Whey proteins denature more easily with heat than casein does.
D. Casein becomes insoluble and precipitates near its isoelectric point (approximately pH 4.6).
E. Whey and casein have identical amino acid sequences.

4. Refer to Image 1, the Haworth projection structure of lactose. The two monosaccharide rings shown are joined together by which type of chemical bond?

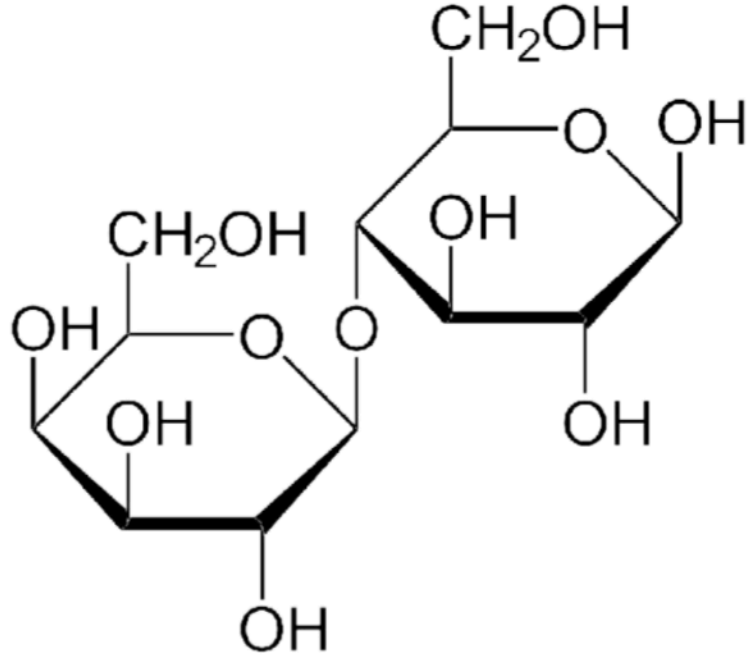


Image 1

A. Peptide bond
B. Ester bond
C. Glycosidic bond
D. Hydrogen bond

5. Under U.S. FDA regulations, which of the following is one of the major food allergens that MUST be declared on a packaged food label if present?

A. Milk
B. Basil
C. Corn
D. Cinnamon

6. List TWO of the major food allergens recognized under U.S. food labeling law, and explain why allergen labeling for milk specifically is important for consumers.

7. Which of the following fatty acids is a SATURATED fatty acid commonly found in milk fat?

A. Oleic acid
B. Palmitic acid
C. Linoleic acid
D. Linolenic acid

8. Refer to Image 2, the chemical structure of cholecalciferol. Which vitamin does this structure represent, one that is commonly added to fortified milk?

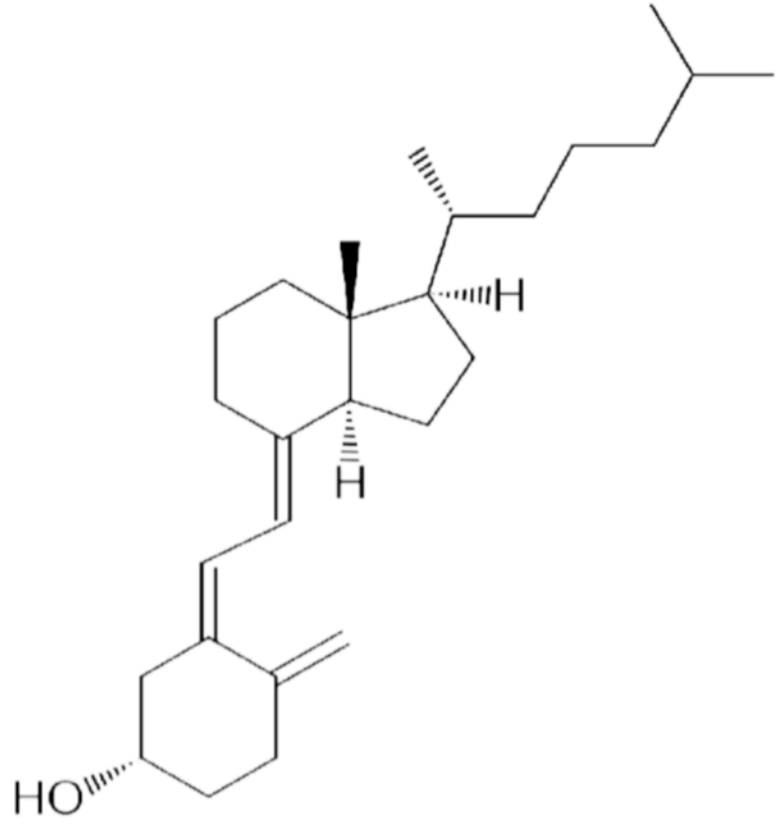


Image 2

A. Vitamin A
B. Vitamin B12
C. Vitamin C
D. Vitamin D3

9. Why is Vitamin D commonly added to milk during fortification rather than relying on milk's natural content alone?

A. Milk naturally contains toxic levels of Vitamin D
B. Milk does not naturally contain significant amounts of Vitamin D
C. Fortification improves the color of milk
D. Vitamin D fortification is required to prevent spoilage

10. Refer to Image 3, the general structural formula of an amino acid. Which labeled feature of this molecule varies between the 20 common amino acids and gives each one its unique chemical properties?

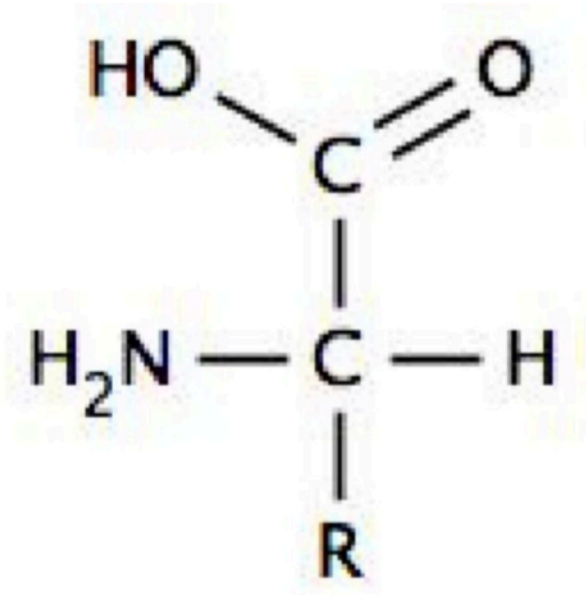


Image 3

A. The carboxyl group
B. The amino group
C. The central alpha carbon
D. The R group (side chain)

11. Which of the following best describes how individual amino acids join together to form a protein such as casein?

A. Glycosidic bonds link sugar rings together
B. Peptide bonds form between the amino group of one amino acid and the carboxyl group of the next
C. Ester bonds form between glycerol and fatty acids
D. Ionic bonds form between calcium and phosphate ions

12. Explain why milk protein is considered a "complete" protein, and name ONE non-dairy food source that also provides complete protein.

13. Which enzyme, naturally found in the stomach of young mammals and used commercially in cheesemaking, causes casein to coagulate into curds?

A. Lactase
B. Rennet (rennin)
C. Amylase
D. Lipase

14. Refer to Image 4, a photo showing separated curds and whey. Which milk protein makes up the majority of the solid curds shown in the image?



Image 4

A. Whey
B. Casein
C. Collagen
D. Keratin

15. Select ALL methods below that can cause milk to curdle (separate into curds and whey). (Select ALL that apply.)

A. Adding an acid such as vinegar or lemon juice
B. Adding rennet enzyme
C. Homogenizing the milk
D. Allowing bacterial fermentation to lower the milk's pH
E. Freezing the milk solid

16. Refer to Image 5, a pH scale diagram. Fresh cow's milk typically has a pH of approximately 6.5 to 6.7. Based on the scale, fresh milk is best described as:

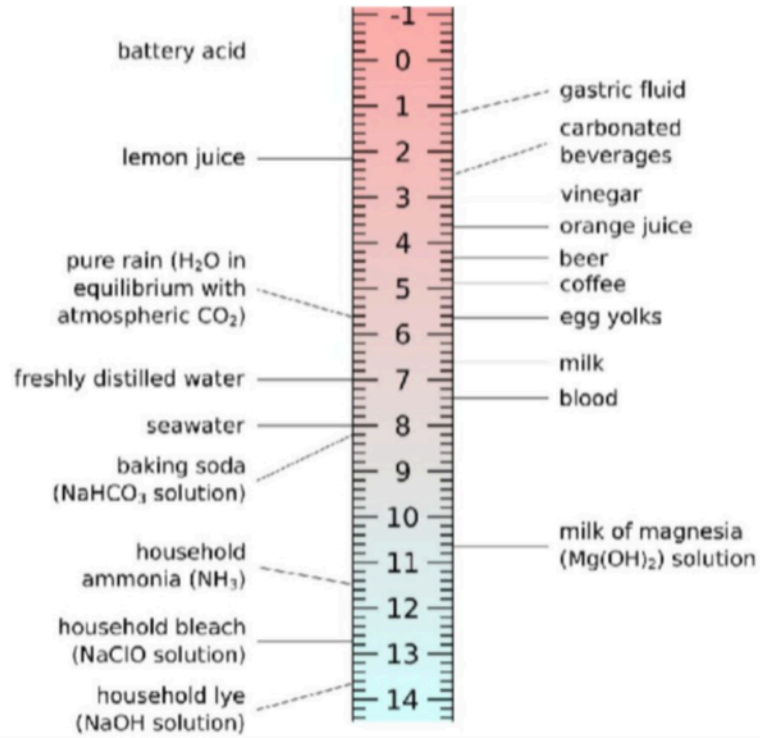


Image 5

A. Strongly acidic
B. Slightly acidic (close to neutral)
C. Strongly basic
D. Perfectly neutral (pH 7.0 exactly)

17. Select ALL statements that are TRUE about milk souring (fermentation) over time. (Select ALL that apply.)

A. Lactic acid bacteria convert lactose into lactic acid.
B. The pH of the milk decreases (becomes more acidic) as it sours.
C. Soured milk is always safer to drink than fresh milk.
D. As acidity increases, casein proteins may coagulate and the milk may curdle.
E. Souring causes the lactose content of the milk to increase.

18. Using the concept of pH and isoelectric point, explain why adding an acid such as vinegar or lemon juice to warm milk causes the casein protein to coagulate into curds.

19. Which of the following best describes an emulsion?

A. A uniform mixture of two liquids that would not normally mix, such as fat dispersed throughout water
B. A solid completely dissolved in a liquid
C. Two gases mixed together
D. A chemical reaction that produces an entirely new compound

20. Which natural component of milk acts as an emulsifier, helping keep fat globules dispersed and suspended in the watery portion of milk?

A. Lactose crystals
B. Casein micelles and milk proteins
C. Calcium carbonate
D. Vitamin C

21. UHT (Ultra-High-Temperature) processed milk is typically heated to approximately what temperature, allowing it to be stored unrefrigerated until opened?

A. 63°C for 30 minutes
B. 72°C for 15 seconds
C. 138°C for 2 seconds
D. 4°C for 24 hours

22. Which of the following is a key advantage of UHT-processed milk compared to standard HTST-pasteurized milk?

A. UHT milk has a much longer unrefrigerated shelf life
B. UHT milk contains significantly more lactose
C. UHT milk is automatically certified organic
D. UHT milk cannot be consumed by lactose-intolerant individuals

23. To qualify as "organic" under USDA standards, dairy cows must NOT be given which of the following?

A. Access to pasture
B. Organic feed
C. Synthetic growth hormones such as rBST
D. Fresh water

24. Identify ONE specific USDA production requirement that differs between conventional and organic dairy farming, and explain ONE reason some consumers choose organic dairy products.

25. Which two monosaccharides make up the disaccharide sucrose, sometimes added as a sweetener to flavored dairy products like ice cream?

A. Glucose and fructose
B. Glucose and galactose

C. Fructose and galactose
D. Two fructose molecules

26. Compared to table sugar (sucrose), lactose is generally:

A. Sweeter tasting
B. Less sweet tasting
C. Chemically identical to sucrose
D. Not a carbohydrate at all

27. Select ALL statements that are TRUE about the lactase enzyme and lactose digestion. (Select ALL that apply.)

A. Lactase is produced by cells in the lining of the small intestine.
B. Lactase breaks the glycosidic bond joining glucose and galactose in lactose.
C. Lactase production naturally decreases in many people after early childhood.
D. Lactase converts lactose into two glucose molecules.
E. Lactase-treated (lactose-free) milk tends to taste slightly sweeter than regular milk.

28. Which of the following best explains why lactose-free milk often tastes slightly sweeter than regular milk?

A. Lactase breaks lactose into glucose and galactose, which taste sweeter individually than lactose does
B. Manufacturers add extra sugar during processing
C. Lactose-free milk naturally contains more milk fat
D. Lactose-free milk undergoes an additional fermentation step

29. Which genus of bacteria is most commonly associated with fermenting milk into yogurt?

A. Escherichia
B. Lactobacillus
C. Salmonella
D. Clostridium

30. Describe the basic biological/chemical process by which bacteria convert milk into yogurt, and explain how this process changes the texture and taste of the milk.

ANSWER KEY

FOOD SCIENCE – DIVISION B (EXAM 2) – REGIONAL EXAM

1. **Correct Answer: C**

   Fermentation is the process of adding bacterial cultures that convert lactose into lactic acid, producing fermented dairy foods like yogurt.

2. **Correct Answer: B**

   Skim milk is produced by removing nearly all of the milk fat, while protein, lactose, and calcium remain largely unchanged.

3. **Correct Answers: A, C, D**

   Whey stays dissolved after acid coagulation and denatures more readily with heat; casein precipitates near its isoelectric point (~pH 4.6). Casein is the majority protein (not the minority), and whey and casein are structurally different proteins.

4. **Correct Answer: C**

   The two monosaccharide units (glucose and galactose) in lactose are joined by a glycosidic bond.

5. **Correct Answer: A**

   Milk is one of the major food allergens (the 'Big Nine') that federal law requires to be clearly declared on packaged food labels.

6. **Sample/Acceptable Answer:**

   Accept any two of the major recognized allergens: milk, eggs, fish, shellfish, tree nuts, peanuts, wheat, soybeans, sesame. Allergen labeling for milk is important because even small or trace amounts of milk protein can trigger a potentially severe immune reaction in someone with a true milk allergy, so clear labeling helps them identify and avoid products that could cause harm.

7. **Correct Answer: B**

   Palmitic acid is a saturated fatty acid (no carbon-carbon double bonds) commonly found in milk fat; oleic, linoleic, and linolenic acids are all unsaturated.

8. **Correct Answer: D**

   Cholecalciferol is the chemical name for Vitamin D3, commonly added to fortify milk.

9. **Correct Answer: B**

   Milk is not naturally a significant source of Vitamin D, so many dairies fortify milk with Vitamin D to help support calcium absorption and bone health.

10. **Correct Answer: D**

    The R group (side chain) is the variable portion of an amino acid that differs between amino acids and determines each one's unique chemical properties; the amino group, carboxyl group, and alpha carbon are common to (nearly) all amino acids.

11. **Correct Answer: B**

    Amino acids are linked into proteins through peptide bonds, formed in a condensation reaction between the amino group of one amino acid and the carboxyl group of the next.

12. **Sample/Acceptable Answer:**

    Milk protein is considered complete because it contains all nine essential amino acids in sufficient proportions -- amino acids the human body cannot synthesize on its own and must obtain from food. Accept any correct non-dairy complete protein source, such as eggs, soybeans/soy products, quinoa, or meat/poultry/fish.

13. **Correct Answer: B**

    Rennet (rennin) is the enzyme traditionally used to coagulate casein into curds during cheesemaking.

14. **Correct Answer: B**

Casein coagulates into the solid curds, while whey protein remains dissolved in the liquid portion.

15. **Correct Answers: A, B, D**

Acid, rennet, and bacterial fermentation (which produces lactic acid) can all cause casein to coagulate and curdle milk. Homogenization and freezing do not cause curdling in this way.

16. **Correct Answer: B**

A pH of 6.5-6.7 falls just below neutral (pH 7), making fresh milk slightly acidic.

17. **Correct Answers: A, B, D**

Lactic acid bacteria ferment lactose into lactic acid, lowering pH and eventually causing casein to coagulate. Souring does not make milk automatically safer, and lactose content decreases (it is consumed by the bacteria), not increases.

18. **Sample/Acceptable Answer:**

Casein micelles carry a net negative charge at milk's normal pH, which causes them to repel one another and stay suspended in solution. Adding acid lowers the pH toward casein's isoelectric point (about pH 4.6), the point at which casein molecules lose their net electrical charge. Without that charge to keep them apart, the casein molecules can no longer repel each other and instead clump together, coagulating into solid curds.

19. **Correct Answer: A**

An emulsion is a stable, uniform mixture of two liquids that would not normally combine, such as fat droplets dispersed throughout the watery portion of milk.

20. **Correct Answer: B**

Casein micelles and other milk proteins coat fat globules and act as natural emulsifiers, keeping fat dispersed throughout milk.

21. **Correct Answer: C**

UHT processing typically heats milk to about 138°C (280°F) for roughly 2 seconds, destroying essentially all microorganisms and allowing shelf-stable, unrefrigerated storage until opened.

22. **Correct Answer: A**

Because UHT processing destroys essentially all microorganisms, UHT milk can be stored unrefrigerated for months until opened, unlike HTST-pasteurized milk, which still requires refrigeration.

23. **Correct Answer: C**

USDA organic standards prohibit the use of synthetic growth hormones (such as rBST) and antibiotics in organic dairy production.

24. **Sample/Acceptable Answer:**

Accept any correct, specific comparison, such as: organic dairy cows must have access to pasture and cannot be treated with synthetic growth hormones or antibiotics, while conventional dairy farming has no such restriction. Consumers may choose organic dairy to avoid synthetic hormones/antibiotics, to support pasture-based animal welfare practices, or to avoid certain pesticides used in conventional feed production.

25. **Correct Answer: A**

Sucrose (table sugar) is composed of one glucose molecule and one fructose molecule joined by a glycosidic bond.

26. **Correct Answer: B**

Lactose is significantly less sweet-tasting than sucrose, which is part of why lactose-free milk (with lactose broken into glucose and galactose) tastes noticeably sweeter.

27. **Correct Answers: A, B, C, E**

Lactase is produced in the small intestine and breaks lactose's glycosidic bond into glucose and galactose (not two glucose molecules); lactase production commonly declines after early childhood in many people, and lactose-free milk tastes sweeter because glucose and galactose are sweeter-tasting than lactose.

28. Correct Answer: A

Lactase enzymatically splits lactose into glucose and galactose, both of which taste sweeter individually than the original disaccharide lactose.

29. Correct Answer: B

Lactobacillus species (often alongside Streptococcus thermophilus) are the bacteria most commonly used to ferment milk into yogurt.

30. Sample/Acceptable Answer:

Live bacterial cultures (such as Lactobacillus species) ferment the lactose in milk, converting it into lactic acid. The buildup of lactic acid lowers the milk's pH, which causes casein proteins to lose their net charge and coagulate, thickening the milk into yogurt's characteristic gel-like texture. The lactic acid produced during fermentation also gives yogurt its characteristic tangy, sour taste.

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
State Exam

State Exam - No questions repeated from the Regional Exam Forms 1 or 2

Team Name: _____ Team Number: _____

- This exam contains 50 questions: 35 multiple choice, 5 multiselect (select ALL correct answers), and 10 short answer.
- Eight questions (Q4, Q8, Q15, Q19, Q26, Q30, Q35, Q40) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; State Tournament teams complete one or two Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Water makes up approximately what percentage of the composition of cow's milk?

A. 25%
B. 50%
C. 87%
D. 99%

2. Chemically, milk is best classified as which type of mixture?

A. A true solution
B. A colloid
C. A pure compound
D. An element

3. Which characteristic of milk fat globules explains why milk is classified as a colloid rather than a true solution?

A. Milk fat globules are small enough to stay suspended but large enough to scatter light
B. Milk fat dissolves completely at the molecular level
C. Milk fat forms ionic bonds with water
D. Milk fat has no measurable particle size

4. Refer to Image 1, the skeletal structure of oleic acid. The bend (kink) in the middle of the carbon chain is caused by which structural feature?

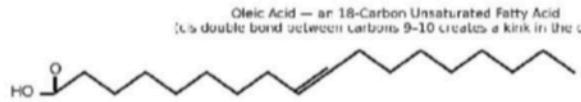


Image 1

A. A peptide bond
B. A cis carbon-carbon double bond
C. A glycosidic bond
D. A branched methyl group

5. Why are saturated fats (like butterfat) typically solid at room temperature, while unsaturated fats (like most vegetable oils) are typically liquid?

A. Saturated fats have more calories per gram
B. Saturated fatty acid chains pack tightly together, while double bonds in unsaturated chains create kinks that prevent tight packing
C. Unsaturated fats contain more protein
D. Saturated fats contain more water

6. Select ALL statements that are TRUE about milk fat-based products. (Select ALL that apply.)

A. Butter is made by churning cream until the fat globules coalesce and separate from the liquid buttermilk.
B. Ghee is butter that has had the milk solids and water removed through gentle heating.
C. Heavy cream contains a higher percentage of milk fat than half-and-half.
D. Butter contains no water at all.
E. Whipped cream relies on air being trapped in a network formed by partially coalesced fat globules.

7. Ghee is produced by gently heating butter to remove which two components, leaving behind purified milk fat?

A. Sugar and salt
B. Milk solids and water
C. Vitamins and minerals
D. Casein and rennet

8. Refer to Image 2, a photograph of a traditional butter churn. Churning cream in a device like this causes which physical change to occur?



Image 2

A. Milk proteins are hydrolyzed into individual amino acids

B. Fat globule membranes are disrupted, allowing fat globules to clump together (coalesce) and separate from the liquid
C. Lactose is converted into glucose and galactose
D. The cream is pasteurized

9. When cream is whipped into whipped cream, what physically happens to the milk fat globules?

A. They dissolve completely into the surrounding liquid
B. They partially coalesce and form a network that traps air bubbles
C. They are chemically converted into protein
D. They evaporate

10. Explain, at the physical/chemical level, why cream can be whipped into a stable foam (whipped cream) while skim milk cannot.

11. Commercial dairies typically separate cream from whole milk using which process?

A. Filtration through cheesecloth
B. Centrifugation in a cream separator
C. Freezing and thawing
D. Adding rennet

12. Ranking from HIGHEST to LOWEST milk fat percentage, which of the following orderings is correct?

A. Whole milk > half-and-half > heavy cream
B. Heavy cream > half-and-half > whole milk
C. Half-and-half > heavy cream > whole milk
D. Whole milk > heavy cream > half-and-half

13. Select ALL statements that are TRUE about cheese categories. (Select ALL that apply.)

A. Soft cheeses generally have higher moisture content than hard, aged cheeses.
B. Hard, aged cheeses typically have LESS moisture than fresh soft cheeses.
C. All cheeses are made using rennet coagulation exclusively.
D. Aging (ripening) cheese generally increases the intensity of its flavor.
E. Cottage cheese is an example of a hard, aged cheese.

14. During cheese aging (ripening), bacterial and enzymatic activity primarily does which of the following?

A. Adds new fat and protein to the cheese
B. Breaks down proteins and fats into smaller flavor and aroma compounds
C. Converts all the cheese's protein into lactose
D. Sterilizes the cheese, halting all chemical activity

15. Refer to Image 3, a micrograph of Lactobacillus bacteria. This genus of bacteria is commonly used in dairy fermentation and cheese aging because it primarily produces which compound from lactose?

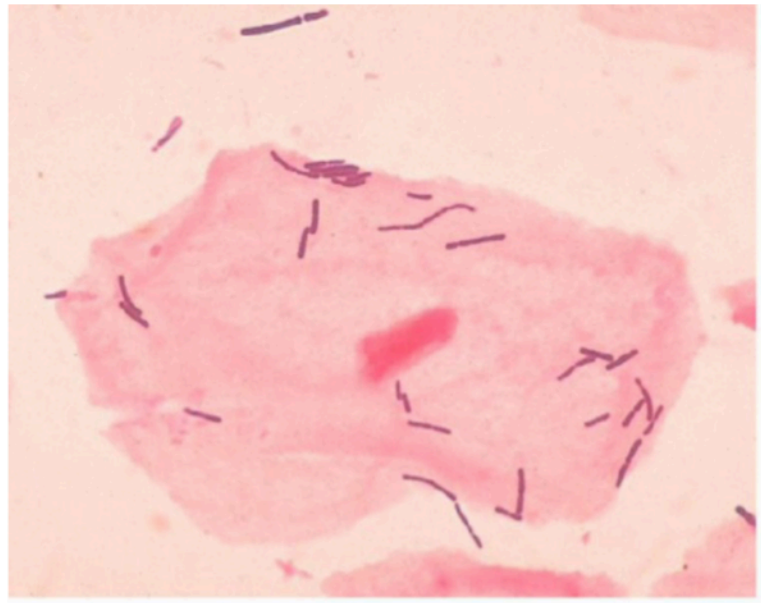


Image 3

A. Ethanol
B. Lactic acid
C. Carbon dioxide gas only
D. Acetone

16. Describe the general chemical process of cheese ripening (aging), and explain how this process develops the cheese's characteristic flavor.

17. Commercial cheesemakers today may use rennet obtained from which of the following sources?

A. Only from calf stomachs
B. Animal (calf stomach), microbial (fungal/bacterial), or plant-derived sources
C. Only from bacterial fermentation
D. Rennet cannot be sourced commercially; it must be made in a lab from scratch each time

18. Which type of casein is located primarily on the surface of the casein micelle and plays the key role in keeping micelles stable and suspended in milk?

A. Alpha-s1-casein
B. Beta-casein
C. Kappa-casein
D. Whey protein

19. Refer to Image 4, a schematic diagram of the casein sub-micelle model. According to this model, what holds the individual casein sub-units together within the micelle?

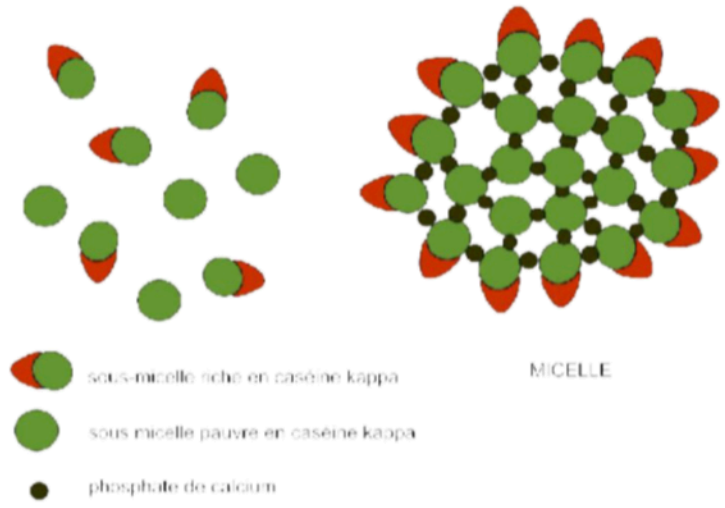


Image 4

A. Covalent peptide bonds between sub-units
B. Phospho-calcium (calcium phosphate) bridges linking the sub-units
C. Hydrogen bonds with lactose molecules
D. Disulfide bonds with whey proteins

20. Select ALL statements that are TRUE about kappa-casein and casein micelle stability. (Select ALL that apply.)

A. Kappa-casein is concentrated on the outer surface of the casein micelle.
B. Rennet enzymatically cleaves kappa-casein, destabilizing the micelle and causing coagulation.
C. Kappa-casein has no role in keeping casein micelles suspended in solution.
D. After rennet cleaves kappa-casein, casein micelles can clump together and form curds.
E. Kappa-casein content in milk varies depending on the species and breed of the animal.

21. Which two proteins make up the majority of whey protein in cow's milk?

A. Alpha-lactalbumin and beta-lactoglobulin
B. Kappa-casein and beta-casein
C. Collagen and elastin
D. Myosin and actin

22. Explain the difference between whey protein concentrate and whey protein isolate in terms of processing and protein purity.

23. Which best describes the difference between a Recommended Dietary Allowance (RDA) and a Percent Daily Value (%DV) shown on a Nutrition Facts label?

A. They are exactly the same thing, just with different names

B. RDA is a nutrient intake target set by age/sex group; %DV shows how much a serving contributes toward a single, standardized daily reference value used on food labels

C. %DV changes for every individual person based on their exact age and weight printed on the label

D. RDA only applies to vitamins, while %DV only applies to minerals

24. According to U.S. dietary guidelines, what is the RDA for calcium for teens aged 14-18?

A. 700 mg/day

B. 1,000 mg/day

C. 1,300 mg/day

D. 2,500 mg/day

25. Explain ONE specific health consequence that can result from consistently low calcium intake during adolescence, and why this life stage is particularly important for calcium consumption.

26. Refer to Image 5, an NIH chart of recommended daily calcium intake by life stage. According to the chart, which age group has the HIGHEST calcium RDA?

Recommended Dietary Allowance (RDA) for Calcium by Life Stage
(Source: NIH Office of Dietary Supplements)

Life Stage	Calcium RDA (mg/day)
1–3 years	700
4–8 years	1,000
9–13 years	1,300
14–18 years	1,300
19–50 years	1,000
51–70 years (male)	1,000
51–70 years (female)	1,200
71+ years	1,200

Image 5

A. Children 4-8 years
B. Children/teens 9-18 years
C. Adults 19-50 years
D. Adults 71 years and older

27. How does "ultra-pasteurized" milk differ from standard HTST-pasteurized milk?

A. Ultra-pasteurized milk is heated to a higher temperature than standard pasteurization, extending shelf life further
B. Ultra-pasteurized milk is not heated at all
C. Ultra-pasteurized milk has all of its lactose removed
D. Ultra-pasteurized and standard pasteurized milk are processed identically

28. The Percent Daily Value (%DV) shown on a Nutrition Facts label is based on a reference diet of how many calories per day?

A. 1,000 calories
B. 1,500 calories
C. 2,000 calories
D. 2,500 calories

29. Select ALL nutrients that U.S. federal regulations REQUIRE to be listed on a packaged food's Nutrition Facts label. (Select ALL that apply.)

A. Total Fat
B. Sodium
C. Vitamin D
D. Beta-carotene
E. Total Carbohydrate

30. Refer to Image 6, an older-format (2006) FDA Nutrition Facts label. Compared to the current (2016-era) label format, which nutrient was NOT required to be listed on this older label?

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving

Calories 230	Calories from Fat 40
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	
Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Image 6

A. Total Fat
B. Added Sugars
C. Sodium
D. Total Carbohydrate

31. Which best distinguishes a "fortified" food from an "enriched" food?

A. Fortified foods have nutrients added that were not originally present (or present in only small amounts); enriched foods have nutrients added back that were lost during processing

B. Fortified and enriched mean exactly the same thing
C. Enriched foods always contain more calories than fortified foods
D. Only fortified foods can legally be sold in the United States

32. Using a dairy example, explain the difference between a fortified food and an enriched food.

33. Cultured buttermilk is produced by:

A. Adding lactic acid bacteria cultures to skim or low-fat milk, allowing fermentation to thicken and sour it
B. Removing all bacteria from milk using UHT processing
C. Whipping heavy cream until it becomes solid
D. Adding rennet to whole milk

34. How does kefir differ from yogurt in terms of the culture used to ferment it?

A. Kefir uses only a single bacterial species, while yogurt uses many species
B. Kefir is fermented using a more complex symbiotic culture of bacteria AND yeast, while yogurt is fermented using bacteria alone
C. Kefir contains no live cultures at all
D. Yogurt uses yeast exclusively, while kefir uses only bacteria

35. Refer to Image 7, a photograph of milk kefir grains. These "grains" are best described as:



Image 7

A. A pure crystal of milk sugar (lactose)
B. A symbiotic culture of bacteria and yeast held together in a polysaccharide matrix
C. A type of hardened cheese curd
D. A synthetic starter powder

36. Select ALL statements that are TRUE about fermented dairy products in general. (Select ALL that apply.)

A. Fermentation typically lowers the pH of milk through the production of lactic acid.
B. Fermented dairy products such as yogurt and kefir often contain live probiotic cultures.
C. Fermentation always destroys all of the protein in milk.
D. Fermented dairy products can have a longer shelf life than fresh milk due to their lower pH.
E. All fermented dairy products use identical bacterial cultures.

37. The Maillard reaction is best defined as:

A. A reaction between amino acids/proteins and reducing sugars that produces browning and flavor compounds when heated
B. The freezing of a liquid due to added solute
C. The coagulation of casein by acid
D. The separation of cream from milk by centrifugation

38. How does the Maillard reaction differ from caramelization?

A. The Maillard reaction involves both amino acids/proteins and sugars, while caramelization involves the browning of sugars alone
B. Caramelization requires amino acids while the Maillard reaction does not
C. The Maillard reaction only occurs in dairy products
D. Caramelization and the Maillard reaction are the same chemical process

39. Explain, at the chemical level, what happens when sweetened milk is slowly heated to make dulce de leche (a browned, caramel-flavored milk product).

40. Refer to Image 8, a photograph of dulce de leche. The characteristic brown color and rich flavor of this product develop primarily through which chemical process?



Image 8

A. Emulsification
B. The Maillard reaction (non-enzymatic browning)
C. Pasteurization alone, with no chemical reaction
D. Freezing point depression

41. In ice cream production, "overrun" refers to:

A. The percentage increase in volume of the ice cream mix due to air incorporated during churning
B. The amount of time it takes ice cream to melt at room temperature
C. The percentage of milk fat in the final product
D. The temperature at which the ice cream mix freezes

42. Stabilizers and emulsifiers are commonly added to commercial ice cream primarily to:

A. Increase the fat content dramatically
B. Help control ice crystal size and improve texture/smoothness during storage
C. Replace the need for sugar entirely
D. Eliminate the need for pasteurization

43. Which food additive commonly used as a stabilizer in commercial ice cream is derived from seaweed?

A. Carrageenan
B. Aspartame
C. Sodium benzoate
D. Citric acid

44. Explain the role that fat, sugar, and stabilizers each play in preventing the formation of large, gritty ice crystals in ice cream during freezing and storage.

45. Adding sugar to an ice cream mix lowers its freezing point primarily because of which principle?

A. Sugar reacts chemically with water to form a new compound
B. Sugar is a solute that depresses the freezing point of the water-based mix, a colligative property
C. Sugar increases the mix's density, which has no effect on freezing point
D. Sugar evaporates during freezing, concentrating the remaining liquid

46. If a solute fully dissociates into two particles per molecule in solution (such as NaCl into Na+ and Cl-), how does this affect the magnitude of freezing point depression compared to a solute that does not dissociate (such as sucrose)?

A. Dissociating solutes cause LESS freezing point depression per mole added
B. Dissociating solutes cause roughly TWICE the freezing point depression per mole added, due to the increased number of dissolved particles
C. Dissociation has no effect on freezing point depression
D. Only non-dissociating solutes can lower the freezing point at all

47. At approximately what pH does casein reach its isoelectric point, and explain why this pH value is significant for dairy processing (such as cheese and yogurt production).

48. Cottage cheese is typically made using acid coagulation, while many aged, hard cheeses use rennet coagulation. Describe ONE difference between acid-set and rennet-set curds in terms of texture or moisture content, and briefly explain the chemistry behind acid coagulation of casein.

49. Which coagulation method is typically used to produce firm, aged cheeses that can be pressed, shaped, and stored for extended ripening?

A. Acid coagulation
B. Rennet coagulation
C. Homogenization
D. Ultra-pasteurization

50. The Food Science event's lab tasks involve making ice cream, measuring curd mass, and measuring milk fat mass from cream. Choose ONE of these three lab tasks and explain the underlying food chemistry (involving fats, proteins, and/or carbohydrates) that makes the task work, and why understanding that chemistry helps a team predict or interpret their lab results.

ANSWER KEY

FOOD SCIENCE – DIVISION B – STATE EXAM

1. **Correct Answer: C**

   Cow's milk is roughly 87% water by weight, with the remaining ~13% made up of fat, protein, lactose, and minerals.

2. **Correct Answer: B**

   Milk is a colloid: fat globules and casein micelles are dispersed throughout the water-based liquid without fully dissolving or settling out.

3. **Correct Answer: A**

   Colloidal particles, like milk fat globules, are larger than dissolved molecules (so they scatter light and don't fully dissolve) but small enough to stay dispersed rather than settle out.

4. **Correct Answer: B**

   The kink in oleic acid's chain comes from a cis carbon-carbon double bond, which prevents the chain from packing tightly and is characteristic of unsaturated fatty acids.

5. **Correct Answer: B**

   Straight, saturated fatty acid chains can pack closely together and solidify more easily, while the kinks caused by double bonds in unsaturated fats prevent tight packing, keeping them liquid at room temperature.

6. **Correct Answers: A, B, C, E**

   Butter forms when churning coalesces fat globules, separating them from buttermilk. Ghee is clarified butter with milk solids and water removed. Heavy cream has a higher fat percentage than half-and-half. Butter does contain a small amount of water (commonly ~16-18%), so that statement is false. Whipped cream's structure comes from air trapped in a network of partially coalesced fat globules.

7. **Correct Answer: B**

   Ghee (clarified butter) is made by heating butter until the water evaporates and the milk solids (proteins, lactose) separate out and are removed, leaving nearly pure milk fat.

8. **Correct Answer: B**

   Churning agitates cream enough to damage the membranes surrounding fat globules, causing the fat to coalesce into solid butter and separate from the remaining liquid (buttermilk).

9. **Correct Answer: B**

   Whipping partially disrupts the fat globule membranes, causing the globules to partially coalesce and form a structural network around trapped air bubbles, giving whipped cream its light, foamy texture.

10. **Sample/Acceptable Answer:**

    Whipping incorporates air into the liquid while agitation partially disrupts the membranes surrounding the milk fat globules. The partially coalesced fat globules then link together around the air bubbles, forming a stable network that holds the foam's structure. Skim milk lacks sufficient fat globules to form this supporting network, so it cannot hold a stable foam the way cream does.

11. **Correct Answer: B**

    A centrifugal cream separator spins milk at high speed; because fat is less dense than the surrounding liquid, it collects toward the center and can be drawn off as cream.

12. **Correct Answer: B**

    Heavy cream has the highest fat content (about 36% or more), half-and-half is a mix of milk and cream (about 10-18% fat), and whole milk has the lowest fat percentage of the three (about 3.25%).

13. **Correct Answers: A, B, D**

Soft cheeses have higher moisture than hard, aged cheeses, and aging generally intensifies flavor as enzymes and bacteria break down proteins and fats. Not all cheeses use rennet (some use acid coagulation), and cottage cheese is a soft, fresh (unaged) cheese, not a hard, aged one.

14. Correct Answer: B

During aging, enzymes and bacteria gradually break down (via proteolysis and lipolysis) the cheese's proteins and fats into smaller compounds that create the characteristic flavors and aromas of aged cheese.

15. Correct Answer: B

Lactobacillus species are lactic acid bacteria; they ferment lactose into lactic acid, which lowers pH and contributes to flavor development in cheese and other fermented dairy products.

16. Sample/Acceptable Answer:

During ripening, bacterial cultures and enzymes (naturally present or added, such as from rennet) gradually break down the cheese's proteins (proteolysis) and fats (lipolysis) into smaller peptides, free amino acids, fatty acids, and other flavor/aroma compounds. Continued microbial fermentation of residual lactose also produces lactic acid. Over weeks to months, this breakdown produces the complex flavors, aromas, and textures associated with aged cheeses, which differ from the milder flavor of fresh, unaged cheese.

17. Correct Answer: B

Modern rennet can come from several sources: traditional animal rennet (from calf stomachs), microbial rennet (produced by fungi or genetically engineered microorganisms), or plant-derived coagulating enzymes.

18. Correct Answer: C

Kappa-casein sits on the outer surface of the casein micelle and provides steric and electrostatic stabilization that keeps micelles suspended and prevents them from clumping together.

19. Correct Answer: B

In the sub-micelle model, individual casein sub-units are linked together by phospho-calcium (calcium phosphate) bridges, forming the larger colloidal casein micelle structure.

20. Correct Answers: A, B, D, E

Kappa-casein sits on the micelle surface and stabilizes it; rennet's enzymatic action cleaves kappa-casein, removing that stabilization so micelles can aggregate and form curds. Kappa-casein content does vary by species/breed. The statement that kappa-casein has no stabilizing role is false.

21. Correct Answer: A

Alpha-lactalbumin and beta-lactoglobulin are the two major whey proteins found in cow's milk.

22. Sample/Acceptable Answer:

Whey protein concentrate is processed less extensively and retains more lactose, fat, and other milk components, resulting in a lower overall protein percentage (commonly around 70-80% protein by weight). Whey protein isolate undergoes additional filtration/processing to remove nearly all of the fat and lactose, resulting in a higher, more purified protein content (commonly 90% or more protein by weight).

23. Correct Answer: B

The RDA is a nutrient-specific intake recommendation based on age and sex groups, while %DV on food labels is based on a single standardized reference value (Daily Value) used for labeling purposes across the general population, not tailored to the individual.

24. Correct Answer: C

Teens aged 14-18 have a calcium RDA of 1,300 mg/day, the same as children aged 9-13, reflecting the high calcium demands of adolescent bone growth.

25. Sample/Acceptable Answer:

Consistently low calcium intake during adolescence can result in lower peak bone mass, increasing the risk of osteoporosis and bone fractures later in life. Adolescence is a particularly important time for calcium intake because this is when the body builds the majority of its lifetime peak bone mass; bones absorb and accumulate calcium most efficiently during these growth years, so insufficient intake during this window cannot be easily made up for later in life.

26. Correct Answer: B

Children and teens aged 9-18 have the highest calcium RDA (1,300 mg/day) of the groups shown, reflecting the intense bone growth that occurs during these years.

27. Correct Answer: A

Ultra-pasteurization heats milk to a higher temperature (commonly around 138°C, similar to UHT) for a short time, destroying more microorganisms than standard HTST pasteurization and extending refrigerated shelf life.

28. Correct Answer: C

%DV values on U.S. Nutrition Facts labels are calculated based on a standard 2,000-calorie daily reference diet.

29. Correct Answers: A, B, C, E

Total Fat, Sodium, Vitamin D, and Total Carbohydrate are all required nutrients on the current Nutrition Facts label. Beta-carotene specifically is not a required label entry.

30. Correct Answer: B

The requirement to separately declare "Added Sugars" was introduced in the FDA's 2016 label update and was not present on the older (2006-era) label format shown.

31. Correct Answer: A

Fortification adds nutrients not naturally present in significant amounts (such as adding Vitamin D to milk); enrichment adds back nutrients that were removed or lost during processing (such as adding B vitamins back to refined grain products).

32. Sample/Acceptable Answer:

A fortified dairy food has a nutrient added that was not originally present in significant amounts, such as milk fortified with Vitamin D, which milk does not naturally contain in meaningful amounts. An enriched food has nutrients added back that were lost during processing; while less common with dairy, this is more typical of foods like enriched refined flour, which has B vitamins and iron added back after processing removes them from the whole grain.

33. Correct Answer: A

Cultured buttermilk is made by adding lactic acid bacteria cultures to skim or low-fat milk; fermentation thickens the milk and gives it a tangy flavor, unlike traditional buttermilk, which was originally the liquid left over from churning butter.

34. Correct Answer: B

Kefir grains contain a complex symbiotic community of both lactic acid bacteria and yeast, while yogurt is typically fermented using specific bacterial strains alone (commonly Lactobacillus and Streptococcus species).

35. Correct Answer: B

Kefir grains are gelatinous clusters made up of a symbiotic community of bacteria and yeast embedded in a polysaccharide (kefiran) matrix, used to ferment milk into kefir.

36. Correct Answers: A, B, D

Fermentation lowers pH via lactic acid production, often leaves behind live probiotic cultures, and the resulting lower pH can extend shelf life by inhibiting spoilage organisms. Fermentation does not destroy all protein (it often coagulates/modifies it), and different fermented products use different specific cultures.

37. **Correct Answer: A**

The Maillard reaction is a non-enzymatic chemical reaction between amino acids (from proteins) and reducing sugars that occurs with heat, producing browning and a range of flavor and aroma compounds.

38. **Correct Answer: A**

The Maillard reaction requires both an amino acid/protein source and a reducing sugar, while caramelization is the browning of sugars alone (without amino acids) under heat.

39. **Sample/Acceptable Answer:**

As sweetened milk is heated over time, the reducing sugars (from lactose and any added sugar) react with the amino groups of milk proteins in the Maillard reaction. This non-enzymatic browning reaction produces melanoidins (brown pigments) and a wide range of new flavor and aroma compounds, giving dulce de leche its characteristic caramel-brown color and rich, toasted flavor. The slow evaporation of water also concentrates the sugars and proteins, further promoting the reaction and thickening the mixture.

40. **Correct Answer: B**

Dulce de leche's brown color and deep caramelized flavor develop primarily through the Maillard reaction, as milk proteins and sugars react under prolonged heating.

41. **Correct Answer: A**

Overrun is the percentage increase in volume that results from air being whipped into the ice cream mix during freezing/churning; higher overrun means more air (and typically a lighter texture).

42. **Correct Answer: B**

Stabilizers and emulsifiers help control ice crystal formation, improve texture and smoothness, and help the ice cream resist melting and texture changes during storage.

43. **Correct Answer: A**

Carrageenan is a stabilizer/thickener extracted from red seaweed, commonly used in ice cream and other dairy products to improve texture and stability.

44. **Sample/Acceptable Answer:**

Fat globules coat and interrupt the growth of ice crystals, helping keep them small and contributing to a smooth, creamy texture. Dissolved sugar lowers the freezing point of the mix (a colligative property) and increases the viscosity of the unfrozen liquid portion, slowing the rate of ice crystal growth. Stabilizers (such as guar gum or carrageenan) bind water and increase the mix's viscosity, which physically restricts water molecules from migrating to and enlarging existing ice crystals, especially during temperature fluctuations in storage.

45. **Correct Answer: B**

Dissolved sugar acts as a solute that lowers the freezing point of the water-based ice cream mix -- a colligative property that depends on the number of dissolved particles, not their identity.

46. **Correct Answer: B**

Freezing point depression depends on the total number of dissolved particles (the van't Hoff factor). A solute like NaCl that dissociates into two ions per formula unit produces roughly double the freezing point depression, per mole dissolved, compared to a non-dissociating solute like sucrose.

47. **Sample/Acceptable Answer:**

Casein's isoelectric point is approximately pH 4.6. This pH is significant because at this point, casein molecules have no net electrical charge, so they no longer repel one another and can clump (coagulate) together. This is the underlying chemistry behind acid-based coagulation used to make products such as cottage cheese, cream cheese, and yogurt.

48. **Sample/Acceptable Answer:**

Acid-set curds (such as cottage cheese) tend to be softer, more crumbly, and retain more moisture than rennet-set curds, which tend to form a firmer, more elastic gel structure that can be pressed and aged. Acid coagulation works by lowering milk's pH toward casein's isoelectric point (~pH 4.6), at which point

casein molecules lose their net charge and precipitate out of solution as soft curds, rather than being enzymatically cross-linked the way rennet-coagulated curds are.

49. Correct Answer: B

Rennet coagulation produces a firmer, more elastic curd structure (compared to the softer curd from acid coagulation), which is better suited to being pressed, shaped, and aged into firm cheeses.

50. Sample/Acceptable Answer:

Answers will vary depending on the task chosen; award full credit for a correct, complete chemical explanation. Sample answer (Ice Cream): Making ice cream relies on freezing point depression -- dissolved salt in the ice bath lowers the freezing point of the surrounding ice/water mixture below 0°C, allowing it to draw heat from and freeze the milk/cream/sugar mixture inside the bag. Understanding this helps a team predict that adding more salt (up to a point) or using a colder starting temperature will freeze the mixture faster and potentially yield a taller, firmer ice cream sample, improving their lab score. (Equivalent credit for a correct explanation of curd mass, based on acid coagulation of casein near its isoelectric point, or milk fat mass from cream, based on physically disrupting fat globule membranes through agitation/churning to coalesce milk fat into butter.)

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
State Exam

Team Name: _____ Team Number: _____

- This exam contains 50 questions: 35 multiple choice, 5 multiselect (select ALL correct answers), and 10 short answer.
- Eight questions (Q2, Q8, Q11, Q12, Q16, Q18, Q24, Q30) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; State Tournament teams complete one or two Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which of the following is closest to whole milk's typical specific gravity (density relative to water)?

A. 0.85
B. 1.03
C. 1.50
D. 2.00

2. Refer to Image 1, a photograph of a lactometer. This instrument is used to quickly screen raw milk for:



Image 1

A. Bacterial contamination
B. Possible dilution with added water, based on milk's density
C. Fat percentage exclusively
D. Vitamin content

3. A lactometer's reading is based on which physical principle?

A. Archimedes' principle of buoyancy
B. Newton's third law
C. Osmosis
D. Capillary action

4. Explain why adding water to raw milk lowers its measured density, and describe how a lactometer reading could indicate this form of adulteration.

5. Because added water measurably raises milk's freezing point (bringing it closer to 0°C, water's freezing point), a laboratory cryoscope test that measures a milk sample's freezing point can be used to detect:

A. Fat content
B. Possible addition of water
C. Vitamin fortification levels
D. Bacterial count

6. The original, slower method of pasteurization, sometimes called batch or vat pasteurization (LTLT, "Low Temperature Long Time"), typically heats milk to approximately:

A. 63°C for 30 minutes
B. 72°C for 15 seconds
C. 138°C for 2 seconds
D. 100°C for 1 hour

7. Select ALL statements that are TRUE about batch (vat/LTLT) pasteurization compared to HTST pasteurization. (Select ALL that apply.)

A. Batch pasteurization uses a lower temperature held for a longer time.
B. Batch pasteurization is generally slower and less suited to high-volume continuous processing.
C. Batch pasteurization uses a higher temperature than HTST.
D. Both methods are legally recognized ways of achieving pasteurization.
E. Batch pasteurization cannot ever adequately destroy pathogens.

8. Refer to Image 2, a photograph of cottage cheese. Cottage cheese curd is traditionally formed using which coagulation method?

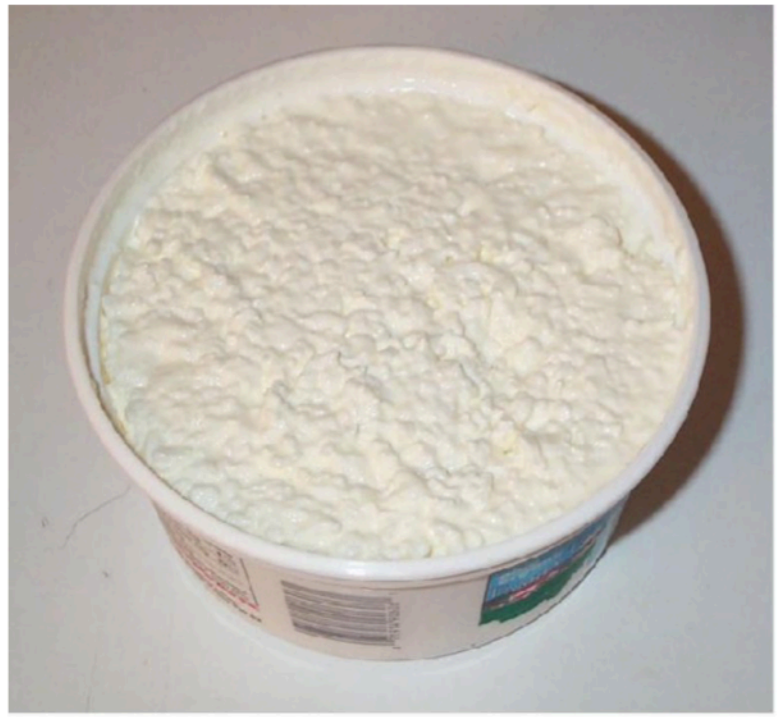


Image 2

A. Acid coagulation
B. Rennet coagulation only
C. Ultra-filtration
D. Reverse osmosis

9. Cottage cheese is commonly sold in "small curd" and "large curd" varieties, which primarily differ in:

A. The size the curd is cut into before cooking, affecting the final texture
B. The type of milk used
C. The amount of salt added
D. The cooking temperature only

10. Describe the general process used to make cottage cheese, from acid coagulation through the addition of "creaming" (dressing), and explain why cottage cheese is classified as an unaged (fresh) cheese.

11. Refer to Image 3, a photograph of cream cheese. Under FDA Standards of Identity, the primary difference between cream cheese and Neufchâtel cheese is that Neufchâtel:



Image 3

A. Contains significantly less milkfat than cream cheese
B. Contains no dairy ingredients
C. Is always aged for 60 days
D. Is made exclusively from goat milk

12. Refer to Image 4, the chemical structure of retinol. Retinol is the chemical name for which fat-soluble vitamin naturally found in milk fat?

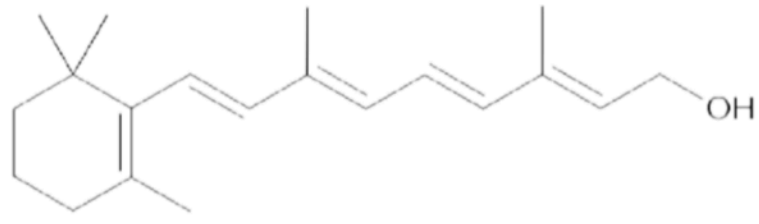


Image 4

A. Vitamin A
B. Vitamin B12
C. Vitamin C
D. Vitamin K

13. Because Vitamin A is fat-soluble and travels with milk fat, why must skim and low-fat milk be fortified with Vitamin A during processing?

A. Removing fat during processing also removes most of the milk's naturally occurring Vitamin A
B. Skim milk naturally contains too much Vitamin A
C. Vitamin A is water-soluble and washes out during pasteurization
D. Fortification is required by law purely for flavor reasons

14. Select ALL statements that are TRUE about Vitamin A in dairy products. (Select ALL that apply.)

A. Vitamin A is fat-soluble and associated with milk fat.
B. Whole milk naturally contains more Vitamin A than skim milk before fortification.
C. A severe, prolonged Vitamin A deficiency can contribute to vision problems such as night blindness.
D. Vitamin A is added to skim and low-fat milk to compensate for fat removal.
E. Vitamin A is a water-soluble vitamin, like Vitamin C.

15. Beta-carotene, a plant pigment sometimes discussed alongside Vitamin A, is significant in dairy science because it:

A. Is a precursor the body can convert into Vitamin A, and contributes to the yellow-orange color of butter/cheese from grass-fed cows
B. Has no relationship to Vitamin A
C. Is only found in skim milk
D. Destroys Vitamin A on contact

16. Refer to Image 5, a photograph of latte art created in steamed milk microfoam. Explain, at the protein level, how steaming and frothing milk creates a stable microfoam, and identify which class of milk protein is primarily responsible for stabilizing the tiny air bubbles.



Image 5

17. Which milk type generally produces the most voluminous foam when steamed, due to its lower fat content interfering less with protein's ability to stabilize air bubbles?

A. Whole milk
B. Skim (nonfat) milk
C. Heavy cream
D. Half-and-half

18. Refer to Image 6, a photograph of the cardoon (Cynara cardunculus) thistle in bloom. Extracts from this plant have historically been used as a source of:



Image 6

A. Plant-based (vegetable) rennet, providing an alternative coagulating enzyme for cheesemaking
B. Artificial food coloring
C. Lactase enzyme
D. Casein protein

19. Cheese made using a plant-based (vegetable) rennet, such as one derived from cardoon thistle, is often favored for:

A. Vegetarian cheesemaking, since no animal-derived coagulating enzyme is used
B. Producing lactose-free cheese
C. Eliminating the need for salt
D. Making cheese without any milk at all

20. Compared to cheese made with traditional animal or microbial rennet, cheese made with certain plant-based rennets, such as thistle rennet, is sometimes noted for developing a:

A. Identical flavor profile in every case
B. Slightly more bitter or distinctively different flavor profile during aging
C. Complete lack of any flavor
D. Sweeter flavor than added sugar

21. Select ALL statements that are TRUE about rennet sources used in cheesemaking. (Select ALL that apply.)

A. Traditional rennet is extracted from the stomach lining of young ruminant animals.
B. Fermentation-produced chymosin (FPC) is produced by genetically engineered microorganisms.
C. Vegetable rennet can be extracted from certain plants, such as cardoon thistle.
D. All rennet, regardless of source, is chemically identical with no functional differences.
E. The rennet source used can affect whether a cheese is considered vegetarian.

22. Explain what a "colloidal calcium phosphate" (CCP) bridge is within a casein micelle, and describe its role in holding the micelle's structure together.

23. If colloidal calcium phosphate is removed from a casein micelle (for example, by adding a calcium-chelating agent), the micelle structure generally:

A. Becomes more stable and rigid
B. Becomes destabilized and can partially disintegrate
C. Is completely unaffected
D. Converts entirely into whey protein

24. Refer to Image 7, a photograph of a whole wheel of soft-ripened cheese with a natural rind, sliced open to show the rind and interior paste. Cheeses aged this way, developing a hard, dry, unwaxed "natural rind" directly from their own surface, generally require which of the following during aging?



Image 7

A. No maintenance whatsoever

B. Regular turning, brushing, and humidity/temperature control to manage surface mold and moisture loss

C. Constant storage below freezing

D. Complete submersion in brine for the entire aging period

25. Compared to a wax-coated cheese, a cheese aged with a natural (unwaxed) rind will generally:

A. Lose more moisture through its surface over time, requiring more careful humidity control during aging

B. Never lose any moisture

C. Age at an uncontrollably fast rate regardless of conditions

D. Require identical care to a wax-coated cheese

26. The specific combination of temperature and humidity maintained in a cheese aging cellar or cave primarily affects:

A. Nothing measurable about the cheese

B. The rate of moisture loss, microbial activity, and enzymatic ripening reactions within the cheese

C. Only the cheese's color, with no effect on flavor or texture

D. The cheese's lactose content exclusively

27. Homogenization is typically achieved by forcing warm milk at high pressure through a narrow valve gap. This process breaks fat globules into smaller sizes primarily through:

A. Intense shear and turbulence forces as the milk is forced through the narrow gap
B. Freezing the fat globules solid
C. Chemical dissolution of the fat
D. Adding extra water to dilute the fat

28. Explain why reducing the size of fat globules during homogenization helps prevent cream from separating out of milk during storage, referencing the physical principle involved.

29. Homogenized milk, compared to non-homogenized (cream-line) milk, has fat globules that are:

A. Much larger on average
B. Much smaller and more uniform in size
C. Completely removed
D. Chemically converted into protein

30. Refer to Image 8, a photograph of Greek yogurt. Compared to regular (unstrained) yogurt, Greek yogurt has undergone an additional straining step that:



Image 8

A. Removes much of the liquid whey, concentrating the remaining protein and creating a thicker texture
B. Adds extra lactose
C. Adds extra water
D. Removes all protein from the yogurt

31. Select ALL statements that are TRUE about Greek yogurt compared to regular (unstrained) yogurt. (Select ALL that apply.)

A. Greek yogurt generally has a higher protein concentration per serving.
B. Greek yogurt is produced by straining out much of the liquid whey.
C. Straining removes some lactose along with the whey.
D. Greek yogurt always contains added thickening gums instead of being strained.
E. Greek yogurt generally has a thicker, denser texture than regular yogurt.

32. One byproduct of Greek yogurt production at commercial scale is a large volume of acid whey, which presents a processing/environmental challenge similar to the byproduct whey generated during:

A. Butter churning
B. Cheesemaking
C. Homogenization
D. Pasteurization

33. Non-dairy coffee creamers, unlike real dairy cream, typically achieve a creamy mouthfeel using:

A. Milk fat exclusively
B. Vegetable oil, along with emulsifiers and stabilizers such as sodium caseinate or carrageenan
C. Only water and sugar
D. Casein protein extracted from cheese whey exclusively

34. Some non-dairy coffee creamers list "sodium caseinate" as an ingredient, even though the product is marketed as non-dairy or lactose-free. Explain why sodium caseinate is derived from milk, and why a product containing it may still be inappropriate for someone with a true milk protein allergy, despite being labeled lactose-free.

35. The term "non-dairy," as used on some U.S. food labels, is regulated more loosely than "dairy-free," and a product labeled "non-dairy" may still legally:

A. Contain a milk-derived ingredient such as sodium caseinate
B. Never contain any milk-derived ingredient under any circumstances
C. Only be sold in liquid form
D. Always be certified organic

36. Milk naturally contains a small amount of the enzyme lipase, which can break down milk fat into free fatty acids, contributing to rancid off-flavors if not properly inactivated. Lipase is primarily inactivated during milk processing by:

A. Homogenization
B. Pasteurization (heat treatment)
C. Refrigeration alone
D. Adding sugar

37. The alkaline phosphatase test, used in quality control at dairy processing plants, is significant because this naturally occurring milk enzyme is:

A. Destroyed by proper pasteurization, so a negative phosphatase test result helps confirm that pasteurization was correctly performed
B. Completely unaffected by any heat treatment
C. Only found in cheese, not milk
D. Added artificially to milk after pasteurization

38. Select ALL statements that are TRUE about the alkaline phosphatase test used in dairy quality control. (Select ALL that apply.)

A. It is used to verify that milk has been properly pasteurized.
B. Alkaline phosphatase is a naturally occurring enzyme in raw milk.
C. A positive phosphatase test (enzyme still active) can indicate under-pasteurization or contamination with raw milk.
D. The test measures milk's fat percentage.
E. Properly pasteurized milk should test negative for active alkaline phosphatase.

39. If a batch of milk labeled as pasteurized tests POSITIVE for active alkaline phosphatase, this most likely indicates:

A. The milk was properly and fully pasteurized
B. The milk may have been under-pasteurized or contaminated with raw milk after processing
C. The milk has an unusually high vitamin content
D. The test result has no food-safety significance

40. Lipase and alkaline phosphatase are both naturally occurring milk enzymes, but they serve very different practical purposes in dairy science: lipase mainly as a potential source of off-flavors, and alkaline phosphatase mainly as a quality-control indicator. Describe ONE practical use of each enzyme's behavior in the dairy industry.

41. Light cream (sometimes called coffee cream), as defined by FDA Standards of Identity, generally contains a minimum milkfat percentage of approximately:

A. 2%
B. 18%
C. 36%
D. 50%

42. Light whipping cream and heavy whipping cream both contain enough milkfat to whip into stable peaks, but heavy whipping cream contains:

A. Less milkfat than light whipping cream
B. More milkfat than light whipping cream, generally producing a more stable, stiffer whipped foam
C. Identical milkfat to light whipping cream
D. No milkfat at all

43. When cream is whipped, its "overrun" (percentage increase in volume from incorporated air) is generally:

A. Impossible to measure
B. Roughly double (about a 100% increase) for well-whipped cream, meaning the whipped volume is about twice the original liquid volume
C. Always negative, meaning the volume decreases
D. Unrelated to the cream's fat content

44. Explain why heavy cream (with its higher fat content) generally whips into a more stable foam than light cream, referencing the role of fat globules in stabilizing whipped foam.

45. Leucine, a branched-chain amino acid particularly abundant in whey protein and often highlighted in sports nutrition marketing, is significant because it:

A. Plays a key role in stimulating muscle protein synthesis
B. Has no known biological function
C. Is only found in plant proteins
D. Causes lactose intolerance

46. The formation of a thin "skin" on the surface of milk that has been heated (such as when scalding milk on a stovetop) is primarily caused by:

A. Evaporation-driven concentration and denaturation of proteins at the milk's surface
B. Freezing of the milk's surface
C. A chemical reaction with the cooking pot's metal
D. Bacterial growth occurring on the surface during heating

47. Explain why heating milk on a stovetop (such as when scalding milk for a recipe) tends to form a thin protein "skin" on the surface, and suggest ONE practical technique, based on this chemical understanding, that could help reduce skin formation.

48. Milk's pH is typically around 6.6-6.8 (slightly acidic), while yogurt's pH is typically much lower, around 4.0-4.5. This drop in pH during yogurt fermentation is caused by:

A. Bacterial fermentation of lactose into lactic acid
B. Addition of citric acid from fruit
C. Removal of all protein from the milk
D. Addition of table salt

49. Aged cheeses can vary widely in pH depending on their production method. Compared to a fresh acid-set cheese like cottage cheese, a well-aged, rennet-set hard cheese like Parmesan generally has a pH that is:

A. Always identical to cottage cheese
B. Often somewhat higher (closer to neutral), because further ripening processes can raise pH back somewhat over time
C. Always far more acidic than fresh cottage cheese
D. Impossible to measure in a solid cheese

50. Compare the typical pH ranges of fresh milk, yogurt, and aged hard cheese, and explain in general terms why these dairy products differ so much in acidity despite all originating from the same starting ingredient (milk).

ANSWER KEY

FOOD SCIENCE – DIVISION B – STATE EXAM (FORM 2)

1. **Correct Answer: B**

   Whole milk is slightly denser than water, with a typical specific gravity of approximately 1.03.

2. **Correct Answer: B**

   A lactometer measures milk's density; because adding water lowers milk's density, a lactometer reading below the expected range can indicate possible water adulteration.

3. **Correct Answer: A**

   A lactometer is a type of hydrometer that floats at a depth determined by the buoyant force acting on it, per Archimedes' principle, allowing density to be read from a calibrated scale.

4. **Sample/Acceptable Answer:**

   Water has a lower density (specific gravity of exactly 1.00) than milk's naturally denser mixture of fat, protein, lactose, and minerals dissolved/suspended in water (specific gravity around 1.03). Diluting milk with added water shifts the overall mixture's density closer to that of pure water, lowering the measured specific gravity below the expected range for genuine, undiluted milk. Because a lactometer floats deeper in a less dense liquid, a lactometer reading noticeably lower than the expected value for milk can suggest that the sample has been diluted with water.

5. **Correct Answer: B**

   Genuine milk has a slightly lower (more negative) freezing point than pure water due to dissolved solutes; added water raises (moves closer to 0°C) the measured freezing point, so cryoscope testing can help detect water adulteration.

6. **Correct Answer: A**

   Batch (vat/LTLT) pasteurization typically heats milk to about 63°C (145°F) and holds it there for 30 minutes, a slower alternative to HTST or UHT methods.

7. **Correct Answers: A, B, D**

   Batch pasteurization uses a lower temperature for a longer time and is slower/less suited to continuous high-volume processing, but is a legally recognized pasteurization method that does adequately destroy pathogens when properly performed.

8. **Correct Answer: A**

   Cottage cheese is traditionally made by acid-coagulating skim milk, producing soft curds that are then cut, cooked, drained, and typically mixed with a creamy dressing.

9. **Correct Answer: A**

   "Small curd" and "large curd" cottage cheese differ mainly in how finely the coagulated curd is cut before cooking, which affects the size and texture of the final curd pieces.

10. **Sample/Acceptable Answer:**

    To make cottage cheese, skim milk is acidified (using a starter culture and/or direct acidification) until the casein coagulates into soft curds, which are then cut into pieces, gently cooked/heated to firm them, and drained to separate the curds from the whey. The drained curds are typically rinsed, then mixed with a "creaming" dressing (a light cream mixture) and salt to add flavor and richness. Cottage cheese is classified as an unaged (fresh) cheese because it is consumed shortly after production, without any extended ripening or aging period during which enzymes and bacteria would further transform its flavor and texture.

11. **Correct Answer: A**

    Neufchâtel, as legally defined in the U.S., must contain significantly less milkfat than cream cheese, giving it a lighter texture and fewer calories per serving.

12. **Correct Answer: A**

Retinol is the chemical name for Vitamin A, a fat-soluble vitamin naturally associated with milk fat.

13. **Correct Answer: A**

    Because Vitamin A is fat-soluble, removing milk fat (to make skim or low-fat milk) also removes most of the naturally associated Vitamin A, making fortification necessary to restore adequate levels.

14. **Correct Answers: A, B, C, D**

    Vitamin A is fat-soluble (not water-soluble), naturally more abundant in whole milk than skim milk before fortification, linked to vision health with severe deficiency causing night blindness, and added to reduced-fat milks to compensate for fat removal.

15. **Correct Answer: A**

    Beta-carotene, obtained from a cow's diet (especially fresh grass/forage), is a precursor the body can convert into Vitamin A, and it also contributes to the characteristic yellow-orange color seen in butter and cheese from grass-fed cows.

16. **Sample/Acceptable Answer:**

    When milk is steamed, steam injects heat and tiny air bubbles into the milk while agitating it. The heat and mechanical agitation partially denature (unfold) whey proteins, exposing both hydrophilic and hydrophobic regions of the protein; these unfolded proteins migrate to and coat the surface of the tiny air bubbles, forming a stabilizing protein film around each bubble, similar to how proteins stabilize other foams like whipped egg whites. Whey proteins are primarily responsible for stabilizing this fine, stable "microfoam" texture, which is what allows a barista to hold and pour a defined pattern for latte art.

17. **Correct Answer: B**

    Skim (nonfat) milk generally produces the largest volume of foam when steamed, since fat can interfere with the protein film's ability to fully stabilize air bubbles, though whole milk foam is often prized for a creamier, more stable microfoam texture.

18. **Correct Answer: A**

    Extracts from cardoon thistle flowers contain plant-based coagulating enzymes that have traditionally been used as a vegetable rennet alternative in certain regional cheesemaking traditions, particularly in parts of Spain and Portugal.

19. **Correct Answer: A**

    Because vegetable rennet comes from a plant source rather than an animal, cheese made with it can be marketed as vegetarian.

20. **Correct Answer: B**

    Plant-based rennets can have somewhat different proteolytic activity than animal or microbial rennet, which can contribute to a distinctively different, sometimes slightly more bitter, flavor profile as the cheese ages.

21. **Correct Answers: A, B, C, E**

    Traditional, microbial (FPC), and vegetable (plant-derived) rennets are all real sources used in cheesemaking, and the source used affects whether the resulting cheese can be marketed as vegetarian. Different rennet sources are not chemically identical and can behave somewhat differently.

22. **Sample/Acceptable Answer:**

    Within a casein micelle, colloidal calcium phosphate refers to small clusters of calcium and phosphate ions embedded throughout the micelle's structure. These mineral clusters act as chemical bridges that help link individual casein sub-units (particularly alpha-s-casein and beta-casein) together, contributing to the overall structural integrity and stability of the micelle, in addition to the surface stabilization role provided by kappa-casein.

23. **Correct Answer: B**

    Removing colloidal calcium phosphate disrupts the internal mineral bridges holding the casein micelle together, generally destabilizing the structure and causing it to partially disintegrate.

24. Correct Answer: B

Natural-rind cheeses require active management during aging -- including regular turning, brushing, and careful control of cellar humidity and temperature -- to manage surface mold growth and moisture loss as the rind develops.

25. Correct Answer: A

Because a natural rind is more porous/permeable than a sealed wax coating, natural-rind cheeses lose more moisture through the surface during aging, requiring more careful humidity management in the aging environment.

26. Correct Answer: B

Aging temperature and humidity directly influence how quickly moisture is lost from the cheese, how actively surface and internal microorganisms grow, and how quickly enzymatic ripening reactions proceed, all of which shape the final flavor and texture.

27. Correct Answer: A

Forcing milk at high pressure through a narrow homogenizer valve creates intense shear and turbulence forces that mechanically break large fat globules into much smaller, more uniform droplets.

28. Sample/Acceptable Answer:

Cream separation occurs because larger fat globules are more buoyant and rise more quickly through milk, since larger particle size increases the rate at which a less-dense particle rises through a denser fluid (related to Stokes' Law). By mechanically breaking fat globules into much smaller, more uniformly sized particles during homogenization, their rate of rise is dramatically slowed, allowing them to stay evenly dispersed throughout the milk for a much longer time rather than quickly separating into a visible cream layer at the top.

29. Correct Answer: B

Homogenization mechanically breaks fat globules into much smaller, more uniformly sized particles compared to non-homogenized milk, where larger fat globules remain and can rise to form a visible cream line.

30. Correct Answer: A

Straining removes much of the liquid whey from fermented yogurt, concentrating the remaining protein and solids and producing Greek yogurt's characteristically thick texture.

31. Correct Answers: A, B, C, E

Straining concentrates protein, removes whey (and some lactose along with it), and produces a thicker texture. True Greek yogurt is strained rather than thickened with added gums, though some "Greek-style" products do use added thickeners instead.

32. Correct Answer: B

Like traditional cheesemaking, straining yogurt to make Greek yogurt produces a large volume of leftover whey, presenting similar handling, utilization, or disposal challenges at commercial scale.

33. Correct Answer: B

Non-dairy creamers typically use vegetable oil in place of milk fat, along with emulsifiers and stabilizers (which may include milk-derived sodium caseinate or plant-derived carrageenan) to mimic cream's mouthfeel.

34. Sample/Acceptable Answer:

Sodium caseinate is a milk-derived ingredient made by treating casein protein to make it more water-soluble; it is often used as an emulsifier/whitener in non-dairy creamers. Even though such a product may be free of lactose (making it suitable for someone who is only lactose intolerant), sodium caseinate still contains milk protein. Because a true milk protein allergy is an immune reaction to milk proteins like casein, rather than an inability to digest lactose, a product containing sodium caseinate could still trigger an allergic reaction in someone with a genuine milk protein allergy, even if the product is labeled "non-dairy" or "lactose-free."

35. Correct Answer: A

Under U.S. labeling rules, "non-dairy" is not as strictly defined as "dairy-free," and products labeled "non-dairy" can still legally contain certain milk-derived ingredients such as sodium caseinate.

36. Correct Answer: B

The heat treatment used in pasteurization denatures and inactivates naturally occurring lipase enzyme, helping prevent the hydrolytic rancidity that unchecked lipase activity would otherwise cause.

37. Correct Answer: A

Alkaline phosphatase is reliably inactivated by proper pasteurization, so testing for its absence (a negative result) provides a simple, standardized way to confirm that milk has been adequately heat-treated.

38. Correct Answers: A, B, C, E

The phosphatase test verifies proper pasteurization; alkaline phosphatase occurs naturally in raw milk; a positive result can indicate under-pasteurization or raw-milk contamination; and properly pasteurized milk should test negative. The test does not measure fat percentage.

39. Correct Answer: B

A positive phosphatase result on milk labeled as pasteurized suggests it may not have been adequately heat-treated, or that it was contaminated with raw milk after pasteurization -- either way, a food-safety concern worth investigating.

40. Sample/Acceptable Answer:

Lipase, if not inactivated, breaks down milk fat into free fatty acids that can cause rancid off-flavors, so dairy processors rely on pasteurization's heat treatment to inactivate lipase and prevent this flavor defect from developing during storage and shelf life. Alkaline phosphatase, in contrast, is not itself a flavor or spoilage concern; instead, because it happens to be reliably destroyed by proper pasteurization heat treatment, dairy processors use a simple phosphatase test as a quality-control indicator: if the enzyme is inactive (test negative), that result helps confirm the milk was heated sufficiently to achieve proper pasteurization.

41. Correct Answer: B

Light cream is generally defined as containing at least about 18% milkfat, distinguishing it from lower-fat half-and-half and higher-fat whipping/heavy creams.

42. Correct Answer: B

Heavy whipping cream contains a higher milkfat percentage than light whipping cream, generally allowing it to whip into a more stable, stiffer foam.

43. Correct Answer: B

Well-whipped cream typically roughly doubles in volume (about 100% overrun) due to air incorporated during whipping, and this overrun is closely related to the cream's fat content and how it is whipped.

44. Sample/Acceptable Answer:

Heavy cream contains a higher concentration of milk fat globules than light cream. When whipped, these fat globules partially coalesce -- clumping together at their disrupted membrane surfaces -- and form a supportive, semi-solid network around the air bubbles being incorporated. Because heavy cream has more fat globules available to build this network, it can form a denser, more extensive, and more stable structural framework than light cream, resulting in stiffer peaks and a more stable whipped foam; light cream, lacking enough fat globules to build as strong a supporting structure, whips into a much less stable foam or may not hold stiff peaks at all.

45. Correct Answer: A

Leucine is a branched-chain amino acid found in relatively high concentration in whey protein and is recognized for its role in stimulating muscle protein synthesis, a key reason whey protein is popular in sports nutrition products.

46. Correct Answer: A

As milk heats, evaporation from the surface concentrates milk solids there, and heat-driven protein denaturation at that exposed, concentrated surface layer forms the characteristic thin "skin."

47. Sample/Acceptable Answer:

As milk heats, water evaporates from its surface, which concentrates the milk solids (proteins and minerals) there; combined with heat-driven denaturation of proteins at the exposed surface, this creates a thin, coagulated protein layer -- the "skin." A practical technique to reduce this, based on this understanding, is to stir the milk periodically as it heats (redistributing the concentrated surface layer back into the bulk milk) or to cover the pot to reduce surface evaporation, both of which limit the buildup of concentrated, denatured protein at the surface.

48. Correct Answer: A

Lactic acid bacteria ferment lactose into lactic acid during yogurt production, which is what lowers the product's pH from milk's near-neutral range down to yogurt's more acidic range.

49. Correct Answer: B

While rennet-set cheeses also acidify somewhat during production, extended aging/ripening (including microbial and enzymatic activity that metabolizes acids and produces buffering compounds) can raise a hard aged cheese's pH back somewhat closer to neutral compared to a fresh, unaged acid-set cheese like cottage cheese.

50. Sample/Acceptable Answer:

Fresh milk has a pH around 6.6-6.8 (only mildly acidic); yogurt is much more acidic, typically around pH 4.0-4.5, because bacterial fermentation converts much of milk's lactose into lactic acid, which accumulates since the product is not aged further after fermentation. Aged hard cheeses can vary but are often somewhat less acidic than fresh yogurt, because although initial lactic acid fermentation also lowers their pH during cheesemaking, further ripening/aging (including the activity of aging bacteria and enzymes that metabolize lactic acid and produce buffering compounds) can gradually raise the pH back somewhat closer to neutral over weeks or months of aging. These differences arise because each product undergoes a different combination of fermentation intensity, aging time, and microbial activity, even though they all start from the same base ingredient, milk.

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
National Exam

Team Name: _____ Team Number: _____

- This exam contains 80 questions: 60 multiple choice, 5 multiselect (select ALL correct answers), 10 short answer, and 5 long answer.
- Ten questions (Q2, Q14, Q20, Q26, Q38, Q40, Q48, Q50, Q60, Q62) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write a concise response in the space provided. For long answer questions, write a complete, multi-part response addressing every part of the prompt in the larger space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; National Tournament teams complete all Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Besides water, fat, protein, and lactose, what term describes the collective mineral content that remains after milk is completely combusted (burned off)?

A. Ash
B. Slag
C. Residue
D. Curd

2. Refer to Image 1, a photo of Holstein dairy cows, the most common dairy breed in the U.S. Compared to other common dairy breeds such as Jersey, Holstein milk is generally characterized by:



Image 1

A. Higher milk volume but relatively lower butterfat percentage
B. Lower milk volume and lower butterfat percentage
C. The highest butterfat percentage of any dairy breed
D. No measurable compositional difference from other breeds

3. Which term describes a genetic variant of beta-casein found in some cow's milk that has been marketed (though not conclusively proven scientifically) as easier to digest than conventional milk?

A. A2 beta-casein
B. Kappa-casein
C. Alpha-lactalbumin
D. Rennet casein

4. Explain what the term "A2 milk" refers to, and briefly describe why scientific evidence for its claimed digestive benefits is still considered limited or inconclusive.

5. The membrane that surrounds each milk fat globule, composed largely of phospholipids and proteins, is known as the:

A. Casein micelle
B. Milk fat globule membrane (MFGM)

C. Whey protein complex
D. Lactose shell

6. Phospholipids, a key component of the milk fat globule membrane, are unique among milk lipids because they:

A. Contain both hydrophilic and hydrophobic regions, allowing them to stabilize the fat-water interface
B. Are entirely hydrophobic, like triglycerides
C. Are a type of protein rather than a lipid
D. Are entirely water-soluble simple sugars

7. Oxidative rancidity in milk fat, which produces off-flavors, primarily occurs through a reaction between unsaturated fatty acids and:

A. Oxygen
B. Nitrogen gas
C. Carbon dioxide
D. Calcium

8. Select ALL factors that can accelerate oxidative rancidity (off-flavor development) in milk and dairy fats. (Select ALL that apply.)

A. Exposure to light
B. Exposure to oxygen
C. Presence of trace metal ions (e.g., copper, iron)
D. Consistent, proper refrigeration temperatures
E. Complete absence of unsaturated fatty acids

9. Milk's slightly yellow-green fluorescent pigment, riboflavin (Vitamin B2), is significant in dairy processing because it:

A. Is degraded by exposure to light, contributing to off-flavors in light-exposed milk
B. Has no sensitivity to light at all
C. Is entirely destroyed by pasteurization
D. Is only found in skim milk, not whole milk

10. Which packaging characteristic helps protect milk from light-induced riboflavin degradation and off-flavor development?

A. Clear glass bottles
B. Opaque or pigmented plastic or cardboard packaging
C. Thin, fully transparent plastic film
D. Milk does not need any light protection

11. According to FDA Standards of Identity, butter sold in the United States must contain at least what minimum percentage of milkfat?

A. 50%
B. 65%
C. 80%
D. 95%

12. Explain what a "Standard of Identity" is in U.S. food regulation, and give ONE example of how it applies to a dairy product.

13. Under FDA regulations, "heavy cream" or "heavy whipping cream" must contain a minimum milkfat percentage of approximately:

A. 10%
B. 18%
C. 30%
D. 36%

14. Refer to Image 2, a photo of a Jersey cow. Jersey cattle are widely known in the dairy industry for producing milk with a relatively:



Image 2

A. Lower fat and protein percentage than Holstein milk
B. Higher fat and protein percentage than Holstein milk
C. Composition identical to Holstein milk
D. Complete absence of milkfat

15. Somatic cell count (SCC) in raw milk is primarily used by the dairy industry as an indicator of:

A. Milk's calcium content
B. Udder health and potential mastitis infection
C. Milk's lactose content
D. The cow's breed

16. Discuss the importance of somatic cell count (SCC) testing in the dairy industry. In your answer: define what somatic cells are, explain what an elevated SCC indicates about herd health, and describe how a high SCC can affect milk quality and downstream dairy processing (such as cheese yield or shelf life).

17. Standard Plate Count (SPC) is a laboratory test used to estimate which of the following in raw milk?

A. Total bacterial count
B. Fat percentage
C. Lactose concentration
D. pH

18. The Grade "A" Pasteurized Milk Ordinance (PMO) is a model regulatory document primarily used to establish:

A. International trade tariffs on dairy products
B. Uniform sanitation and safety standards for Grade A milk production and processing in the U.S.
C. Genetic breeding standards for dairy cattle
D. Global milk pricing agreements

19. Which federal agency has primary regulatory authority over the safety and labeling of most fluid milk and dairy products in the United States?

A. USDA
B. FDA
C. EPA
D. CDC

20. Refer to Image 3, a photograph of blue cheese showing characteristic blue-green veining. Identify the genus of mold most commonly responsible for this veining, and briefly explain how it is typically introduced into the cheese during production.



Image 3

21. HACCP, a food safety management system used in dairy processing, stands for:
    A. Hazard Analysis and Critical Control Points
    B. High Acid Concentration Control Protocol
    C. Health and Cleanliness Certification Process
    D. Homogenization and Cream Control Procedure

22. Soft, unpasteurized, or improperly aged cheeses carry an elevated food safety risk primarily from which bacterium, of particular concern to pregnant women?
    A. Lactobacillus
    B. Listeria monocytogenes
    C. Penicillium roqueforti
    D. Streptococcus thermophilus

23. Mandatory milk pasteurization laws in the early-to-mid 20th century United States were adopted largely in response to public health concerns about which diseases historically transmitted through raw milk?
    A. The common cold and influenza
    B. Tuberculosis and brucellosis
    C. Lactose intolerance
    D. Adverse reactions to food coloring

24. Select ALL statements that are TRUE regarding raw (unpasteurized) milk. (Select ALL that apply.)
    A. Raw milk carries a higher risk of harmful bacterial contamination than pasteurized milk.
    B. Pasteurization destroys essentially all of milk's nutritional value.

C. Young children, older adults, pregnant women, and immunocompromised individuals face higher risk from raw milk consumption.
D. Sale of raw milk for direct human consumption is regulated differently across U.S. states.
E. Raw milk cannot legally be used to produce any cheese sold in the United States.

25. Bactofugation is a dairy processing technique that uses centrifugal force to:

A. Add bacterial cultures to milk for fermentation
B. Remove bacterial spores and somatic cells from raw milk
C. Whip air into cream
D. Measure milk's acidity

26. Refer to Image 4, a diagram of a titration setup. Titratable acidity testing, commonly used in dairy quality control for cultured products, measures milk's acidity by:

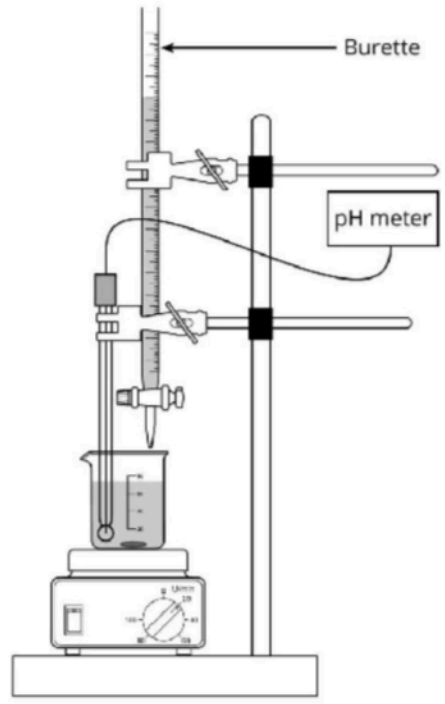


Image 4

A. Adding a measured base (such as NaOH) until a color-change endpoint is reached, then calculating acid content from the volume used
B. Measuring electrical conductivity only
C. Weighing the milk sample before and after heating
D. Observing the milk's color under UV light

27. Which best describes the difference between pH and titratable acidity (TA) when evaluating milk or cultured dairy products?

A. pH and TA measure exactly the same property and are interchangeable
B. pH measures the concentration of free hydrogen ions, while TA measures the total amount of acid (free and bound) that can be neutralized by a base
C. TA can only be measured electronically, while pH is only measured by titration
D. pH only applies to liquid samples, and TA only applies to solid samples

28. Explain why titratable acidity (TA), rather than pH alone, is often considered a more useful measurement for tracking fermentation progress in cultured dairy products like yogurt.

29. Most rennet used in commercial cheesemaking today is produced by which method?

A. Extracted exclusively from calf stomachs
B. Fermentation-produced chymosin (FPC) from genetically engineered microorganisms
C. Synthesized entirely from plant cellulose
D. Extracted directly from milk itself

30. Cheese made using fermentation-produced chymosin (FPC) instead of traditional animal rennet is often marketed as:

A. Non-dairy
B. Vegetarian
C. Lactose-free
D. Organic

31. Conjugated linoleic acid (CLA), a fatty acid naturally found in dairy fat, is of research interest primarily because it:

A. Has no known biological activity
B. Has been studied for potential health effects, including anti-inflammatory properties
C. Causes milk to spoil more quickly
D. Is only found in plant oils, not dairy

32. Milk fat contains a complex mixture of fatty acids, including saturated fats, unsaturated fats, and minor bioactive compounds like conjugated linoleic acid (CLA). Explain the general structural difference between saturated and unsaturated fatty acids, describe what makes CLA structurally unique among unsaturated fatty acids, and discuss why milk fat's fatty acid profile can vary based on a cow's diet.

33. Compared to grain-fed dairy cows, grass-fed dairy cows generally produce milk with:

A. A lower omega-3 fatty acid content
B. A higher omega-3 fatty acid content

C. No measurable difference in fatty acid profile
D. Higher lactose content only

34. In milk processing, "standardization" refers to the process of:

A. Adjusting milk's fat content to a specific target percentage by adding or removing cream
B. Adding vitamins to milk
C. Pasteurizing milk at a standardized temperature
D. Testing milk for bacterial contamination

35. Milk "clarification," typically performed early in processing, uses centrifugal force to remove:

A. Lactose
B. Sediment, somatic cells, and other solid debris
C. Water
D. All milk fat

36. Describe, in order, at least FOUR major steps that raw milk typically undergoes to become pasteurized, homogenized, fortified whole milk ready for retail sale, and briefly explain the purpose of each step.

37. Extended Shelf Life (ESL) milk achieves a longer refrigerated shelf life than standard HTST-pasteurized milk primarily by using:

A. Lower pasteurization temperatures than standard milk
B. Higher heat treatment and/or advanced microfiltration to remove more microorganisms
C. Artificial chemical preservatives
D. No heat treatment at all

38. Refer to Image 5, a photograph of ricotta cheese. Ricotta is traditionally made by heating and slightly acidifying which dairy processing byproduct?



Image 5

A. Cream
B. Whey
C. Buttermilk
D. Casein curd

39. Because most casein has already been removed as curds before ricotta production, the proteins that coagulate to form ricotta when whey is reheated and acidified are primarily:

A. Casein proteins
B. Whey proteins (such as beta-lactoglobulin), which denature and aggregate with heat and acid
C. Collagen
D. Amylase

40. Refer to Image 6, a photograph of powdered milk. Select ALL statements that are TRUE about spray-dried milk powder. (Select ALL that apply.)



Image 6

A. Milk is first concentrated by evaporation before spray drying.

B. Spray drying rapidly evaporates moisture from fine milk droplets in a heated chamber.

C. Milk powder generally has a SHORTER shelf life than liquid milk.

D. Powdered milk does not require refrigeration before opening, due to its low moisture content.

E. Nonfat dry milk, whole milk powder, and dry whey are all examples of powdered dairy products.

41. Compared to spray drying, freeze-drying (lyophilization) of dairy products generally:

A. Uses much higher heat, damaging more nutrients
B. Better preserves heat-sensitive nutrients and flavor compounds, but is more costly and slower
C. Is identical in process and cost to spray drying
D. Cannot be used for dairy products at all

42. Microfiltration, increasingly used in dairy processing, separates components primarily based on:

A. Their electrical charge
B. Their particle or molecular size, using a fine membrane
C. Their color
D. Their temperature sensitivity

43. Lactoferrin, a minor iron-binding protein found in milk (in higher concentration in colostrum), is of interest in food science primarily for its:

A. Antimicrobial and immune-supporting properties
B. Role as milk's primary energy source
C. Function as an artificial sweetener
D. Use as a synthetic preservative

44. Colostrum, the first milk produced by mammals after giving birth, differs chemically from mature milk in several ways. Describe TWO chemical or compositional differences between colostrum and mature milk, and explain the biological purpose of at least one of these differences.

45. Compared to cow's milk, human breast milk generally contains:

A. A higher percentage of casein protein
B. A lower percentage of casein protein relative to whey protein
C. Identical casein content to cow's milk
D. No casein protein at all

46. Compared to cow's milk, goat's milk generally contains lower levels of which specific casein protein, which some research suggests may make it easier for some individuals to digest?

A. Alpha-s1-casein
B. Kappa-casein exclusively
C. Beta-lactoglobulin
D. Lactose

47. Compared to cow's milk, sheep's milk generally has a:

A. Lower fat and protein content
B. Higher fat and protein content
C. Composition identical to cow's milk
D. Complete absence of lactose

48. Refer to Image 7, a photograph of whey protein powder. Whey, once considered primarily a low-value byproduct of cheesemaking, is now processed into a range of valuable dairy ingredients. Describe the general process used to separate and concentrate whey proteins into whey protein concentrate or isolate, explain at least TWO different commercial uses of whey-derived ingredients, and discuss why using whey this way is considered more sustainable than discarding it as waste.


whey
whey
whey



Image 8

A. Larger than cow milk fat globules
B. Smaller than cow milk fat globules, providing more surface area for enzymatic digestion
C. Identical in size to cow milk fat globules
D. Entirely absent of fat

51. Which of the following best distinguishes sherbet from sorbet?

A. Sherbet contains a small amount of dairy (milk or cream), while sorbet contains no dairy at all
B. Sherbet is entirely fruit-based with no dairy, while sorbet contains dairy
C. They are identical products marketed under different names
D. Sherbet always contains eggs, while sorbet never does

52. Explain the FDA's compositional requirement that distinguishes sherbet from ice cream in terms of milkfat content, and describe how this difference affects sherbet's flavor and texture compared to ice cream.

53. Compared to traditional American ice cream, Italian-style gelato is generally characterized by:

A. Higher fat content and more air (overrun) than ice cream
B. Lower fat content, less air (overrun), and a denser, more intense flavor than ice cream
C. A composition identical to standard ice cream
D. No dairy content at all

54. The gradual growth of large, gritty ice crystals in ice cream that has been improperly stored (e.g., through temperature fluctuation, partial thawing, and refreezing) is primarily explained by which physical process?

A. Ostwald ripening, in which smaller ice crystals melt and redeposit onto larger crystals over time
B. The Maillard reaction
C. Esterification
D. Emulsification

55. Before freezing, commercial ice cream mix is typically "aged" (held cold, around 4°C, for several hours) primarily to:

A. Allow fat to crystallize and proteins/stabilizers to fully hydrate, improving final texture
B. Begin the freezing process early
C. Pasteurize the mix
D. Add flavoring ingredients

56. Select ALL factors that generally help minimize large ice crystal formation and improve the smooth texture of ice cream. (Select ALL that apply.)

A. Rapid freezing during initial manufacture
B. Consistent, cold storage temperature (avoiding fluctuation)
C. Higher total solids (fat, sugar, stabilizers) in the mix
D. Repeated partial thawing and refreezing during storage
E. Proper overrun (air incorporation) during freezing

57. Under FDA Standards of Identity, ice cream sold in the U.S. must contain a minimum milkfat percentage of at least:

A. 2%
B. 10%
C. 25%
D. 50%

58. On U.S. food labels, an ice cream product labeled "light" or "lite" must generally contain:

A. No fat or calorie reduction requirement at all
B. At least 50% less fat or 33% fewer calories than the reference regular product
C. More fat than regular ice cream
D. No dairy ingredients

59. A frozen dessert made with plant-based milk (such as oat or almond "ice cream") generally CANNOT legally be labeled simply "ice cream" in the U.S. because:

A. FDA Standards of Identity for ice cream require dairy milkfat as an ingredient
B. Plant-based desserts are always more expensive to produce

C. There is no regulation of frozen dessert labeling at all
D. Plant-based desserts cannot physically be frozen

60. Refer to Image 9, a historical photograph of a centrifugal cream separator. Explain the physical principle that allows a centrifugal separator to divide whole milk into cream and skim milk, and explain why cream ends up at the center of the device while skim milk moves toward the outside.



Image 9

61. The commercial centrifugal cream separator, which revolutionized dairy processing in the late 1800s, is most closely associated with which inventor?

A. Louis Pasteur
B. Gustaf de Laval
C. John Deere
D. Marco Polo

62. Refer to Image 10, a photograph of vanilla ice cream. The percentage increase in volume of an ice cream mix due to air whipped in during freezing is called:



Image 10

A. Standardization
B. Overrun
C. Homogenization
D. Pasteurization

63. If a fixed volume of ice cream mix yields a larger finished volume of ice cream due to air incorporation, a HIGHER overrun percentage generally results in a finished product that is:

A. Denser and heavier per unit volume
B. Lighter and less dense per unit volume
C. Unaffected in density
D. Always higher in fat content

64. Describe, using specific food-science concepts (colligative properties/freezing point depression, fat and protein structure, and air incorporation/overrun), how the ingredients and freezing process work together to produce ice cream's characteristic smooth, scoopable texture. Explain what can go wrong, in terms of ingredients or storage, to produce a final product that is icy/gritty, or one that is overly hard and dense.

65. Which food additive derived from soybeans is commonly used as an emulsifier in commercial ice cream and other dairy products?

A. Lecithin
B. Carrageenan
C. Guar gum
D. Pectin

66. Guar gum, a common stabilizer in ice cream and other dairy products, is derived from:

A. Seaweed
B. The seeds of the guar plant (a legume)
C. Animal collagen
D. Milk protein

67. Pectin, sometimes used as a stabilizer in cultured dairy products like yogurt drinks, is most commonly extracted from:

A. Citrus fruit peels and apple pomace
B. Animal bones
C. Seaweed
D. Milk whey

68. Compare carrageenan (from seaweed) and guar gum (from guar seeds) as dairy stabilizers: describe their biological source and explain ONE similarity in how they function to improve texture in dairy products.

69. The lactoperoxidase system, a natural antimicrobial system present in raw milk, helps to:

A. Naturally inhibit some bacterial growth before processing
B. Add flavor compounds to aged cheese
C. Increase milk's fat content
D. Break lactose down into glucose and galactose

70. Galactosemia is a rare genetic metabolic disorder in which an individual cannot properly metabolize which milk sugar component?

A. Sucrose
B. Galactose
C. Fructose
D. Maltose

71. How does galactosemia differ from common lactose intolerance?

A. They are the same condition with different names

B. Galactosemia is a rare, serious genetic enzyme deficiency present from birth requiring strict avoidance of galactose-containing foods, while lactose intolerance is a more common, often milder condition involving reduced lactase enzyme activity
C. Lactose intolerance is more dangerous than galactosemia
D. Galactosemia only affects adults, never infants

72. Select ALL statements that are TRUE about metabolic/digestive conditions related to milk sugar. (Select ALL that apply.)

A. Lactose intolerance results from reduced lactase enzyme activity in the small intestine.
B. Galactosemia is caused by reduced lactase enzyme activity.
C. Galactosemia requires strict dietary avoidance of galactose from birth.
D. Lactose intolerance symptoms are generally milder and more common than galactosemia symptoms.
E. Both conditions have identical treatment/dietary recommendations.

73. "Sandiness," a textural defect sometimes found in ice cream or overly aged sweetened condensed milk, is caused by the crystallization of:

A. Milk fat
B. Lactose, forming gritty lactose crystals
C. Casein protein
D. Salt

74. The key compositional difference between sweetened condensed milk and evaporated milk is that sweetened condensed milk:

A. Contains no milk at all
B. Has a large amount of added sugar, which along with water removal helps preserve it without sterilization
C. Is never heated during processing
D. Contains no lactose

75. Unlike sweetened condensed milk (which contains little to no added sugar), evaporated milk is preserved primarily through:

A. High sugar content alone
B. Sterilization via retort (canning) heat processing after being sealed in its container
C. Freezing
D. Fermentation

76. Compare sweetened condensed milk and evaporated milk: describe ONE compositional difference and explain how each product achieves shelf stability without refrigeration before opening.

77. In the modern U.S. dairy industry, farmers are often paid for raw milk based partly on a "multiple component pricing" system that accounts for the milk's:

A. Only its total volume in gallons, regardless of composition
B. Fat, protein, and sometimes other solids content, not just total volume
C. Color only
D. The cow's breed registration papers

78. The Babcock test, a classic laboratory method still referenced in dairy science, was developed to measure:

A. Milk's bacterial count
B. Milk's fat percentage, using sulfuric acid and centrifugation
C. Milk's pH
D. Milk's lactose content

79. The Gerber test, an alternative to the Babcock test still used in some countries for measuring milk fat content, uses which reagent to dissolve non-fat milk solids?

A. Sulfuric acid
B. Sodium hydroxide
C. Hydrochloric acid only
D. Distilled water only

80. Synthesize your understanding of dairy food science by choosing ONE of the following processing or quality-control methods discussed on this exam -- titratable acidity testing, the Babcock/Gerber fat test, somatic cell count testing, or pasteurization -- and explain in detail: (1) what the test/process measures or accomplishes, (2) the underlying chemical or physical principle involved, and (3) why this test/process is important to the overall quality, safety, or economic value of dairy products reaching consumers.

ANSWER KEY

FOOD SCIENCE – DIVISION B – NATIONAL EXAM

1. **Correct Answer: A**

   The mineral content of milk (calcium, phosphorus, potassium, etc.) that remains after complete combustion of the organic components is referred to as ash content.

2. **Correct Answer: A**

   Holsteins are bred primarily for high milk volume and tend to produce milk with a comparatively lower butterfat percentage than breeds like Jersey or Guernsey.

3. **Correct Answer: A**

   "A2 milk" refers to milk containing only the A2 variant of beta-casein rather than the more common A1 variant; digestive benefit claims remain scientifically inconclusive.

4. **Sample/Acceptable Answer:**

   "A2 milk" comes from cows that produce only the A2 genetic variant of beta-casein protein, rather than the more common A1 variant found in most conventional milk. Some marketing claims suggest A2 milk is easier to digest or causes less digestive discomfort than regular milk. However, scientific evidence for this claim is limited: existing studies are relatively few, often small in scale, sometimes funded by companies with a commercial interest in the outcome, and have produced mixed or inconclusive results, so the scientific and medical community does not consider the digestive-benefit claim well established.

5. **Correct Answer: B**

   The milk fat globule membrane (MFGM) is a phospholipid- and protein-rich layer that surrounds and stabilizes each fat globule within milk's aqueous phase.

6. **Correct Answer: A**

   Phospholipids are amphipathic (having both a hydrophilic head and hydrophobic tail), which allows them to orient at the fat-water interface and stabilize the emulsion.

7. **Correct Answer: A**

   Oxidative rancidity occurs when double bonds in unsaturated fatty acids react with oxygen, producing off-flavor compounds such as aldehydes and ketones.

8. **Correct Answers: A, B, C**

   Light, oxygen exposure, and trace metal ions (which act as catalysts) all accelerate oxidative rancidity. Proper refrigeration slows rather than accelerates rancidity, and a fat with no unsaturated fatty acids would not be susceptible to this particular oxidative pathway.

9. **Correct Answer: A**

   Riboflavin is photosensitive; light exposure can degrade it and trigger light-oxidized off-flavors in milk, which is one reason milk is often sold in opaque packaging.

10. **Correct Answer: B**

    Opaque or pigmented packaging blocks light exposure, helping protect light-sensitive nutrients like riboflavin and preventing light-oxidized off-flavors.

11. **Correct Answer: C**

    FDA Standards of Identity require butter to contain at least 80% milkfat by weight.

12. **Sample/Acceptable Answer:**

    A Standard of Identity is an FDA regulation that legally defines what a specific food product must contain (and in what proportions) in order to be labeled and sold under that product's common name. For example, FDA Standards of Identity require butter to contain at least 80% milkfat, and ice cream to contain at least 10% milkfat; a product that does not meet these requirements cannot legally be labeled "butter" or "ice cream" in the U.S.

13. Correct Answer: D

Heavy cream (heavy whipping cream) must legally contain at least 36% milkfat under FDA Standards of Identity.

14. Correct Answer: B

Jersey cattle are prized for producing milk with a higher butterfat and protein percentage than Holstein milk, making it especially valuable for butter and cheese production.

15. Correct Answer: B

Somatic cells are largely white blood cells; an elevated SCC generally indicates udder inflammation or infection (mastitis), making SCC a key milk-quality and herd-health indicator.

16. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Somatic cells are primarily white blood cells (with a small proportion of epithelial cells) naturally present in milk; they are part of the cow's immune response. A low SCC is normal and expected in healthy milk, but an elevated SCC generally signals udder inflammation or infection (mastitis), often caused by bacterial infection of the mammary gland. Beyond indicating animal health issues, milk with a high SCC tends to have altered composition -- for example, increased enzyme activity (such as proteases and lipases) that can break down milk proteins and fats prematurely, reducing shelf life, flavor quality, and cheese-making yield, since damaged casein does not form curds as efficiently. For these reasons, SCC is closely monitored and often directly tied to the price dairy farmers are paid for their milk.

17. Correct Answer: A

Standard Plate Count estimates the total number of viable bacteria present in a milk sample, an important microbiological quality indicator.

18. Correct Answer: B

The PMO, developed by the FDA in cooperation with states, provides model regulations that most U.S. states adopt to standardize sanitation and safety requirements for Grade A milk.

19. Correct Answer: B

The FDA holds primary authority over the safety and labeling of most dairy products, though USDA separately provides voluntary quality grading services for some products like butter and cheese.

20. Sample/Acceptable Answer:

The mold is Penicillium, most commonly the species Penicillium roqueforti. Mold spores are typically introduced by adding a powdered mold culture directly to the milk or curd during cheesemaking, or by inoculating the cheese after formation; the cheese is then pierced with needles or skewers to create air channels, allowing the mold (which requires oxygen) to grow along these channels through the interior of the cheese, producing the characteristic blue-green veining.

21. Correct Answer: A

HACCP (Hazard Analysis and Critical Control Points) is a systematic, preventive food safety approach that identifies and controls hazards at critical points in a production process.

22. Correct Answer: B

Listeria monocytogenes can survive and grow at refrigeration temperatures and poses a serious risk of miscarriage or severe illness, particularly from soft, unpasteurized, or improperly aged cheeses.

23. Correct Answer: B

Historically, raw milk was a significant vector for diseases such as bovine tuberculosis and brucellosis; pasteurization requirements were adopted largely to eliminate these serious public health risks.

24. Correct Answers: A, C, D

Raw milk does carry a higher contamination risk, vulnerable populations face higher risk, and state regulation of raw milk sale varies widely. Pasteurization does not destroy essentially all nutritional value

(only modestly affects some heat-sensitive nutrients), and federal rules do permit raw-milk cheeses that are aged at least 60 days.

25. Correct Answer: B

Bactofugation uses high-speed centrifugation to physically remove bacterial spores (and some somatic cells) from raw milk, particularly useful for milk destined for aged cheese production.

26. Correct Answer: A

Titratable acidity testing involves slowly adding a standardized base solution to a milk sample until a pH-indicator color-change endpoint is reached, then calculating total acid content from the volume of base used.

27. Correct Answer: B

pH reflects only the concentration of free hydrogen ions in solution at a given moment, while titratable acidity measures the total acid content, including acid that has not yet dissociated, giving a more complete picture of total acidity.

28. Sample/Acceptable Answer:

TA measures the total amount of acid developing in the product, including lactic acid molecules that have not yet fully dissociated into free hydrogen ions, which correlates more directly and sensitively with the total amount of lactic acid produced by bacterial fermentation. Because milk has natural buffering capacity, pH can change relatively little in the early stages of fermentation even as substantial acid is being produced, making pH alone a less sensitive early indicator of fermentation progress than TA.

29. Correct Answer: B

Most commercial rennet today is fermentation-produced chymosin (FPC), made by genetically engineered microorganisms (such as certain yeast or fungi) that produce the same coagulating enzyme found in traditional animal rennet.

30. Correct Answer: B

Because FPC is produced by microorganisms rather than extracted from animal stomachs, cheeses made with it can be marketed as vegetarian.

31. Correct Answer: B

CLA is a minor but biologically active fatty acid naturally present in ruminant dairy fat that has been studied for various potential health effects.

32. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Saturated fatty acids contain only single carbon-carbon bonds along their hydrocarbon chain, allowing them to pack tightly together and remain solid at room temperature, while unsaturated fatty acids contain one or more carbon-carbon double bonds, which introduce kinks in the chain that prevent tight packing, keeping them liquid at room temperature. CLA is structurally unique among unsaturated fatty acids because its double bonds are conjugated -- meaning they are directly adjacent to one another (separated by only one single bond) rather than separated by an intervening methylene (-CH2-) group, as in most naturally occurring polyunsaturated fatty acids. Milk fat's fatty acid profile, including its CLA content, varies with a cow's diet because rumen bacteria in the cow's digestive system biohydrogenate (partially saturate) dietary fats differently depending on the feed composition; cows on fresh pasture/grass diets tend to produce milk with higher levels of CLA and omega-3 fatty acids than cows fed primarily grain-based diets, because fresh forage contains more of the precursor fatty acids that rumen bacteria convert into CLA.

33. Correct Answer: B

Grass-fed cows generally produce milk with a higher omega-3 fatty acid content (and higher CLA) than grain-fed cows, due to differences in the fatty acid precursors present in their diet.

34. Correct Answer: A

Standardization adjusts milk's fat content (by adding cream or skim milk, or separating out fat) to reach a specific target percentage, such as whole, 2%, 1%, or skim milk.

35. Correct Answer: B

Clarification uses a centrifuge to remove sediment, somatic cells, and other undesirable solid particles from raw milk before further processing.

36. Sample/Acceptable Answer:

Accept any four correctly ordered and explained steps, such as: (1) Clarification -- centrifugal removal of sediment and somatic cells. (2) Standardization -- adjusting milk fat to the target percentage for the final product. (3) Pasteurization -- heat treatment (e.g., HTST) to destroy harmful pathogens and extend shelf life. (4) Homogenization -- mechanically breaking fat globules into smaller, evenly dispersed particles to prevent cream separation. (5) Fortification -- adding Vitamin D (and Vitamin A for reduced-fat/skim milks) since processing removes some naturally fat-soluble vitamins. (6) Packaging -- sealing milk in clean, often light-protective containers to prevent contamination and nutrient degradation.

37. Correct Answer: B

ESL milk typically uses higher-temperature heat treatment and/or microfiltration to remove or destroy more spoilage microorganisms than standard HTST pasteurization, extending refrigerated shelf life without reaching full UHT sterilization.

38. Correct Answer: B

Ricotta (meaning "recooked") is traditionally made from whey, the liquid byproduct left over after casein curds are removed during other cheesemaking.

39. Correct Answer: B

Ricotta production relies on the heat- and acid-induced denaturation and aggregation of remaining whey proteins, since most casein has already been removed in earlier cheesemaking steps.

40. Correct Answers: A, B, D, E

Milk is concentrated before spray drying, which rapidly evaporates moisture from atomized droplets; the resulting low-moisture powder does not require refrigeration and has a much LONGER shelf life than liquid milk (not shorter). Nonfat dry milk, whole milk powder, and dry whey are all real examples of powdered dairy products.

41. Correct Answer: B

Freeze-drying uses low temperatures and sublimation (rather than heat evaporation) to remove water, better preserving heat-sensitive nutrients and flavor, but it is a slower and more expensive process than spray drying.

42. Correct Answer: B

Microfiltration uses membranes with very small, precise pore sizes to physically separate particles (such as bacteria, somatic cells, or fat globules) based on size.

43. Correct Answer: A

Lactoferrin is studied for its antimicrobial and immune-supporting properties, partly related to its ability to bind and sequester iron that bacteria need to grow.

44. Sample/Acceptable Answer:

Accept any two correct differences, such as: colostrum is much higher in protein, especially immunoglobulins (antibodies), than mature milk; colostrum is generally lower in lactose than mature milk; colostrum often contains higher concentrations of certain bioactive compounds, such as lactoferrin, than mature milk. Biological purpose: the high immunoglobulin content in colostrum helps transfer passive immunity from mother to newborn, providing antibody protection before the newborn's own immune system is fully developed.

45. Correct Answer: B

Human breast milk has a much lower casein-to-whey ratio than cow's milk, with whey proteins making up a larger relative share, which is one reason infant formulas are often modified to be more digestible for infants.

46. Correct Answer: A

Goat's milk generally contains lower levels of alpha-s1-casein than cow's milk, which some research associates with a softer curd structure and easier digestibility for some individuals.

47. Correct Answer: B

Sheep's milk is notably richer than cow's milk, with significantly higher fat and protein content, which is part of why it is prized for cheesemaking (such as Roquefort and Pecorino).

48. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Whey protein concentrate and isolate are typically produced using membrane filtration: microfiltration first removes remaining fat and casein particles, and ultrafiltration then concentrates the protein while allowing lactose, minerals, and water to pass through; further processing (such as ion exchange or additional filtration) can be used to produce a more highly purified whey protein isolate with even less lactose and fat. The resulting liquid concentrate is typically spray-dried into a shelf-stable powder. Commercial uses include sports nutrition/protein supplements, infant formula (whey is often the primary protein source because its digestibility profile is closer to human breast milk than casein-dominant cow's milk), baked goods (for texture and browning), and as an ingredient in processed cheese or other dairy products, as well as being used to make ricotta cheese. Using whey this way is more sustainable than discarding it because raw whey disposed of as wastewater carries a very high biological oxygen demand (BOD), meaning it can severely deplete oxygen levels and harm aquatic ecosystems if released untreated into waterways; converting whey into valuable food ingredients instead reduces this environmental burden while creating economic value from what was previously treated as waste.

49. Correct Answer: B

Before modern filtration and drying technology made whey protein products commercially viable, whey was frequently treated as a low-value waste product, often disposed of as wastewater or used as low-value animal feed.

50. Correct Answer: B

Goat milk fat globules tend to be smaller on average than cow milk fat globules, which is thought to provide more relative surface area for digestive enzymes to act on, potentially contributing to easier digestibility for some individuals.

51. Correct Answer: A

Sherbet legally must contain a small percentage of milkfat, distinguishing it from sorbet, which by definition contains no dairy ingredients at all.

52. Sample/Acceptable Answer:

Sherbet must contain a small percentage of milkfat, generally between about 1% and 2%, far less than the FDA's minimum of at least 10% milkfat required for ice cream. Because sherbet contains much less fat, it has a lighter, less creamy texture that is more icy/granular than ice cream, and its lower fat content allows fruit flavors to come through more prominently and vividly than in the richer, fat-coated flavor profile typical of ice cream.

53. Correct Answer: B

Gelato is typically made with less fat and churned to incorporate less air (lower overrun) than American ice cream, resulting in a denser texture with a more concentrated, intense flavor.

54. Correct Answer: A

Ostwald ripening describes the thermodynamically favorable process by which smaller ice crystals melt and redeposit onto larger existing crystals during temperature fluctuations, causing crystal size to grow and texture to become gritty over time.

55. Correct Answer: A

Aging the mix at refrigeration temperature allows fat to begin crystallizing and gives proteins and stabilizers time to fully hydrate, which improves whipping properties and final texture during freezing.

56. Correct Answers: A, B, C, E

Rapid initial freezing, stable storage temperature, higher total solids, and proper overrun all help minimize large ice crystal formation. Repeated partial thawing and refreezing does the opposite, promoting Ostwald ripening and gritty texture.

57. Correct Answer: B

FDA Standards of Identity require ice cream to contain a minimum of 10% milkfat.

58. Correct Answer: B

FDA labeling rules require "light" or "lite" versions of a food to contain at least 50% less fat or at least 33% fewer calories than the standard reference version of that product.

59. Correct Answer: A

Because FDA's Standard of Identity for "ice cream" specifically requires dairy milkfat, plant-based frozen desserts must instead use alternate labeling, such as "frozen dessert" or a plant-specific term.

60. Sample/Acceptable Answer:

A centrifugal separator spins milk at very high speed, generating centrifugal force. Because milk fat is less dense than the surrounding aqueous (skim milk) portion of milk, the denser skim milk is thrown outward toward the spinning bowl's edge, while the lighter fat globules are displaced toward the center of rotation. This density-based separation allows the cream (concentrated fat) to be collected from the center outlet and the skim milk from the outer outlet, achieving rapid separation without needing to wait for gravity settling.

61. Correct Answer: B

Gustaf de Laval developed and popularized the centrifugal cream separator in the 1870s-1880s, dramatically speeding up cream separation compared to older gravity-settling methods.

62. Correct Answer: B

Overrun is the percentage increase in volume from air incorporated into the mix during freezing/churning.

63. Correct Answer: B

Higher overrun means more air has been incorporated per unit volume, resulting in a lighter, less dense finished product.

64. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Dissolved sugar in the ice cream mix lowers the freezing point of the water-based portion (freezing point depression, a colligative property), which means the mix never freezes completely solid at typical freezer temperatures -- a portion of unfrozen, syrupy liquid always remains between ice crystals, contributing to a soft, scoopable texture rather than a solid block of ice. As the mix freezes and is simultaneously churned, milk fat globules partially coalesce and, along with emulsifiers/stabilizers, form a structural network that traps small air bubbles (overrun), which lightens the texture and interrupts the growth of large ice crystals. Stabilizers (such as guar gum or carrageenan) bind water and increase viscosity, further slowing ice crystal growth. A gritty, icy final product typically results from large ice crystals forming due to slow initial freezing, insufficient stabilizers/sugar, or -- most commonly -- temperature fluctuation during storage that triggers Ostwald ripening (smaller crystals melting and redepositing onto larger ones). An overly hard, dense product can result from too little overrun (not enough air incorporated during freezing), too little sugar (insufficient freezing point depression, so more of the mix freezes solid), or excessively cold storage temperatures that solidify the remaining unfrozen liquid phase.

65. Correct Answer: A

Soy lecithin is a phospholipid-based emulsifier commonly extracted from soybeans and used to help stabilize fat-water emulsions in products like ice cream.

66. Correct Answer: B

Guar gum is extracted from the ground endosperm of guar plant seeds (a legume) and is valued as a strong thickener even at low concentrations.

67. Correct Answer: A

Pectin is a plant-derived polysaccharide most commonly extracted commercially from citrus peels and apple pomace (a byproduct of juice production).

68. Sample/Acceptable Answer:

Carrageenan is a polysaccharide extracted from red seaweed, while guar gum is a polysaccharide extracted from the ground endosperm of guar plant seeds (a legume). Despite their different biological sources, both function similarly as hydrocolloids: they dissolve or disperse in the water phase of a dairy product, bind water, and increase viscosity, which slows the movement of water molecules and helps prevent large ice crystal growth (in frozen products) or ingredient separation/settling (in liquid or semi-solid products), improving overall texture and stability.

69. Correct Answer: A

The lactoperoxidase system is a naturally occurring enzymatic antimicrobial system in raw milk that provides some inherent, limited protection against bacterial growth before processing.

70. Correct Answer: B

Galactosemia is caused by a deficiency in enzymes needed to metabolize galactose (one of the two monosaccharides that make up lactose), requiring strict dietary avoidance of galactose from birth.

71. Correct Answer: B

Galactosemia is a rare, serious genetic disorder present from birth requiring strict galactose avoidance, while lactose intolerance is a far more common and generally milder condition caused by reduced (not absent) lactase enzyme activity, usually developing later in childhood or adulthood.

72. Correct Answers: A, C, D

Lactose intolerance results from reduced lactase; galactosemia requires strict lifelong galactose avoidance from birth; and lactose intolerance is far more common and generally milder than galactosemia. Galactosemia is not caused by lactase deficiency (it is a downstream metabolic enzyme deficiency), and the two conditions do not have identical treatment recommendations.

73. Correct Answer: B

Sandiness results from the crystallization of lactose into large, gritty crystals, which can occur when lactose concentration exceeds its solubility limit, particularly in products like sweetened condensed milk or improperly processed ice cream.

74. Correct Answer: B

Sweetened condensed milk contains a large amount of added sugar; combined with water removal, the resulting high sugar concentration (low water activity) inhibits microbial growth, allowing shelf stability without full sterilization.

75. Correct Answer: B

Evaporated milk, which contains little or no added sugar, achieves shelf stability through sterilization: it is sealed in its can and then heat-processed (retorted) to destroy microorganisms and enzymes.

76. Sample/Acceptable Answer:

Sweetened condensed milk contains a large amount of added sugar along with water removed by evaporation, while evaporated milk contains little to no added sugar. Sweetened condensed milk achieves shelf stability through its high sugar concentration, which creates a low-water-activity environment that inhibits microbial growth, without requiring full sterilization. Evaporated milk, lacking this high sugar content, instead achieves shelf stability through sterilization: after being concentrated and sealed in its can, it is heat-processed (retorted) to destroy microorganisms and enzymes that would otherwise cause spoilage.

77. Correct Answer: B

Multiple component pricing pays farmers based on the actual fat, protein, and other solids content of their milk, not simply its total volume, reflecting the differing processing value of milk components.

78. Correct Answer: B

The Babcock test uses sulfuric acid to digest non-fat milk solids and centrifugation to separate and measure the resulting fat layer, providing a standardized measurement of milk fat percentage.

79. Correct Answer: A

Like the Babcock test, the Gerber test uses sulfuric acid (along with amyl alcohol and centrifugation) to dissolve non-fat solids and isolate milk fat for measurement.

80. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Answers will vary depending on the method chosen; award full credit for an accurate, detailed explanation covering all three required parts. Sample answer (Pasteurization): (1) Pasteurization heats raw milk to a specific temperature for a specific time (e.g., 72°C for 15 seconds, HTST) to accomplish destruction of pathogenic microorganisms. (2) The underlying principle is thermal inactivation of proteins in microbial cells -- heat denatures essential enzymes and structural proteins in bacteria, killing or inactivating them, while the carefully chosen time/temperature combination is selected to achieve this pathogen reduction while minimizing damage to milk's own proteins, flavor, and nutrients. (3) Pasteurization is critically important because it prevents transmission of dangerous milk-borne diseases (historically including tuberculosis and brucellosis, and today pathogens like Salmonella, E. coli, and Listeria), extends shelf life, and gives consumers confidence in the safety of a widely consumed staple food; without it, milk-borne illness would be far more common, and milk's economic value and marketability as a safe food product would be significantly reduced. (Equivalent full credit applies for well-developed answers on titratable acidity, the Babcock/Gerber test, or SCC testing, covering the same three required components.)

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
National Tournament Written Exam – Honors Level

Team Name: _____ Team Number: _____

- This exam contains 80 questions: 60 multiple choice, 5 multiselect (select ALL correct answers), 10 short answer, and 5 long answer.
- Ten questions (Q2, Q14, Q20, Q26, Q38, Q40, Q48, Q50, Q60, Q62) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write a concise response in the space provided. For long answer questions, write a complete, multi-part response addressing every part of the prompt in the larger space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; National Tournament teams complete all Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which classic dairy laboratory test uses infrared (Mid-IR) spectroscopy to rapidly measure a milk sample's fat, protein, and lactose content simultaneously?

A. Babcock test
B. Gerber test
C. Mid-infrared (Mid-IR) spectroscopic analysis
D. Standard Plate Count

2. Refer to Image 1, a photograph of Emmental (Swiss) cheese. The characteristic round holes ("eyes") in this cheese are traditionally attributed to carbon dioxide gas produced by which type of bacteria during ripening?



Image 1

A. Lactobacillus acidophilus
B. Propionibacterium (propionic acid bacteria)
C. Penicillium roqueforti
D. Streptococcus thermophilus alone

3. The propionic acid fermentation responsible for Swiss cheese eyes also contributes to the cheese's flavor by producing which two byproducts, in addition to CO2 gas?

A. Propionic acid and acetic acid
B. Ethanol and methane
C. Citric acid and butter
D. Casein and whey

4. Explain, at a basic level, why Swiss-type cheeses like Emmental develop characteristic round holes ("eyes") during aging, and why cheese without these holes is sometimes called "blind."

5. Which term describes a cheese rind formed primarily by surface mold growth, giving cheeses like Brie and Camembert their characteristic soft white exterior?

A. Washed rind
B. Bloomy rind
C. Natural rind
D. Waxed rind

6. Which mold species is primarily responsible for the white, velvety bloomy rind on cheeses like Brie and Camembert?

A. Penicillium roqueforti
B. Penicillium camemberti
C. Aspergillus niger
D. Rhizopus oryzae

7. As a bloomy-rind cheese like Brie ripens, enzymes produced by the surface mold break down proteins and fats primarily from the:

A. Center of the cheese inward, evenly throughout
B. Outside (rind) toward the center, giving Brie its characteristic gradient of ripeness
C. Bottom of the cheese only
D. Nowhere; bloomy-rind cheeses do not ripen at all

8. Select ALL statements that are TRUE about bloomy-rind cheeses such as Brie and Camembert. (Select ALL that apply.)

A. They ripen from the outside (rind) inward.
B. Their rind is edible and is intentionally cultivated as part of the cheesemaking process.
C. Penicillium camemberti is typically responsible for their characteristic white rind.
D. They become firmer and less creamy the longer they ripen past peak ripeness.
E. They are hard, aged cheeses with very low moisture content.

9. "Washed rind" cheeses are periodically rinsed during aging with brine, wine, or other liquid, which encourages the growth of a bacterium responsible for their strong aroma and orange-tinted rind. This bacterium is:

A. Lactobacillus bulgaricus
B. Brevibacterium linens
C. Propionibacterium freudenreichii
D. Penicillium camemberti

10. Cheddaring, a step unique to cheddar-style cheesemaking, involves repeatedly cutting, stacking, and turning slabs of curd. The primary purpose of this process is to:

A. Add flavoring ingredients
B. Mechanically expel additional whey and develop the cheese's characteristic fibrous texture
C. Introduce mold spores
D. Pasteurize the curd a second time

11. Under FDA regulations, which product category allows manufacturers to use emulsifying salts and a broader range of ingredients not permitted in natural cheese, resulting in products like American cheese singles?

A. Aged cheddar
B. Pasteurized process cheese (cheese food/cheese product)
C. Raw milk cheese
D. Farmstead cheese

12. Explain the general difference between "natural cheese" and "pasteurized process cheese" (such as American cheese singles) in terms of ingredients and production, and describe ONE practical advantage of process cheese.

13. Salt added during cheesemaking serves several functions. Which of the following is NOT a typical function of salt in cheese?

A. Controlling moisture content by drawing out whey
B. Slowing the growth of unwanted spoilage bacteria
C. Contributing to flavor
D. Increasing the cheese's lactose content

14. Refer to Image 2, a photograph of Brie cheese showing its soft white bloomy rind. Which enzyme-producing organism is primarily responsible for creating this rind and contributing to Brie's characteristic ripening?



Image 2

A. Penicillium roqueforti
B. Penicillium camemberti
C. Lactobacillus casei
D. Saccharomyces cerevisiae

15. Compared to fresh, unripened Brie, fully ripened Brie is generally:

A. Firmer and drier
B. Softer, creamier, and more pungent in flavor
C. Identical in texture and flavor
D. Higher in lactose content

16. Compare and contrast bloomy-rind cheeses (such as Brie, ripened by Penicillium camemberti) and blue cheeses (such as Roquefort, ripened by Penicillium roqueforti). In your answer: describe how each type of mold is introduced and where it grows in/on the cheese, explain how each affects the direction and pattern of ripening, and describe ONE difference in the resulting flavor or texture between the two cheese types.

17. "Farmstead cheese" is a marketing/production term referring to cheese made:

A. Using only imported milk from other countries
B. On the same farm where the milk-producing animals are raised, using that farm's own milk
C. Exclusively from goat's milk
D. Using entirely synthetic ingredients

18. A cheese labeled with a Protected Designation of Origin (PDO), such as Parmigiano-Reggiano, legally means:

A. The cheese can be produced anywhere in the world using the same recipe
B. The cheese must be produced in a specific geographic region following defined traditional methods to use that name
C. The cheese contains no animal products
D. The cheese has no minimum aging requirement

19. Which of the following cheeses is an example of a PDO-protected cheese that must be produced in a specific region of Italy using traditional methods?

A. American cheese
B. Parmigiano-Reggiano
C. Generic mozzarella string cheese
D. Processed cheese spread

20. Refer to Image 3, a photograph of the mozzarella stretching (pasta filata) process. Describe what physically happens to the cheese curd's protein structure during this hot-water stretching process, and explain how this creates mozzarella's characteristic fibrous, stringy texture.



Image 3

21. Which of the following is an example of a "pasta filata" (stretched-curd) cheese, made using the same hot-water stretching technique as mozzarella?

A. Cheddar
B. Provolone
C. Brie
D. Roquefort

22. String cheese, a popular snack product, exploits mozzarella's aligned protein fiber structure because this structure allows the cheese to:

A. Melt instantly at room temperature
B. Be peeled apart into strings along the direction the fibers were stretched
C. Dissolve completely in water
D. Never be sliced or cut

23. Which of the following best describes "ultra-filtered" milk, a newer dairy product marketed for its higher protein and lower sugar content compared to regular milk?

A. Milk that has been filtered to remove all fat
B. Milk processed through a membrane filtration system that concentrates protein while reducing lactose (sugar) content
C. Milk boiled to remove water
D. Milk with artificial protein powder added

24. Select ALL statements that are TRUE about ultra-filtration as applied to milk processing. (Select ALL that apply.)

A. It uses a membrane to separate milk components based largely on molecular size.
B. It can be used to increase a milk product's protein concentration relative to its lactose content.
C. It requires boiling the milk at high temperatures.

D. It is a type of membrane filtration technology, related to microfiltration and reverse osmosis.

E. It destroys all protein in the milk.

25. Reverse osmosis (RO), sometimes used in dairy processing, differs from ultra-filtration primarily in that RO membranes:

A. Have larger pores that let protein and lactose pass through freely

B. Have extremely small pores that block nearly all dissolved solutes, allowing mostly only water to pass through

C. Cannot be used with any liquid other than milk

D. Only filter out bacteria, not dissolved solids

26. Refer to Image 4, a photograph of milk being pasteurized at a dairy using industrial heat-exchange equipment. This type of equipment (a plate heat exchanger) heats milk efficiently by:



Image 4

A. Submerging milk directly in an open flame

B. Passing milk and a hot fluid through separate, closely spaced thin metal plates, maximizing surface area for rapid heat transfer

C. Freezing the milk first, then thawing it

D. Adding chemical preservatives instead of heat

27. A key advantage of plate heat exchangers over older batch (vat) pasteurization methods is that plate heat exchangers:

A. Allow continuous, high-volume, energy-efficient processing of milk

B. Cannot achieve the temperatures required for pasteurization

C. Require far more time to process the same volume of milk

D. Eliminate the need for any temperature monitoring

28. Explain why a large surface area between milk and the heating medium (such as in a plate heat exchanger) allows for faster, more efficient pasteurization compared to heating milk in a single large batch tank.

29. UHT aseptic packaging technology (such as Tetra Pak cartons) allows shelf-stable milk to be stored without refrigeration primarily because the process combines UHT sterilization with:

A. Packaging the sterilized milk into a sterile, airtight container under sterile conditions, preventing recontamination
B. Adding chemical preservatives to the carton
C. Leaving the package open to air
D. Freezing the package after filling

30. Which of the following best explains why aseptically packaged UHT milk can be stored unrefrigerated for months, while HTST-pasteurized milk in a normal carton cannot?

A. UHT milk contains added preservatives that HTST milk lacks
B. The combination of higher heat treatment AND aseptic (sterile) packaging prevents any microbial recontamination after processing, unlike standard HTST packaging
C. UHT milk contains no lactose
D. There is no real difference between the two

31. Cultured (or "ripened") butter differs from standard sweet cream butter in that cultured butter is made by:

A. Adding artificial butter flavoring
B. Fermenting the cream with lactic acid bacteria before churning, developing a more complex, tangy flavor
C. Using only skim milk
D. Omitting the churning step entirely

32. Compare sweet cream butter and cultured butter: describe the key difference in how each is produced, explain how this difference affects flavor, and discuss why cultured butter has historically been more common in parts of Europe while sweet cream butter has been more common in the United States.

33. Traditional buttermilk was historically defined as:

A. Milk with butter blended into it
B. The liquid left over after churning cream into butter

C. A synthetic dairy substitute
D. Milk with baking soda added

34. Modern "cultured buttermilk" sold in stores today is produced differently from traditional buttermilk. Modern cultured buttermilk is made by:

A. Collecting the leftover liquid from butter churning, as in the traditional method
B. Adding lactic acid bacteria cultures directly to pasteurized skim or low-fat milk to ferment and thicken it
C. Removing all bacteria from traditional buttermilk
D. Mixing butter directly into whole milk

35. In baking, buttermilk (or buttermilk powder) is often used because its acidity reacts with baking soda to:

A. Prevent the batter from rising at all
B. Produce carbon dioxide gas, which helps leaven (raise) baked goods
C. Turn the batter a different color only
D. Destroy the gluten structure completely

36. Explain the chemical reaction that occurs when buttermilk (or another acidic dairy ingredient) is combined with baking soda in a baking recipe, and describe the practical effect this reaction has on the finished baked good.

37. Crème fraîche, a soured cream product popular in French cooking, differs from American-style sour cream primarily in its:

A. Complete absence of dairy ingredients
B. Higher fat content and slightly less tangy flavor
C. Bright blue color
D. Use of only skim milk

38. Refer to Image 5, a photograph of buttons made from Galalith, an early 20th-century plastic. Galalith is produced through a chemical reaction between casein and which compound, which cross-links and hardens the protein into a durable plastic material?



Image 5

A. Formaldehyde
B. Sulfuric acid
C. Sodium hydroxide
D. Rennet

39. Before the widespread availability of modern petroleum-based plastics, casein-based plastics like Galalith were commonly used to manufacture small items such as buttons, buckles, and knitting needles because casein plastic is:

A. Extremely flammable and unstable
B. Hard, durable, and can be dyed in a wide range of colors
C. Edible and intended to be eaten
D. Only available in a single color, black

40. Refer to Image 6, a photograph of sour cream. Select ALL statements that are TRUE about sour cream production and composition. (Select ALL that apply.)



Image 6

A. Sour cream is produced by fermenting cream with lactic acid bacteria cultures.
B. The fermentation process lowers the cream's pH and thickens its texture.
C. Sour cream typically has a higher fat content than fat-free milk.
D. Sour cream is produced without any bacterial culture at all.
E. The tangy flavor of sour cream comes primarily from lactic acid produced during fermentation.

41. Which of the following distinguishes "ice milk," a legacy dairy dessert category, from standard ice cream?

A. Ice milk contains a higher percentage of milkfat than ice cream
B. Ice milk contains a lower percentage of milkfat than ice cream
C. Ice milk contains no dairy ingredients at all
D. There is no compositional difference

42. In the U.S., the historical "ice milk" labeling category has largely been replaced by which modern labeling term for lower-fat frozen dairy desserts?

A. "Light" or "low-fat" ice cream
B. "Non-dairy" ice cream
C. "Raw" ice cream
D. "Organic" ice cream exclusively

43. Which of the following dairy products generally has the LEAST regulatory milkfat requirement among the options listed?

A. Butter
B. Ice cream
C. Milkshake/soft-serve mix
D. Heavy cream

44. Explain why cheese labeled "imitation cheese" or a "cheese analog" might use vegetable oil in place of some or all of the milkfat found in natural cheese, and describe ONE reason a food manufacturer might choose to use a cheese analog instead of natural cheese in a product.

45. Shredded cheese sold in bags is often coated with a small amount of cellulose powder (or similar anti-caking agent) primarily to:

A. Add flavor
B. Prevent the shredded pieces from clumping together in the bag
C. Increase the cheese's fat content
D. Replace the need for refrigeration

46. Shredded cheese packages are often flushed with nitrogen gas (modified atmosphere packaging) instead of leaving normal air inside primarily to:

A. Add flavor compounds
B. Displace oxygen, slowing mold growth and oxidation to extend shelf life
C. Increase the cheese's moisture content
D. Speed up spoilage intentionally

47. Gouda and Edam cheeses are traditionally coated in a layer of colored wax primarily to:

A. Add flavor to the cheese
B. Create an airtight barrier that prevents moisture loss and protects the cheese from mold and contamination during aging/storage
C. Speed up the aging process
D. Replace the need for salt

48. Refer to Image 7, a photograph of fresh cheese curds. Fresh curds are famous for "squeaking" against the teeth when bitten, but this squeak fades within days. Explain, at the level of protein structure, why fresh curds squeak, describe what changes in the cheese over time that causes the squeak to disappear, and explain why this makes curd freshness difficult to preserve during shipping/storage.



Image 7

49. Which of the following dairy starter culture types grow and ferment optimally at warmer temperatures (around 40-45°C), such as those used in yogurt production?

A. Mesophilic cultures
B. Thermophilic cultures
C. Psychrophilic cultures
D. Rennet cultures (not a bacterial culture type)

50. Refer to Image 8, a simplified schematic diagram of a reverse osmosis system. Applied to dairy processing (such as concentrating milk or whey before spray drying), reverse osmosis works by using pressure to:

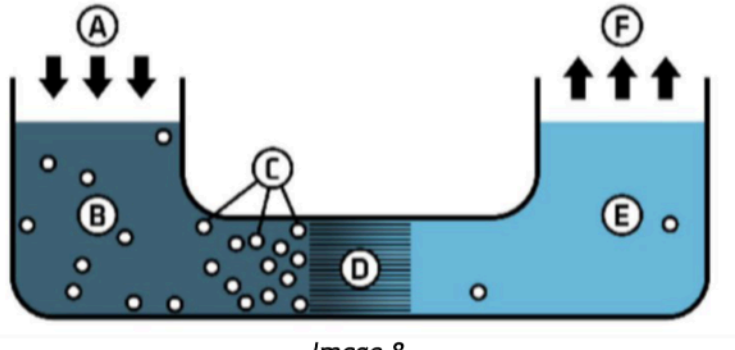


Image 8

A. Force water molecules through a semi-permeable membrane, leaving behind a more concentrated solution of milk solids
B. Add extra water to dilute the milk
C. Heat the milk until all water evaporates
D. Freeze the milk solid

51. Compared to evaporation (heat-based concentration), using reverse osmosis to pre-concentrate milk or whey before spray drying offers which advantage?

A. It requires much higher heat, improving flavor
B. It can concentrate the product with less heat exposure, helping preserve heat-sensitive nutrients and flavor
C. It cannot be used with any dairy liquid
D. It always produces a less concentrated final product

52. Explain the basic physical principle of osmosis, and describe how reverse osmosis "reverses" this natural process to concentrate a dairy liquid such as milk or whey.

53. The term "withdrawal period," relevant to antibiotic use in dairy cattle, refers to:

A. The time a farmer must wait after treating a cow with antibiotics before that cow's milk can legally be sold for human consumption
B. The time it takes to milk a cow
C. The shelf life of pasteurized milk
D. The time required to age a cheese

54. Maximum Residue Level (MRL), a term used in dairy food safety regulation, refers to:

A. The maximum amount of milk a single cow can produce per day

B. The legal upper limit for the concentration of a substance (such as an antibiotic) permitted to remain in a food product

C. The maximum number of cows allowed on a dairy farm

D. The maximum fat percentage allowed in whole milk

55. Why are dairy processors required to test raw milk for antibiotic residues before accepting it for processing?

A. Antibiotic residues improve milk's flavor

B. Antibiotic residues in milk can pose health risks to sensitive consumers and can interfere with the bacterial starter cultures needed to ferment cheese, yogurt, and other cultured products

C. Antibiotics increase milk's shelf life, so testing ensures enough is present

D. Federal law has no requirements regarding antibiotics in milk

56. Select ALL statements that are TRUE about antibiotic residue testing in the dairy industry. (Select ALL that apply.)

A. Rapid microbial inhibition tests (such as Delvotest) are commonly used to screen milk for antibiotic residues before processing.

B. Antibiotic residues in milk can inhibit the bacterial starter cultures used to make cheese and yogurt.

C. Dairy farmers have no legal obligation to observe a withdrawal period after treating a cow with antibiotics.

D. A positive antibiotic residue test can result in an entire tanker load of milk being rejected.

E. Antibiotic residues are never a food safety or regulatory concern in the dairy industry.

57. Which type of infant formula is designed for infants with an allergy or sensitivity to intact cow's milk protein, using protein that has been broken down into smaller fragments?

A. Standard cow's milk-based formula

B. Hydrolyzed (partially or extensively hydrolyzed) formula

C. Whole milk

D. Evaporated milk formula

58. Whey protein is often used as a primary protein source in standard infant formula (rather than casein-dominant cow's milk protein alone) because whey's amino acid profile and digestibility are considered:

A. Closer to that of human breast milk than cow's milk's natural casein-dominant profile

B. Identical to soy protein

C. Completely indigestible for infants

D. Irrelevant to infant nutrition

59. "Extensively hydrolyzed" infant formulas break down milk proteins into very small peptide fragments primarily to:

A. Increase the formula's fat content
B. Reduce the likelihood of triggering an allergic immune response to intact milk proteins
C. Add extra lactose
D. Make the formula taste sweeter

60. Refer to Image 9, a photograph of a container of infant formula. Explain why standard cow's-milk-based infant formula must be modified from ordinary cow's milk before it is considered safe and appropriate for young infants, describing at least TWO specific compositional changes typically made.



Image 9

61. Which of the following is a reason some Kosher dietary certification standards restrict the type of rennet that can be used in cheesemaking?

A. Rennet has no relevance to Kosher dietary law
B. Traditional animal rennet is derived from the stomach lining of animals, and Kosher law has specific requirements about the source and slaughter method of animal-derived ingredients
C. Kosher law forbids all dairy products entirely
D. Rennet always contains gluten

62. Refer to Image 10, an image related to antibiotic residue testing across the dairy value chain. Rapid antibiotic screening tests (such as Delvotest) work by observing whether a milk sample:

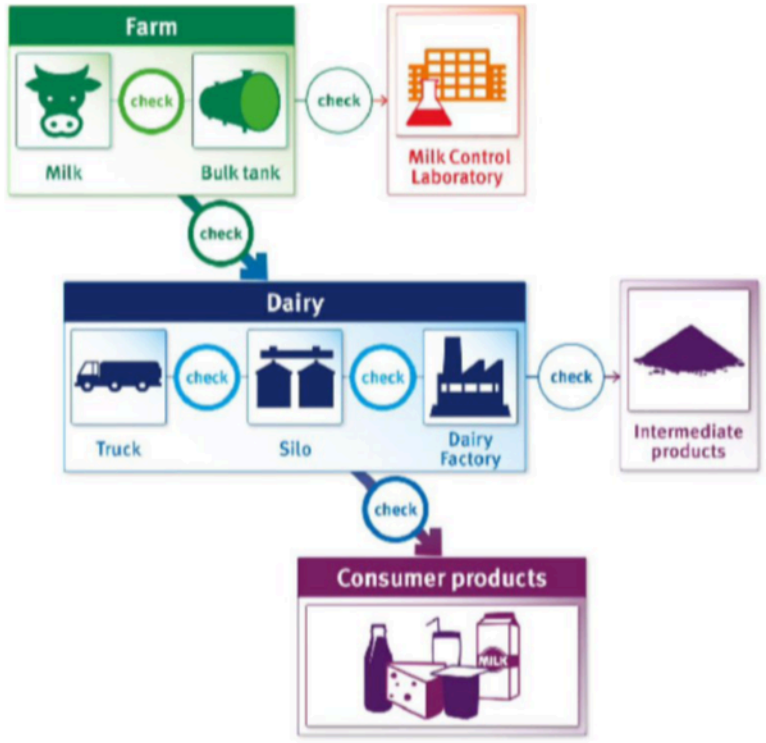


Image 10

A. Changes color when exposed to sunlight

B. Inhibits the growth of a standardized test bacterium, indicating the presence of antibiotic residues

C. Freezes at a different temperature than normal milk

D. Produces more cream than untreated milk

63. If a milk sample inhibits bacterial growth in a Delvotest-style microbial inhibition assay, this result suggests that the sample:

A. Is completely free of antibiotic residues

B. May contain antibiotic residues above a detectable threshold, warranting further testing or rejection

C. Has an unusually high fat content

D. Has been successfully pasteurized

64. Discuss the dairy industry's multi-layered approach to preventing antibiotic residues from reaching consumers. In your answer: explain the purpose of a withdrawal period, describe how rapid on-farm or receiving-dock screening tests (such as Delvotest) are used, and explain what happens (from both a food-safety and an economic standpoint) when a raw milk sample tests positive for antibiotic residues.

65. Cheese yield (the amount of finished cheese produced from a given volume of milk) is most directly influenced by the milk's:

A. Color and temperature only
B. Fat and protein (casein) content
C. Lactose content alone
D. Vitamin D content

66. All else being equal, milk with a HIGHER fat and casein protein content will generally produce:

A. A lower cheese yield per unit of milk
B. A higher cheese yield per unit of milk
C. No change in cheese yield
D. Only affects cheese color, not yield

67. Milk protein-based paint, an early form of paint used historically (including by some old master painters and in early American folk art), was made using:

A. Casein combined with lime or another alkaline binder
B. Whey combined with vegetable oil only
C. Pure lactose crystals
D. Rennet dissolved in water

68. Describe ONE historical, non-food application of milk proteins (such as casein), and briefly explain the chemical property of the protein that made it useful for that application.

69. Compared to natural cheese, imitation/analog cheese products made with vegetable oil generally lack which nutritionally significant dairy fat component naturally found in milkfat?

A. Conjugated linoleic acid (CLA)
B. Sucrose

C. Gluten
D. Vitamin C

70. A cheese labeled "raw milk cheese" that is legally sold at retail in the United States must, under federal law, generally be:

A. Aged for at least 60 days
B. Sold within 24 hours of production
C. Made without any bacterial culture
D. Frozen immediately after production

71. The 60-day aging requirement for raw-milk cheese sold in the U.S. is intended to:

A. Improve the cheese's color only
B. Allow time for the cheese's naturally developing acidity and other factors to reduce the risk of harmful pathogens surviving in the final product
C. Increase the cheese's lactose content
D. Have no food-safety purpose; it is purely a flavor preference

72. Select ALL statements that are TRUE about raw-milk (unpasteurized) cheese production in the United States. (Select ALL that apply.)

A. Federal law generally requires such cheese to be aged at least 60 days before retail sale.
B. Raw-milk cheese carries zero food safety risk compared to pasteurized-milk cheese.
C. The 60-day aging rule is intended to reduce (though not eliminate) the risk of pathogens surviving in the final product.
D. Some soft, high-moisture raw-milk cheeses are considered higher risk and are more strictly regulated or restricted.
E. All fifty U.S. states have identical raw-milk cheese regulations.

73. Which of the following organisms is commonly used to help produce lactase enzyme commercially, which is then added to milk to make lactose-free dairy products?

A. Kluyveromyces lactis (a yeast)
B. Penicillium roqueforti
C. Escherichia coli exclusively
D. Saccharomyces cerevisiae only, never other organisms

74. Commercially produced lactase enzyme, rennet (via fermentation-produced chymosin), and some cheese cultures are all examples of dairy processing aids that are:

A. Produced through industrial fermentation using selected, controlled microorganisms
B. Extracted exclusively from cow's milk itself
C. Entirely synthetic chemicals with no biological origin
D. Illegal for use in U.S. food production

75. Buttermilk powder, a dried dairy ingredient used in commercial baking, is valued in bread and cracker formulas partly because it:

A. Has no effect on dough or baked texture
B. Contributes to browning (via Maillard reaction with its lactose and protein) and can improve dough's water absorption and texture
C. Prevents any browning from occurring

D. Contains no lactose or protein at all

76. Explain why buttermilk powder (or nonfat dry milk) added to a bread dough formula can improve the crust's browning color during baking, referencing a specific chemical reaction.

77. "Recombined" or "reconstituted" milk, sometimes used in regions without a reliable fresh milk supply, is produced by:

A. Mixing milk powder, water, and sometimes milkfat back together to approximate fresh liquid milk
B. Never mixing any ingredients; it is only ever fresh raw milk
C. Adding artificial flavoring to soda water
D. Combining two different types of cheese

78. A key food-science advantage of recombined/reconstituted milk products in regions with limited refrigerated transport infrastructure is that:

A. Milk powder is shelf-stable and can be shipped and stored without refrigeration, then reconstituted with local water close to the point of consumption
B. Milk powder spoils faster than fresh milk
C. Milk powder cannot be safely reconstituted
D. There is no practical advantage compared to shipping fresh liquid milk

79. Nonfat dry milk added to bread dough (beyond its browning contribution) also improves dough structure primarily because its proteins:

A. Compete with wheat gluten and weaken dough structure
B. Help strengthen the dough's gas-holding capacity and improve water absorption, supporting a better texture and rise
C. Have no interaction with the dough's other ingredients
D. Convert gluten protein into starch

80. Synthesize your understanding of dairy food science by choosing ONE non-cheese dairy ingredient or process discussed on this exam -- such as buttermilk powder in baking, reverse osmosis concentration, UHT aseptic packaging, or recombined/reconstituted milk -- and explain: (1) the underlying food-science principle involved, (2) a specific practical application of this ingredient/process in the food industry, and (3) ONE advantage this ingredient/process provides compared to a simpler or more traditional alternative.

ANSWER KEY

FOOD SCIENCE – DIVISION B – NATIONAL EXAM (FORM 2)

1. **Correct Answer: C**

   Modern Mid-IR spectroscopic analyzers can rapidly and simultaneously measure fat, protein, and lactose content in milk, largely replacing slower wet-chemistry methods like Babcock or Gerber for routine testing.

2. **Correct Answer: B**

   Propionic acid bacteria, notably Propionibacterium freudenreichii, ferment compounds in the cheese and release CO2 gas, which slowly collects into the characteristic round "eyes" as the cheese ages.

3. **Correct Answer: A**

   Propionic acid bacteria produce propionic acid and acetic acid as byproducts of fermentation, contributing to Swiss cheese's characteristic nutty, slightly sweet flavor.

4. **Sample/Acceptable Answer:**

   Propionic acid bacteria added during cheesemaking ferment compounds in the cheese and release carbon dioxide gas as a byproduct during the cheese's warm aging/ripening period. Because the cheese's protein matrix is elastic enough to trap the gas without cracking, the CO2 slowly collects into pockets that form smooth, round eyes as the cheese ages. Cheese that lacks these characteristic holes (due to a different culture, gas escaping, or different processing conditions) is informally called "blind."

5. **Correct Answer: B**

   A bloomy rind is a soft, white, fuzzy rind formed by surface mold growth, characteristic of cheeses like Brie and Camembert.

6. **Correct Answer: B**

   Penicillium camemberti is the mold species cultivated on the surface of Brie and Camembert to create their characteristic bloomy white rind.

7. **Correct Answer: B**

   Bloomy-rind cheeses ripen from the outside inward, since the mold and its enzymes are concentrated at the surface, creating a gradient from soft, ripe cheese near the rind to firmer, less-ripe cheese toward the center.

8. **Correct Answers: A, B, C**

   Bloomy-rind cheeses ripen outside-in, have an intentionally cultivated edible rind, and rely on Penicillium camemberti. They generally become softer/runnier (not firmer) and can develop ammonia off-flavors past peak ripeness, and they are soft, high-moisture cheeses, not hard/low-moisture ones.

9. **Correct Answer: B**

   Brevibacterium linens thrives on the moist, salty surface created by washing, producing the strong aroma and orange color characteristic of washed-rind cheeses.

10. **Correct Answer: B**

    Cheddaring mechanically presses out additional whey and aligns/develops the curd's protein structure, giving cheddar its characteristic dense, fibrous texture.

11. **Correct Answer: B**

    Pasteurized process cheese (and related categories like cheese food and cheese product) permits emulsifying salts and other ingredients not allowed in natural cheese, enabling smooth, consistent, shelf-stable products like American cheese singles.

12. **Sample/Acceptable Answer:**

    Natural cheese is made directly from milk through fermentation, coagulation, and aging with minimal additional ingredients, while pasteurized process cheese is made by blending one or more natural cheeses

with emulsifying salts (and sometimes additional dairy ingredients, water, or flavorings), then heating the mixture until it melts into a smooth, homogeneous product. A practical advantage of process cheese is that it has a longer shelf life, melts more smoothly and consistently, and has a more uniform texture and flavor than many natural cheeses, making it well suited to food service and packaged product applications.

13. Correct Answer: D

Salt controls moisture, slows spoilage organisms, and contributes flavor, but it does not add lactose to cheese.

14. Correct Answer: B

Penicillium camemberti is cultivated on the surface of Brie to form its bloomy rind and drive its characteristic outside-in ripening.

15. Correct Answer: B

As bloomy-rind cheeses ripen, enzymatic breakdown of proteins and fats produces a softer, creamier texture and a more pungent, complex flavor.

16. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Bloomy-rind mold (Penicillium camemberti) is cultivated as a surface layer, typically sprayed onto or introduced at the exterior of the cheese after it is formed, and grows as a rind on the outside; this causes the cheese to ripen from the outside inward, creating a soft, gradually softening interior as ripening progresses. Blue cheese mold (Penicillium roqueforti) is mixed into the curd or injected into the cheese's interior, and grows along air channels created by piercing the cheese with needles or skewers (since the mold requires oxygen); this causes ripening to occur from the inside via these internal veins outward toward the surface. In terms of resulting differences, bloomy-rind cheeses develop a soft, creamy, spreadable texture with a mild, buttery, mushroom-like flavor, while blue cheeses develop a more crumbly texture with a sharp, tangy, pungent flavor, due in part to the breakdown of fats into free fatty acids by Penicillium roqueforti.

17. Correct Answer: B

Farmstead cheese is made on the same farm where the milk-producing animals are raised, using milk from that farm's own herd.

18. Correct Answer: B

PDO status legally restricts a cheese name to products made in a specific geographic region using defined traditional production methods.

19. Correct Answer: B

Parmigiano-Reggiano is a classic example of a PDO-protected cheese, legally restricted to production in a defined region of Italy using traditional methods.

20. Sample/Acceptable Answer:

During the pasta filata process, curd is submerged in very hot water (roughly 60-90°C) and repeatedly pulled, folded, and kneaded. The heat and mechanical working cause casein protein strands to align and stretch into long, parallel fibers, similar to how kneading aligns gluten strands in bread dough. This protein alignment is what gives mozzarella its characteristic stretchy, fibrous, stringy texture when pulled or melted, distinguishing it from cheeses made without this stretching step.

21. Correct Answer: B

Provolone is another well-known pasta filata (stretched-curd) cheese, produced using the same hot-water stretching technique as mozzarella.

22. Correct Answer: B

Because pasta filata stretching aligns casein fibers in one direction, string cheese can be peeled apart into long strings along that alignment.

23. Correct Answer: B

Ultra-filtered milk is produced using membrane filtration technology that separates and concentrates milk protein while allowing more of the lactose (and water) to be removed, resulting in a naturally higher-protein, lower-sugar product.

24. Correct Answers: A, B, D

Ultra-filtration is a membrane-based, size-selective filtration technology related to microfiltration and reverse osmosis that can concentrate protein relative to lactose. It does not require boiling, and it does not destroy the protein it concentrates.

25. Correct Answer: B

RO membranes have much smaller effective pore sizes than ultra-filtration membranes, blocking nearly all dissolved solutes (including lactose and minerals) and allowing mostly water to pass through, making RO useful for general concentration rather than selective protein separation.

26. Correct Answer: B

A plate heat exchanger passes milk and a heating (or cooling) fluid through alternating thin channels formed by closely spaced metal plates, maximizing surface area for fast, efficient heat transfer.

27. Correct Answer: A

Plate heat exchangers enable continuous-flow processing of large volumes of milk efficiently, unlike slower batch (vat) pasteurization.

28. Sample/Acceptable Answer:

Heat transfer rate depends on the surface area available for heat exchange, along with the temperature difference between the two fluids. A plate heat exchanger spreads milk into many thin layers across a large total plate surface area in contact with a heating fluid, dramatically increasing the rate of heat transfer compared to a single large batch of milk in a tank, where only the outer surface (and slow internal mixing/convection) transfers heat. This allows milk to reach pasteurization temperature very quickly and continuously, improving efficiency and consistency compared to slower batch heating.

29. Correct Answer: A

Aseptic UHT packaging combines high-heat sterilization with filling into a pre-sterilized, airtight container under sterile conditions, so no recontamination occurs after the sterilizing heat treatment, allowing long shelf-stable storage.

30. Correct Answer: B

It is the combination of more complete sterilization (UHT) and truly sterile, airtight packaging that prevents recontamination, not added preservatives, that allows extended unrefrigerated shelf life.

31. Correct Answer: B

Cultured butter is made by fermenting cream with lactic acid bacteria cultures before churning, developing more complex, tangy flavor compounds compared to sweet cream butter.

32. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Sweet cream butter is churned directly from fresh, unfermented cream, giving it a clean, mild, "sweet" dairy flavor, while cultured butter is made by first fermenting the cream with lactic acid bacteria cultures (similar to yogurt or sour cream cultures) for a period of time before churning, which produces lactic acid and aromatic compounds (such as diacetyl) that give cultured butter a more complex, tangy, slightly nutty flavor. Historically, before mechanical refrigeration was widely available, cream in many parts of Europe would naturally begin to sour/ferment during the time it took to collect enough cream for churning, making cultured butter the traditional style; in the United States, with earlier widespread adoption of refrigeration and centralized dairy processing, cream could be kept fresh and churned before natural souring occurred, making sweet cream butter the more common style.

33. Correct Answer: B

Traditional buttermilk was the liquid byproduct remaining after churning cream into butter.

34. Correct Answer: B

Modern cultured buttermilk is made by fermenting skim or low-fat milk with lactic acid bacteria cultures, rather than being a butter-churning byproduct.

35. Correct Answer: B

Buttermilk's acid reacts with the base baking soda to produce CO2 gas, which helps leaven baked goods.

36. Sample/Acceptable Answer:

Buttermilk's lactic acid reacts with baking soda (sodium bicarbonate, a base) in an acid-base neutralization reaction that produces carbon dioxide gas as a byproduct. As this CO2 gas forms and expands within the batter or dough, it creates small bubbles that help leaven (raise) the baked good, contributing to a lighter, more tender texture than would result without this reaction.

37. Correct Answer: B

Crème fraîche is generally made from a higher-fat cream than American sour cream, giving it a richer texture and a milder, less tangy flavor.

38. Correct Answer: A

Galalith is formed by reacting casein with formaldehyde, which cross-links the protein molecules into a hard, durable plastic material.

39. Correct Answer: B

Casein plastic is hard, durable, virtually nonflammable, and can be produced in a wide range of colors, making it well suited to manufacturing small decorative and functional objects.

40. Correct Answers: A, B, C, E

Sour cream is made by fermenting cream with lactic acid bacteria, which lowers pH, thickens the product, and produces its characteristic tangy lactic-acid flavor; it also has substantially more fat than fat-free milk. It is not produced without a bacterial culture.

41. Correct Answer: B

Ice milk historically contained a lower percentage of milkfat than standard ice cream.

42. Correct Answer: A

FDA labeling changes replaced the old "ice milk" category with "light" or "low-fat" ice cream terminology, which specifies the required fat/calorie reduction relative to regular ice cream.

43. Correct Answer: C

Milkshake and soft-serve mix products generally have far less stringent (or no specific) minimum milkfat requirements compared to the well-defined Standards of Identity for butter, ice cream, and heavy cream.

44. Sample/Acceptable Answer:

Cheese analogs substitute vegetable oil (such as palm or soybean oil) for some or all of the milkfat because vegetable oil is often less expensive than milkfat, has more consistent and controllable melting behavior, and does not require the same aging or dairy-specific processing that natural cheese does. A manufacturer might choose a cheese analog to reduce ingredient cost, achieve more predictable, uniform melting and stretch in a processed food product (such as frozen pizza), or extend shelf life, compared to using natural cheese.

45. Correct Answer: B

A light coating of cellulose or a similar anti-caking agent keeps shredded cheese pieces from sticking together in the package.

46. Correct Answer: B

Displacing oxygen with nitrogen slows aerobic mold growth and oxidative reactions, extending the shredded cheese's shelf life.

47. Correct Answer: B

A wax coating creates an airtight, moisture-retaining barrier that protects the cheese's rind from mold and contamination during aging and storage.

48. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Fresh cheese curds contain a still-intact, elastic protein matrix of casein strands that have not yet been broken down by aging enzymes or extensive proteolysis; when bitten, these elastic, fibrous protein strands rub against tooth enamel and vibrate, producing the characteristic squeaking sound. Over time (typically within days), naturally present enzymes and residual bacterial cultures continue to break down (proteolyze) this casein protein matrix, causing the structure to lose its elasticity and firmness; as the protein network relaxes and breaks down, the curd no longer vibrates against teeth in the same way, and the squeak fades. Because this protein breakdown begins immediately after the curd is formed and continues during storage and shipping (even under refrigeration), it is very difficult to preserve the fresh "squeak" for curds shipped any meaningful distance or held for more than a few days, which is why fresh squeaky curds are prized as a very locally sold, short-shelf-life specialty product.

49. Correct Answer: B

Thermophilic cultures (such as those used in yogurt) grow best at warmer temperatures, roughly 40-45°C, compared to mesophilic cultures, which prefer cooler temperatures around 20-30°C.

50. Correct Answer: A

Reverse osmosis applies pressure to force water molecules through a semi-permeable membrane, leaving a more concentrated milk or whey solution behind.

51. Correct Answer: B

Because reverse osmosis concentrates liquid using pressure rather than heat, it exposes the product to less thermal stress, helping preserve heat-sensitive nutrients and flavor compared to heat-based evaporation.

52. Sample/Acceptable Answer:

Osmosis is the natural movement of water molecules across a semi-permeable membrane from an area of lower solute concentration to an area of higher solute concentration, driven by the difference in osmotic pressure between the two sides, until concentrations equalize. Reverse osmosis "reverses" this natural direction by applying mechanical pressure greater than the natural osmotic pressure to the concentrated side (such as milk or whey), forcing water molecules to move backward through the membrane from the higher-concentration side to the lower-concentration (purified water) side, leaving behind a more concentrated milk or whey solution on the pressurized side.

53. Correct Answer: A

A withdrawal period is the required waiting time after antibiotic treatment before a treated animal's milk may legally re-enter the food supply, allowing residue levels to fall below regulatory limits.

54. Correct Answer: B

MRL is the legal upper limit for how much of a given substance (such as an antibiotic) may remain in a food product, including milk.

55. Correct Answer: B

Antibiotic residues can pose health risks (such as allergic reactions) to sensitive consumers, and can also inhibit the starter bacterial cultures needed for cheese and yogurt fermentation, making residue testing an important quality and safety control.

56. Correct Answers: A, B, D

Rapid screening tests are widely used, antibiotic residues can inhibit starter cultures, and a positive test can lead to an entire load being rejected. Farmers ARE legally required to observe withdrawal periods, and antibiotic residues ARE a genuine food safety/regulatory concern.

57. Correct Answer: B

Hydrolyzed infant formulas use milk protein broken down into smaller peptide fragments, reducing the likelihood of triggering an allergic response in sensitive infants.

58. Correct Answer: A

Whey protein's digestibility profile more closely resembles human breast milk than cow's milk's naturally casein-dominant protein profile, which is part of why formula manufacturers often adjust the whey-to-casein ratio.

59. Correct Answer: B

Breaking proteins into very small fragments reduces the chance that an infant's immune system will recognize and react to the larger, intact protein structures that typically trigger milk protein allergy.

60. Sample/Acceptable Answer:

Accept any two correct modifications, such as: whey protein is often added or the whey-to-casein ratio is adjusted to better resemble human breast milk's digestibility profile; lactose or other carbohydrates are adjusted to appropriate levels; the mineral content (such as sodium and potassium) is reduced compared to whole cow's milk, since infant kidneys cannot yet handle cow milk's naturally higher mineral load; and vitamins (such as Vitamin C, D, and iron) are added, since cow's milk alone does not provide adequate amounts of certain nutrients infants need. Ordinary cow's milk is not recommended for young infants because its unmodified protein, mineral, and nutrient profile is not well suited to an infant's immature digestive and kidney systems.

61. Correct Answer: B

Because traditional rennet is animal-derived, Kosher certification standards apply specific requirements about its source, which is part of why microbial or fermentation-produced chymosin is often preferred for certified Kosher cheese.

62. Correct Answer: B

Microbial inhibition tests like Delvotest expose a standardized bacterial culture to the milk sample; if the sample contains antibiotic residues, it will inhibit the bacteria's normal growth, producing a detectable result.

63. Correct Answer: B

Inhibited bacterial growth in this type of assay is a positive indicator that the milk sample may contain antibiotic residues, prompting further testing or rejection of the load.

64. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

A withdrawal period is the mandated waiting time after a cow is treated with antibiotics before her milk may legally be sold for human consumption, allowing antibiotic concentrations in the milk to fall below the legal Maximum Residue Level before that milk re-enters the food supply. As an additional safeguard beyond farmer compliance with withdrawal periods, rapid microbial inhibition screening tests (such as Delvotest) are run on every load or tanker of raw milk arriving at a processing plant before it is accepted; these tests expose a sample to a standardized bacterial culture and check whether antibiotic residues inhibit that culture's growth, providing a fast go/no-go result before the milk is mixed with other milk or processed further. If a raw milk sample tests positive, the load is typically rejected and cannot be used, protecting consumers from residues that could pose health risks or interfere with fermentation cultures used in downstream products like cheese and yogurt; economically, the farmer (or farmers, since a tanker often combines milk from multiple farms) who supplied the contaminated milk may bear significant financial loss from the rejected load, creating a strong incentive for strict adherence to withdrawal periods.

65. Correct Answer: B

Because cheese curd is primarily formed from coagulated casein protein with entrapped fat, milk's fat and casein protein content are the primary drivers of cheese yield.

66. Correct Answer: B

Milk richer in fat and casein protein generally yields more finished cheese per unit volume of milk processed, since these are the primary components retained in the curd.

67. Correct Answer: A

Historical casein paint was made by combining casein protein with an alkaline binder such as lime, which helps dissolve/activate the casein into a usable, durable paint medium.

68. Sample/Acceptable Answer:

Accept any correct historical application, such as: casein-based plastic (Galalith), made by reacting casein with formaldehyde to cross-link the protein into a hard, durable, moldable material used for buttons and small manufactured objects; or casein-based glue/adhesive, historically used in woodworking, which relies on casein's ability to form a strong, rigid bond as it dries; or casein-based paint, which uses casein (combined with an alkaline binder like lime) as a binder that hardens into a durable paint film as it dries. In each case, the useful property is casein's ability to denature/cross-link or harden into a strong, cohesive solid structure under the right chemical conditions.

69. Correct Answer: A

Because CLA is a bioactive fatty acid specific to ruminant dairy fat, cheese analogs made primarily with vegetable oil generally lack the CLA content naturally found in real dairy milkfat.

70. Correct Answer: A

Federal regulations generally require raw-milk cheese sold at retail to be aged at least 60 days, intended to reduce (though not eliminate) pathogen risk.

71. Correct Answer: B

The extended aging period allows natural acidification and other inhibitory conditions within the cheese to reduce (though not entirely eliminate) the survival of potentially harmful pathogens.

72. Correct Answers: A, C, D

The 60-day aging requirement exists and is meant to reduce (not eliminate) risk, and soft high-moisture raw-milk cheeses are considered higher risk. Raw-milk cheese does carry more risk than pasteurized-milk cheese, and state regulations on raw milk/raw-milk products vary rather than being identical nationwide.

73. Correct Answer: A

Kluyveromyces lactis, a yeast, is commonly used industrially to produce lactase enzyme for lactose-free dairy product manufacturing.

74. Correct Answer: A

Lactase, fermentation-produced chymosin, and many starter cultures are all produced through controlled industrial fermentation using selected microorganisms, rather than being extracted from milk or being synthetic chemicals.

75. Correct Answer: B

Buttermilk powder's lactose and protein support Maillard browning during baking and can improve dough's water absorption and texture.

76. Sample/Acceptable Answer:

Buttermilk powder (like other dried dairy ingredients) contains both protein (a source of amino acids) and lactose (a reducing sugar). During baking, these two components can react through the Maillard reaction --a non-enzymatic browning reaction between amino acids and reducing sugars under heat -- which produces the golden-brown color and characteristic toasted flavor compounds seen on a well-browned crust.

77. Correct Answer: A

Recombined/reconstituted milk is made by mixing milk powder (and sometimes separately stored milkfat) with water to approximate the composition of fresh liquid milk.

78. Correct Answer: A

Because milk powder is shelf-stable without refrigeration, it can be transported and stored much more easily than fresh liquid milk, then reconstituted with local water near the point of consumption, which is especially valuable where cold-chain infrastructure is limited.

79. Correct Answer: B

Milk proteins added to dough can help strengthen the dough's structure and gas-holding capacity and improve water absorption, supporting better texture and rise, rather than weakening the gluten network.

80. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Answers will vary depending on the ingredient/process chosen; award full credit for an accurate, detailed explanation covering all three required parts. Sample answer (UHT Aseptic Packaging): (1) UHT (Ultra-High-Temperature) processing sterilizes milk using very high heat for a very short time, and the milk is then filled into a package under sterile conditions so that no recontamination can occur after sterilization -- the underlying principle is complete microbial sterilization combined with an airtight barrier that prevents any new contamination. (2) A practical application is shelf-stable boxed milk (such as Tetra Pak cartons) sold unrefrigerated on grocery store shelves, widely used internationally and increasingly in the U.S. for extended-shelf-life dairy and plant-based beverages. (3) The key advantage compared to traditional HTST-pasteurized milk in a standard carton is that UHT aseptically packaged milk can be stored for months without refrigeration until opened, dramatically reducing cold-chain/refrigeration costs and food waste from spoilage, and making it far easier to distribute milk to regions or situations (such as emergency relief, school lunch programs, or areas with limited refrigerated transport) where consistent refrigeration is not guaranteed. (Equivalent full credit applies for well-developed answers on buttermilk powder in baking, reverse osmosis concentration, or recombined/reconstituted milk, covering the same three required components.)

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
Regional Exam

Team Name: _____ Team Number: _____

- This exam contains 30 questions: 21 multiple choice, 4 multiselect (select ALL correct answers), and 5 short answer.
- Five questions (Q4, Q6, Q17, Q28, Q29) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules. Content specific to State or National level events is not included.
- Total Time: 50 minutes (shared with lab tasks per event rules). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which macronutrient in milk is primarily responsible for supplying concentrated energy and carrying fat-soluble vitamins such as A and D?

A. Carbohydrates
B. Lipids (fats)
C. Minerals
D. Water

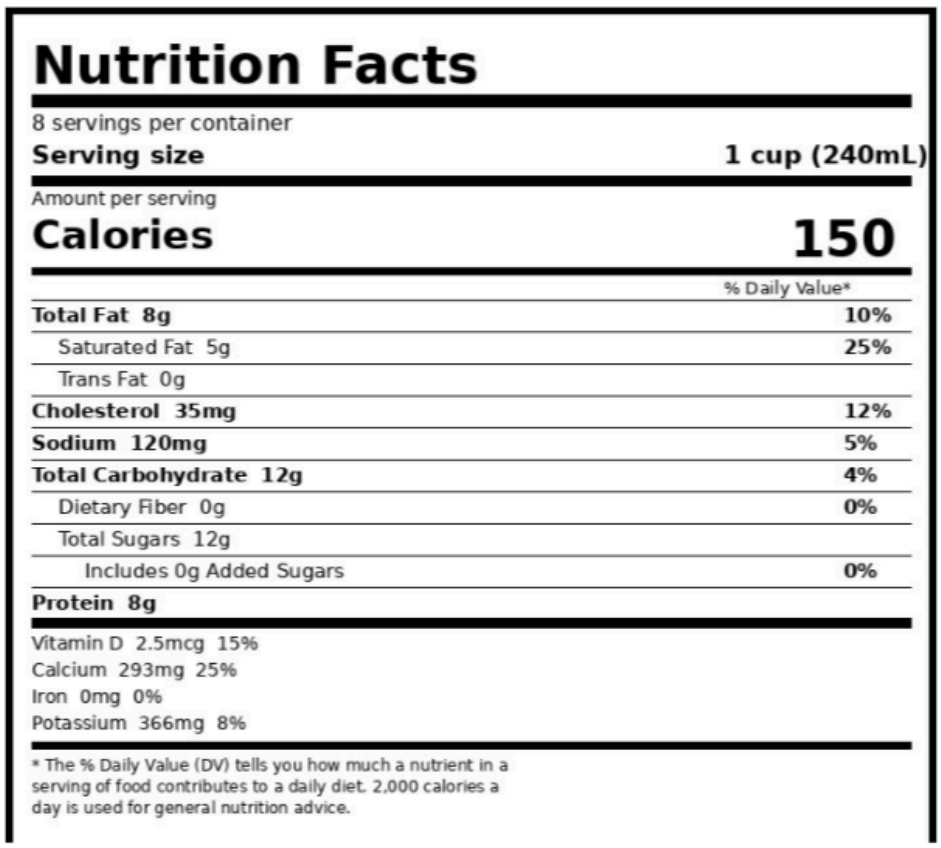
2. What is the primary carbohydrate found naturally in cow's milk?

A. Sucrose
B. Fructose
C. Lactose
D. Maltose

3. Which of the following correctly identifies the two main classes of protein found in milk?

A. Collagen and elastin
B. Casein and whey
C. Gluten and gliadin
D. Myosin and actin

4. Refer to Image 1 (an example U.S. Nutrition Facts label). Based on federal labeling regulations, which statement about the label is TRUE?



Nutrition Facts

8 servings per container

Serving size **1 cup (240mL)**

Amount per serving

Calories **150**

	% Daily Value*
Total Fat 8g	**10%**
Saturated Fat 5g	**25%**
Trans Fat 0g	
Cholesterol 35mg	**12%**
Sodium 120mg	**5%**
Total Carbohydrate 12g	**4%**
Dietary Fiber 0g	**0%**
Total Sugars 12g	
Includes 0g Added Sugars	**0%**
Protein 8g	

Vitamin D 2.5mcg 15%
Calcium 293mg 25%
Iron 0mg 0%
Potassium 366mg 8%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Image 1

A. Manufacturers may choose which nutrients to include on the label.
B. The label must list serving size, calories, and specific required nutrients in a standardized format.
C. Nutrition Facts labels are optional for packaged dairy products sold in the U.S.
D. The % Daily Value listed is always based on a 1,000-calorie diet.

5. Which U.S. federal agency is primarily responsible for regulating the labeling of most packaged dairy foods, including the Nutrition Facts panel?

A. Environmental Protection Agency (EPA)
B. Food and Drug Administration (FDA)
C. Department of Energy (DOE)
D. Federal Trade Commission (acting alone)

6. Refer to Image 2 (the general structural formula of a triglyceride). The bonds joining the glycerol backbone to the fatty acid chains are formed through which type of organic reaction?

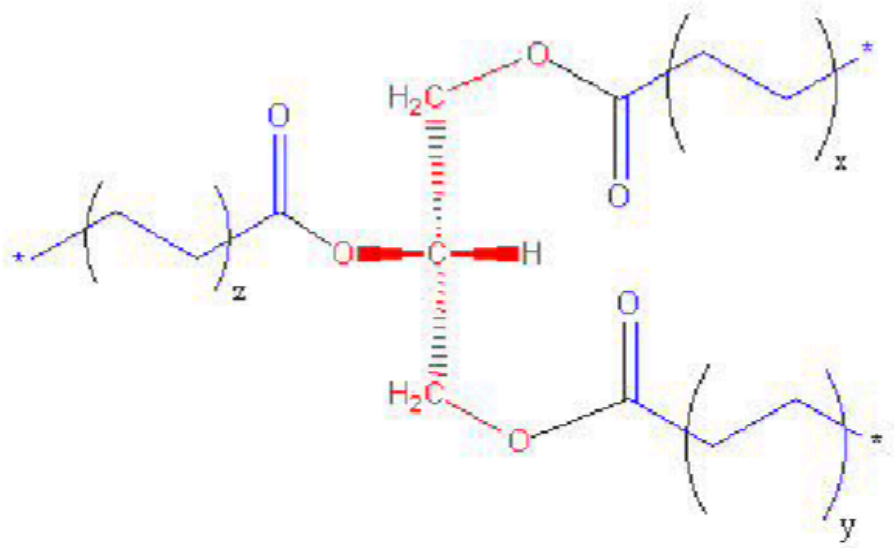


Image 2

A. Hydrolysis
B. Esterification
C. Saponification
D. Fermentation

7. Select ALL statements that correctly describe saturated and unsaturated fats. (Select ALL that apply.)

A. Saturated fats contain no carbon-carbon double bonds.
B. Unsaturated fats are typically liquid at room temperature.
C. Saturated fats are typically liquid at room temperature.
D. Unsaturated fatty acid chains contain one or more carbon-carbon double bonds.
E. Butterfat is composed entirely of unsaturated fat.

8. Lactose is a disaccharide made up of which two monosaccharides?

A. Glucose and fructose
B. Glucose and galactose
C. Fructose and galactose
D. Two glucose molecules

9. Starches are polysaccharides made of long, branched or unbranched chains of which monosaccharide?

A. Fructose
B. Galactose
C. Glucose
D. Ribose

10. Proteins such as casein and whey are built from long chains of which building block, linked together by peptide bonds?

A. Fatty acids
B. Amino acids
C. Nucleotides
D. Monosaccharides

11. Select ALL nutrients that are naturally found in significant amounts in cow's milk and are considered essential to the human diet. (Select ALL that apply.)

A. Vitamin A
B. Vitamin D
C. Vitamin C
D. Calcium
E. Complete (high-quality) protein

12. When milk is heated during cooking, whey proteins unfold and lose their original three-dimensional shape. This process is called:

A. Hydrolysis
B. Denaturation
C. Esterification
D. Fermentation

13. A true milk protein allergy is different from lactose intolerance because an allergy involves:

A. An inability to digest the sugar lactose
B. An immune system response to milk proteins such as casein or whey
C. A build-up of lactic acid in the muscles
D. A deficiency of vitamin D

14. Name and briefly describe TWO different methods used to preserve dairy foods and extend their shelf life.

15. Dairy foods are one of the best dietary sources of which essential mineral, needed for strong bones and teeth?

A. Iron
B. Calcium
C. Potassium
D. Sodium

16. Describe ONE health consequence that can result from a long-term deficiency of Vitamin D, and explain why dairy products are often fortified with this vitamin.

17. Refer to Image 3, a graph plotting the freezing point of a saltwater solution against salt (NaCl) concentration. Based on the trend shown, adding rock salt to the ice bath during a hands-on ice cream-making activity will:

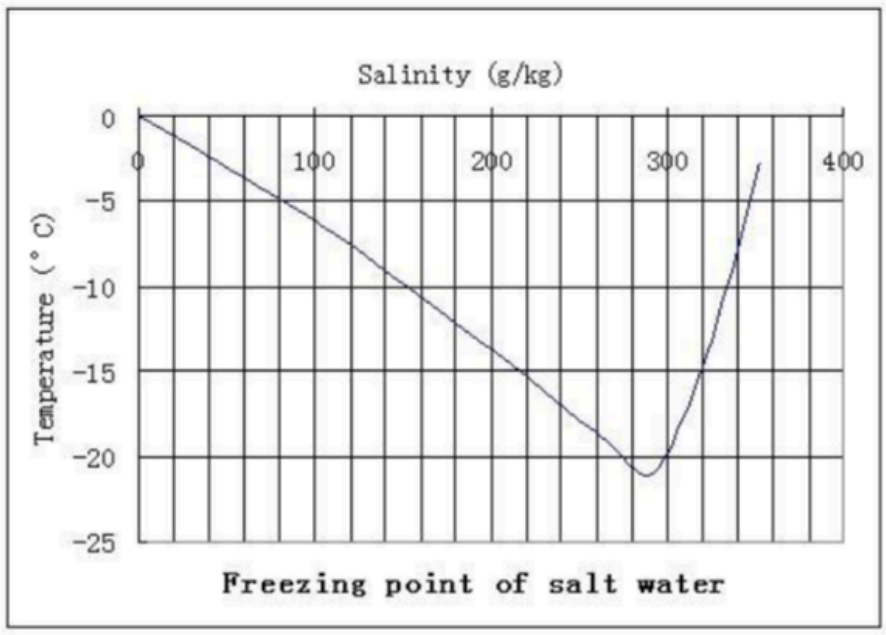


Image 3

A. Raise the freezing point of the ice bath, cooling the mixture faster
B. Have no effect on the freezing point of the ice bath
C. Lower the freezing point of the ice bath, allowing it to reach temperatures below 0°C
D. Cause the ice to melt at a higher temperature than pure water

18. Select ALL statements that are TRUE about non-dairy "milk" products such as almond, soy, or oat milk. (Select ALL that apply.)

A. They are produced by extracting liquid from a plant source rather than from an animal.
B. They naturally contain lactose unless specifically labeled lactose-free.
C. Many are fortified with added calcium and Vitamin D to resemble the nutrient profile of cow's milk.
D. Soy milk generally provides a protein content closer to cow's milk than almond or rice milk does.
E. All non-dairy milks are chemically identical to cow's milk.

19. Lactose-free milk is produced by adding which enzyme to regular milk to break lactose down into glucose and galactose?

A. Amylase
B. Lactase
C. Protease
D. Lipase

20. Identify TWO health benefits associated with regularly consuming dairy foods, and briefly explain why each benefit occurs.

21. Low-fat and fat-free milk are produced primarily by:

A. Adding water to whole milk
B. Mechanically or chemically removing (skimming) the milk fat/cream
C. Adding lactase enzyme
D. Heating the milk at very high temperatures

22. Explain, at the chemical/digestive level, why a person who is lactose intolerant experiences digestive discomfort after consuming dairy products.

23. Homogenization prevents cream from separating out of milk by:

A. Heating milk to kill bacteria
B. Breaking fat globules into smaller, evenly dispersed particles (an emulsification process)
C. Removing all fat from the milk
D. Adding artificial stabilizing salts

24. The HTST (High-Temperature-Short-Time) method of pasteurization typically heats milk to approximately:

A. 45°C for 1 hour

B. 72°C for 15 seconds
C. 100°C for 30 minutes
D. 4°C for 24 hours

25. To be labeled "organic" in the United States, dairy products must come from cows that meet requirements including:

A. Being fed only grain-based feed
B. Never having access to pasture
C. Not being treated with synthetic hormones or antibiotics, and having access to pasture
D. Being raised exclusively indoors on a corn-based diet

26. Select ALL statements that correctly describe casein protein, as compared to whey protein, in milk. (Select ALL that apply.)

A. Casein makes up the majority (about 80%) of the protein in cow's milk.
B. Casein remains dissolved in the liquid (does not coagulate) when milk is curdled with acid.
C. Casein coagulates into curds when milk is acidified or treated with rennet.
D. Whey protein is digested and absorbed by the body more quickly than casein.
E. Casein micelles are colloidal protein structures suspended in milk.

27. Probiotics found in yogurt and other fermented dairy products are best described as:

A. Synthetic preservatives added to extend shelf life
B. Live beneficial bacteria that can support digestive/gut health
C. A type of fat-soluble vitamin
D. An artificial sweetener used in low-fat yogurt

28. Refer to Image 4, a diagram of a casein micelle. Based on current scientific models, which statement best describes the overall structure shown?

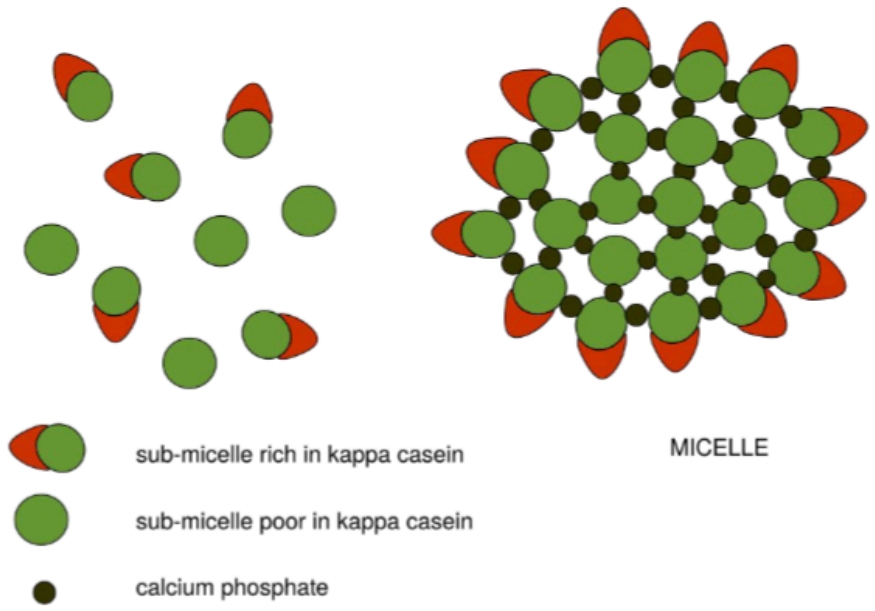


Image 4

A. A single long protein chain with no substructure
B. A colloidal cluster of casein sub-units held together in part by calcium-phosphate bridges
C. A crystal lattice made entirely of fat molecules
D. A simple ring-shaped monosaccharide structure

29. Refer to Image 5, a chart comparing average nutrient amounts in 2% cow's milk to several plant-based milk alternatives. According to the chart, which plant-based milk generally shows a protein content closest to cow's milk?

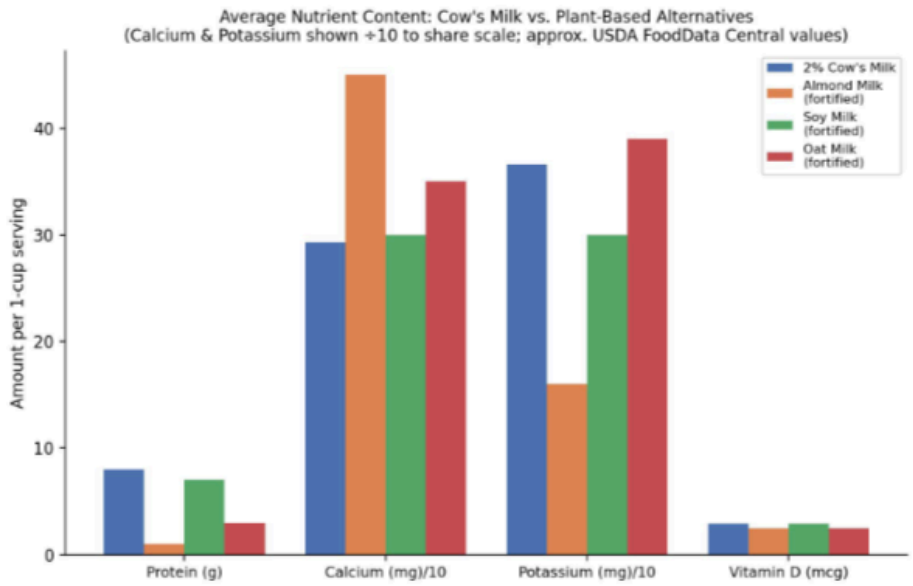


Image 5

A. Almond milk
B. Rice milk
C. Soy milk
D. Coconut milk

30. Compare cow's milk and a plant-based milk alternative (such as almond or oat milk) in terms of their natural macronutrient composition (proteins, fats, and carbohydrates), and explain ONE reason manufacturers often fortify plant-based milks.

ANSWER KEY

FOOD SCIENCE – DIVISION B – REGIONAL EXAM

1. Correct Answer: B

Milk fat (lipids) provides concentrated energy (9 kcal/g) and serves as the carrier for fat-soluble vitamins A and D.

2. Correct Answer: C

Lactose is the disaccharide sugar naturally present in milk.

3. Correct Answer: B

Milk protein is made up mainly of casein (~80%) and whey (~20%) proteins.

4. Correct Answer: B

Federal labeling regulations require a standardized format listing serving size, calories, and mandated nutrients; %DV is based on a 2,000-calorie reference diet, and the label is required, not optional.

5. Correct Answer: B

The FDA regulates Nutrition Facts labeling requirements for most packaged foods, including dairy products.

6. Correct Answer: B

Esterification is the condensation reaction between glycerol's hydroxyl groups and fatty acids' carboxyl groups, releasing water and forming ester bonds.

7. Correct Answers: A, B, D

Saturated fats have no C=C double bonds and are usually solid at room temperature; unsaturated fats have one or more C=C double bonds and are usually liquid at room temperature. Butterfat is a mix of saturated and unsaturated fat, not entirely unsaturated.

8. Correct Answer: B

Lactose is formed from one glucose molecule and one galactose molecule joined by a glycosidic bond.

9. Correct Answer: C

Starch is a polysaccharide composed entirely of repeating glucose units.

10. Correct Answer: B

Proteins are polymers of amino acids joined by peptide bonds.

11. Correct Answers: A, B, D, E

Milk is a significant natural source of Vitamin A, Vitamin D, calcium, and complete protein. It is not a significant natural source of Vitamin C.

12. Correct Answer: B

Heat causes proteins to denature (unfold), which changes their structure and functional properties, such as in scalded milk forming a skin.

13. Correct Answer: B

A milk allergy is an immune reaction to milk proteins, while lactose intolerance is a digestive (enzyme deficiency) issue, not an immune response.

14. Sample/Acceptable Answer:

Accept any two clearly described, correct methods, such as: Pasteurization (heating milk to destroy harmful bacteria and slow spoilage), Refrigeration/Freezing (slowing microbial growth and enzymatic activity), UHT (Ultra-High-Temperature) processing (allows shelf-stable, unrefrigerated storage), Drying/powdering milk (removes water needed for microbial growth), or Fermentation (converting milk into yogurt or cheese, lowering pH to inhibit spoilage organisms).

15. Correct Answer: B

Dairy is a leading dietary source of calcium, essential for bone and tooth mineralization.

16. Sample/Acceptable Answer:

A long-term Vitamin D deficiency can weaken and soften bones, causing rickets in children or osteomalacia/osteoporosis in adults, because Vitamin D is required for the body to properly absorb calcium from the digestive tract. Dairy products are commonly fortified with Vitamin D so that the calcium they provide can be effectively absorbed and used by the body, supporting bone health.

17. Correct Answer: C

As shown on the graph, increasing salt concentration lowers (depresses) the freezing point of the solution, allowing the ice-salt bath to reach temperatures well below 0°C, which is necessary to freeze the ice cream mixture.

18. Correct Answers: A, C, D

Plant-based milks are extracted from plant sources and naturally contain no lactose (lactose is only found in animal milk); many are fortified with calcium and Vitamin D, and soy milk's protein content is closest to cow's milk among common plant milks.

19. Correct Answer: B

Lactase is the enzyme added to break the glycosidic bond in lactose, producing free glucose and galactose.

20. Sample/Acceptable Answer:

Accept any two reasonable, correctly explained benefits, such as: supports bone and tooth health (calcium and Vitamin D support mineralization), supports muscle growth/repair (complete, high-quality protein provides all essential amino acids), or supports digestive/gut health (probiotics in fermented dairy such as yogurt support healthy gut bacteria).

21. Correct Answer: B

Low-fat and fat-free milk are made by separating (skimming) some or nearly all of the fat from whole milk.

22. Sample/Acceptable Answer:

A lactose-intolerant person does not produce enough of the enzyme lactase in the small intestine to break lactose down into glucose and galactose. The undigested lactose passes into the large intestine, where bacteria ferment it, producing gas, and the undigested sugar also draws water into the intestine osmotically, resulting in bloating, cramping, gas, and diarrhea.

23. Correct Answer: B

Homogenization mechanically breaks milk fat globules into smaller particles that stay evenly dispersed (emulsified) throughout the milk, preventing the cream layer from separating.

24. Correct Answer: B

HTST pasteurization is commonly performed at approximately 72°C (161°F) for about 15 seconds.

25. Correct Answer: C

USDA organic dairy standards require cows to be raised without synthetic hormones or antibiotics and to have access to pasture.

26. Correct Answers: A, C, D, E

Casein is the major milk protein (~80%) that coagulates into curds when acidified or treated with rennet, forming colloidal micelles; whey remains in the liquid and is digested more quickly than casein.

27. Correct Answer: B

Probiotics are live microorganisms (beneficial bacteria) that, when consumed, can support gut health.

28. Correct Answer: B

Casein micelles are colloidal particles composed of casein sub-units linked together in part by calcium-phosphate bridges, as illustrated in the sub-micelle model.

29. Correct Answer: C

Soy milk consistently provides a protein content closest to cow's milk among common plant-based alternatives, as shown in the chart.

30. Sample/Acceptable Answer:

Cow's milk naturally contains complete, high-quality protein (casein and whey), lactose as its carbohydrate, and milk fat that includes saturated fatty acids. Most plant-based milks naturally contain little protein, contain no lactose (their carbohydrates instead come from the starches/sugars of the plant source), and their fat content/type varies by plant source. Because many plant milks naturally lack the calcium, Vitamin D, and protein levels found in cow's milk, manufacturers often fortify them with added calcium, Vitamin D, and sometimes protein so their nutrition profile more closely resembles cow's milk.

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B Form 2
Regional Exam

Team Name: _____ Team Number: _____

- This exam contains 30 questions: 21 multiple choice, 4 multiselect (select ALL correct answers), and 5 short answer.
- Five questions (Q4, Q8, Q10, Q14, Q16) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules. Content specific to State or National level events is not included.
- Total Time: 50 minutes (shared with lab tasks per event rules). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which dairy processing method involves adding live lactic acid bacteria cultures to milk to produce a fermented product such as yogurt?

A. Pasteurization
B. Homogenization
C. Fermentation
D. Ultra-filtration

2. Compared to whole milk, skim (fat-free) milk has had which component removed?

A. Protein
B. Milk fat
C. Lactose
D. Calcium

3. Select ALL statements that are TRUE about milk proteins. (Select ALL that apply.)

A. Whey proteins remain dissolved in the liquid after acid coagulation.
B. Casein makes up the minority of the total protein in milk.
C. Whey proteins denature more easily with heat than casein does.
D. Casein becomes insoluble and precipitates near its isoelectric point (approximately pH 4.6).
E. Whey and casein have identical amino acid sequences.

4. Refer to Image 1, the Haworth projection structure of lactose. The two monosaccharide rings shown are joined together by which type of chemical bond?

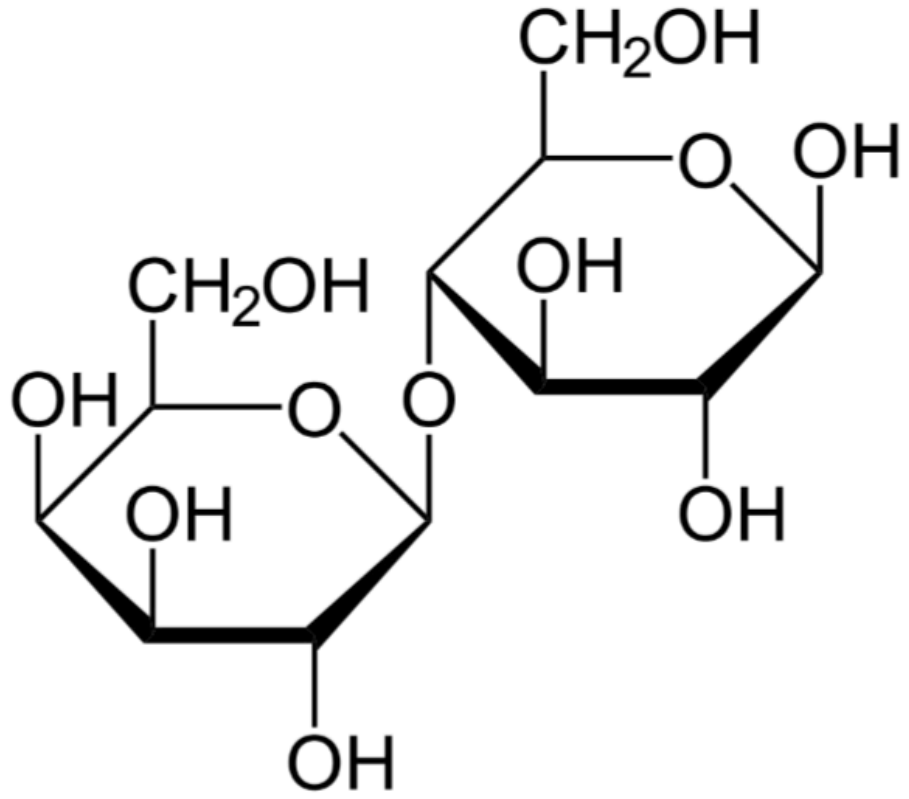


Image 1

A. Peptide bond
B. Ester bond
C. Glycosidic bond
D. Hydrogen bond

5. Under U.S. FDA regulations, which of the following is one of the major food allergens that MUST be declared on a packaged food label if present?

A. Milk
B. Basil
C. Corn
D. Cinnamon

6. List TWO of the major food allergens recognized under U.S. food labeling law, and explain why allergen labeling for milk specifically is important for consumers.

7. Which of the following fatty acids is a SATURATED fatty acid commonly found in milk fat?

A. Oleic acid
B. Palmitic acid
C. Linoleic acid
D. Linolenic acid

8. Refer to Image 2, the chemical structure of cholecalciferol. Which vitamin does this structure represent, one that is commonly added to fortified milk?

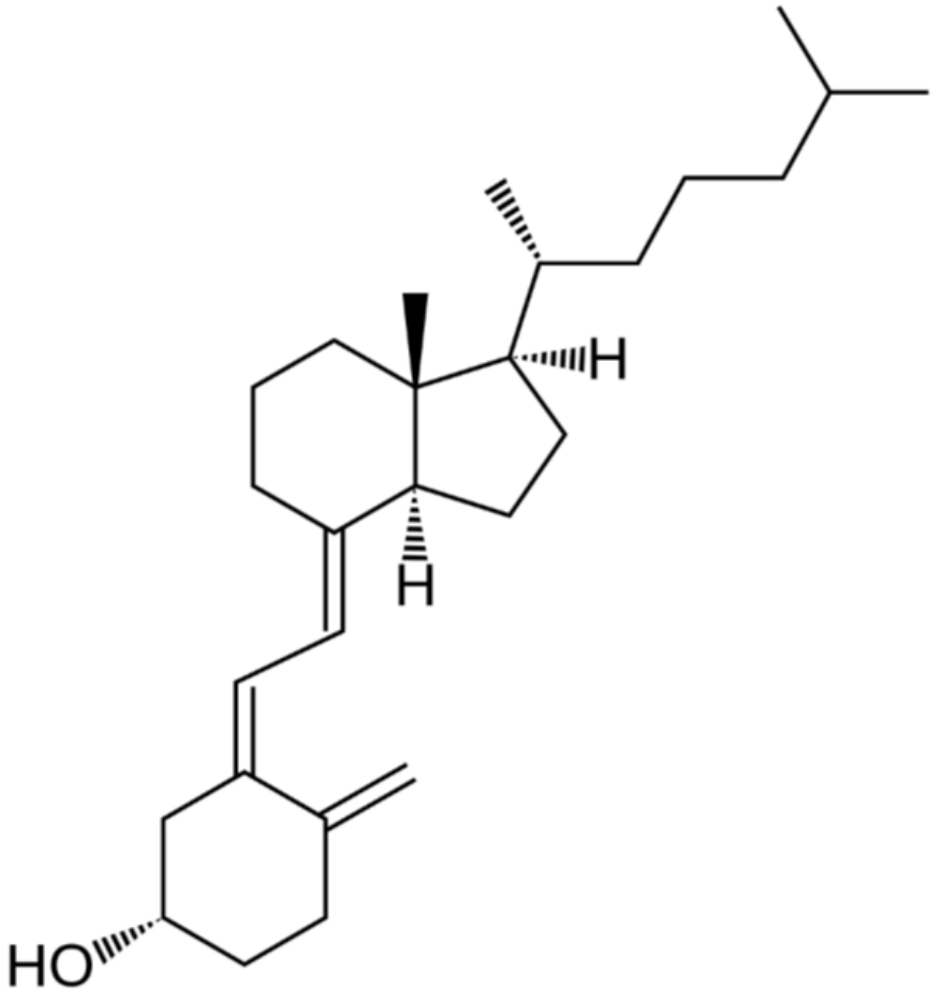


Image 2

A. Vitamin A
B. Vitamin B12
C. Vitamin C
D. Vitamin D3

9. Why is Vitamin D commonly added to milk during fortification rather than relying on milk's natural content alone?

A. Milk naturally contains toxic levels of Vitamin D
B. Milk does not naturally contain significant amounts of Vitamin D
C. Fortification improves the color of milk
D. Vitamin D fortification is required to prevent spoilage

10. Refer to Image 3, the general structural formula of an amino acid. Which labeled feature of this molecule varies between the 20 common amino acids and gives each one its unique chemical properties?

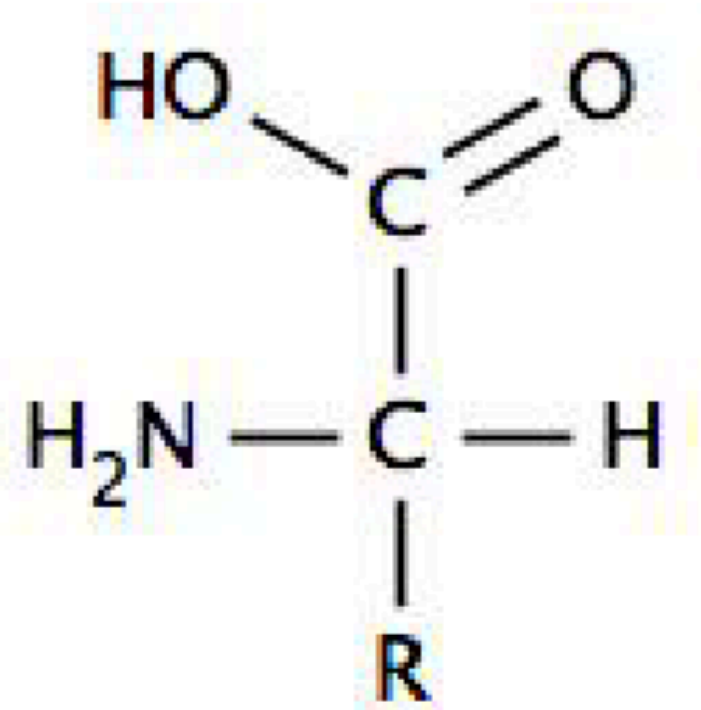


Image 3

A. The carboxyl group
B. The amino group
C. The central alpha carbon
D. The R group (side chain)

11. Which of the following best describes how individual amino acids join together to form a protein such as casein?

A. Glycosidic bonds link sugar rings together
B. Peptide bonds form between the amino group of one amino acid and the carboxyl group of the next
C. Ester bonds form between glycerol and fatty acids
D. Ionic bonds form between calcium and phosphate ions

12. Explain why milk protein is considered a "complete" protein, and name ONE non-dairy food source that also provides complete protein.

13. Which enzyme, naturally found in the stomach of young mammals and used commercially in cheesemaking, causes casein to coagulate into curds?

A. Lactase
B. Rennet (rennin)
C. Amylase
D. Lipase

14. Refer to Image 4, a photo showing separated curds and whey. Which milk protein makes up the majority of the solid curds shown in the image?



Image 4

A. Whey
B. Casein
C. Collagen
D. Keratin

15. Select ALL methods below that can cause milk to curdle (separate into curds and whey). (Select ALL that apply.)

A. Adding an acid such as vinegar or lemon juice
B. Adding rennet enzyme
C. Homogenizing the milk
D. Allowing bacterial fermentation to lower the milk's pH
E. Freezing the milk solid

16. Refer to Image 5, a pH scale diagram. Fresh cow's milk typically has a pH of approximately 6.5 to 6.7. Based on the scale, fresh milk is best described as:

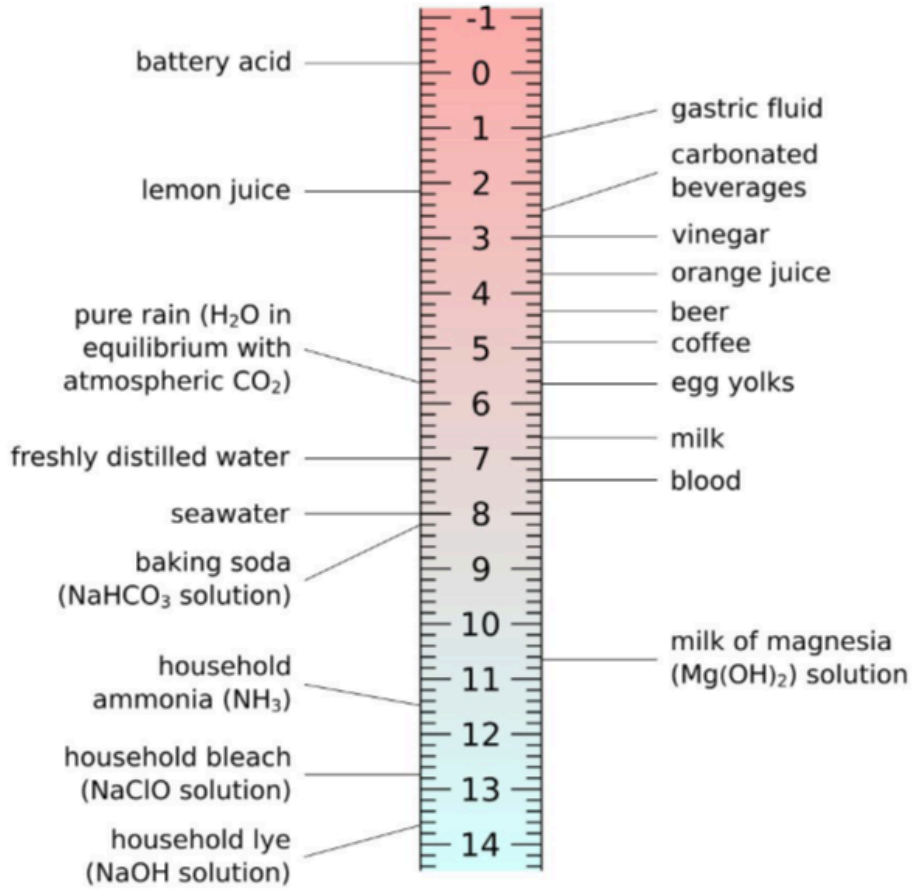


Image 5

A. Strongly acidic
B. Slightly acidic (close to neutral)
C. Strongly basic
D. Perfectly neutral (pH 7.0 exactly)

17. Select ALL statements that are TRUE about milk souring (fermentation) over time. (Select ALL that apply.)

A. Lactic acid bacteria convert lactose into lactic acid.
B. The pH of the milk decreases (becomes more acidic) as it sours.
C. Soured milk is always safer to drink than fresh milk.
D. As acidity increases, casein proteins may coagulate and the milk may curdle.
E. Souring causes the lactose content of the milk to increase.

18. Using the concept of pH and isoelectric point, explain why adding an acid such as vinegar or lemon juice to warm milk causes the casein protein to coagulate into curds.

19. Which of the following best describes an emulsion?

A. A uniform mixture of two liquids that would not normally mix, such as fat dispersed throughout water
B. A solid completely dissolved in a liquid
C. Two gases mixed together
D. A chemical reaction that produces an entirely new compound

20. Which natural component of milk acts as an emulsifier, helping keep fat globules dispersed and suspended in the watery portion of milk?

A. Lactose crystals
B. Casein micelles and milk proteins
C. Calcium carbonate
D. Vitamin C

21. UHT (Ultra-High-Temperature) processed milk is typically heated to approximately what temperature, allowing it to be stored unrefrigerated until opened?

A. 63°C for 30 minutes
B. 72°C for 15 seconds
C. 138°C for 2 seconds
D. 4°C for 24 hours

22. Which of the following is a key advantage of UHT-processed milk compared to standard HTST-pasteurized milk?

A. UHT milk has a much longer unrefrigerated shelf life
B. UHT milk contains significantly more lactose
C. UHT milk is automatically certified organic
D. UHT milk cannot be consumed by lactose-intolerant individuals

23. To qualify as "organic" under USDA standards, dairy cows must NOT be given which of the following?

A. Access to pasture
B. Organic feed
C. Synthetic growth hormones such as rBST
D. Fresh water

24. Identify ONE specific USDA production requirement that differs between conventional and organic dairy farming, and explain ONE reason some consumers choose organic dairy products.

25. Which two monosaccharides make up the disaccharide sucrose, sometimes added as a sweetener to flavored dairy products like ice cream?

A. Glucose and fructose
B. Glucose and galactose

C. Fructose and galactose
D. Two fructose molecules

26. Compared to table sugar (sucrose), lactose is generally:

A. Sweeter tasting
B. Less sweet tasting
C. Chemically identical to sucrose
D. Not a carbohydrate at all

27. Select ALL statements that are TRUE about the lactase enzyme and lactose digestion. (Select ALL that apply.)

A. Lactase is produced by cells in the lining of the small intestine.
B. Lactase breaks the glycosidic bond joining glucose and galactose in lactose.
C. Lactase production naturally decreases in many people after early childhood.
D. Lactase converts lactose into two glucose molecules.
E. Lactase-treated (lactose-free) milk tends to taste slightly sweeter than regular milk.

28. Which of the following best explains why lactose-free milk often tastes slightly sweeter than regular milk?

A. Lactase breaks lactose into glucose and galactose, which taste sweeter individually than lactose does
B. Manufacturers add extra sugar during processing
C. Lactose-free milk naturally contains more milk fat
D. Lactose-free milk undergoes an additional fermentation step

29. Which genus of bacteria is most commonly associated with fermenting milk into yogurt?

A. Escherichia
B. Lactobacillus
C. Salmonella
D. Clostridium

30. Describe the basic biological/chemical process by which bacteria convert milk into yogurt, and explain how this process changes the texture and taste of the milk.

ANSWER KEY

FOOD SCIENCE – DIVISION B (EXAM 2) – REGIONAL EXAM

1. Correct Answer: C

Fermentation is the process of adding bacterial cultures that convert lactose into lactic acid, producing fermented dairy foods like yogurt.

2. Correct Answer: B

Skim milk is produced by removing nearly all of the milk fat, while protein, lactose, and calcium remain largely unchanged.

3. Correct Answers: A, C, D

Whey stays dissolved after acid coagulation and denatures more readily with heat; casein precipitates near its isoelectric point (~pH 4.6). Casein is the majority protein (not the minority), and whey and casein are structurally different proteins.

4. Correct Answer: C

The two monosaccharide units (glucose and galactose) in lactose are joined by a glycosidic bond.

5. Correct Answer: A

Milk is one of the major food allergens (the 'Big Nine') that federal law requires to be clearly declared on packaged food labels.

6. Sample/Acceptable Answer:

Accept any two of the major recognized allergens: milk, eggs, fish, shellfish, tree nuts, peanuts, wheat, soybeans, sesame. Allergen labeling for milk is important because even small or trace amounts of milk protein can trigger a potentially severe immune reaction in someone with a true milk allergy, so clear labeling helps them identify and avoid products that could cause harm.

7. Correct Answer: B

Palmitic acid is a saturated fatty acid (no carbon-carbon double bonds) commonly found in milk fat; oleic, linoleic, and linolenic acids are all unsaturated.

8. Correct Answer: D

Cholecalciferol is the chemical name for Vitamin D3, commonly added to fortify milk.

9. Correct Answer: B

Milk is not naturally a significant source of Vitamin D, so many dairies fortify milk with Vitamin D to help support calcium absorption and bone health.

10. Correct Answer: D

The R group (side chain) is the variable portion of an amino acid that differs between amino acids and determines each one's unique chemical properties; the amino group, carboxyl group, and alpha carbon are common to (nearly) all amino acids.

11. Correct Answer: B

Amino acids are linked into proteins through peptide bonds, formed in a condensation reaction between the amino group of one amino acid and the carboxyl group of the next.

12. Sample/Acceptable Answer:

Milk protein is considered complete because it contains all nine essential amino acids in sufficient proportions -- amino acids the human body cannot synthesize on its own and must obtain from food. Accept any correct non-dairy complete protein source, such as eggs, soybeans/soy products, quinoa, or meat/poultry/fish.

13. Correct Answer: B

Rennet (rennin) is the enzyme traditionally used to coagulate casein into curds during cheesemaking.

14. Correct Answer: B

Casein coagulates into the solid curds, while whey protein remains dissolved in the liquid portion.

15. Correct Answers: A, B, D

Acid, rennet, and bacterial fermentation (which produces lactic acid) can all cause casein to coagulate and curdle milk. Homogenization and freezing do not cause curdling in this way.

16. Correct Answer: B

A pH of 6.5-6.7 falls just below neutral (pH 7), making fresh milk slightly acidic.

17. Correct Answers: A, B, D

Lactic acid bacteria ferment lactose into lactic acid, lowering pH and eventually causing casein to coagulate. Souring does not make milk automatically safer, and lactose content decreases (it is consumed by the bacteria), not increases.

18. Sample/Acceptable Answer:

Casein micelles carry a net negative charge at milk's normal pH, which causes them to repel one another and stay suspended in solution. Adding acid lowers the pH toward casein's isoelectric point (about pH 4.6), the point at which casein molecules lose their net electrical charge. Without that charge to keep them apart, the casein molecules can no longer repel each other and instead clump together, coagulating into solid curds.

19. Correct Answer: A

An emulsion is a stable, uniform mixture of two liquids that would not normally combine, such as fat droplets dispersed throughout the watery portion of milk.

20. Correct Answer: B

Casein micelles and other milk proteins coat fat globules and act as natural emulsifiers, keeping fat dispersed throughout milk.

21. Correct Answer: C

UHT processing typically heats milk to about 138°C (280°F) for roughly 2 seconds, destroying essentially all microorganisms and allowing shelf-stable, unrefrigerated storage until opened.

22. Correct Answer: A

Because UHT processing destroys essentially all microorganisms, UHT milk can be stored unrefrigerated for months until opened, unlike HTST-pasteurized milk, which still requires refrigeration.

23. Correct Answer: C

USDA organic standards prohibit the use of synthetic growth hormones (such as rBST) and antibiotics in organic dairy production.

24. Sample/Acceptable Answer:

Accept any correct, specific comparison, such as: organic dairy cows must have access to pasture and cannot be treated with synthetic growth hormones or antibiotics, while conventional dairy farming has no such restriction. Consumers may choose organic dairy to avoid synthetic hormones/antibiotics, to support pasture-based animal welfare practices, or to avoid certain pesticides used in conventional feed production.

25. Correct Answer: A

Sucrose (table sugar) is composed of one glucose molecule and one fructose molecule joined by a glycosidic bond.

26. Correct Answer: B

Lactose is significantly less sweet-tasting than sucrose, which is part of why lactose-free milk (with lactose broken into glucose and galactose) tastes noticeably sweeter.

27. Correct Answers: A, B, C, E

Lactase is produced in the small intestine and breaks lactose's glycosidic bond into glucose and galactose (not two glucose molecules); lactase production commonly declines after early childhood in many people, and lactose-free milk tastes sweeter because glucose and galactose are sweeter-tasting than lactose.

28. Correct Answer: A

Lactase enzymatically splits lactose into glucose and galactose, both of which taste sweeter individually than the original disaccharide lactose.

29. Correct Answer: B

Lactobacillus species (often alongside Streptococcus thermophilus) are the bacteria most commonly used to ferment milk into yogurt.

30. Sample/Acceptable Answer:

Live bacterial cultures (such as Lactobacillus species) ferment the lactose in milk, converting it into lactic acid. The buildup of lactic acid lowers the milk's pH, which causes casein proteins to lose their net charge and coagulate, thickening the milk into yogurt's characteristic gel-like texture. The lactic acid produced during fermentation also gives yogurt its characteristic tangy, sour taste.

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
State Exam

State Exam - No questions repeated from the Regional Exam Forms 1 or 2

Team Name: _____ Team Number: _____

- This exam contains 50 questions: 35 multiple choice, 5 multiselect (select ALL correct answers), and 10 short answer.
- Eight questions (Q4, Q8, Q15, Q19, Q26, Q30, Q35, Q40) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; State Tournament teams complete one or two Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Water makes up approximately what percentage of the composition of cow's milk?

A. 25%
B. 50%
C. 87%
D. 99%

2. Chemically, milk is best classified as which type of mixture?

A. A true solution
B. A colloid
C. A pure compound
D. An element

3. Which characteristic of milk fat globules explains why milk is classified as a colloid rather than a true solution?

A. Milk fat globules are small enough to stay suspended but large enough to scatter light
B. Milk fat dissolves completely at the molecular level
C. Milk fat forms ionic bonds with water
D. Milk fat has no measurable particle size

4. Refer to Image 1, the skeletal structure of oleic acid. The bend (kink) in the middle of the carbon chain is caused by which structural feature?

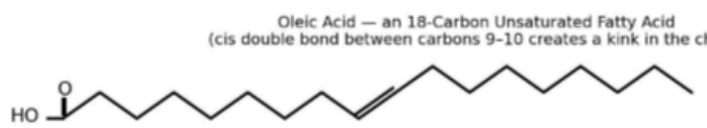


Image 1

A. A peptide bond
B. A cis carbon-carbon double bond
C. A glycosidic bond
D. A branched methyl group

5. Why are saturated fats (like butterfat) typically solid at room temperature, while unsaturated fats (like most vegetable oils) are typically liquid?

A. Saturated fats have more calories per gram
B. Saturated fatty acid chains pack tightly together, while double bonds in unsaturated chains create kinks that prevent tight packing
C. Unsaturated fats contain more protein
D. Saturated fats contain more water

6. Select ALL statements that are TRUE about milk fat-based products. (Select ALL that apply.)

A. Butter is made by churning cream until the fat globules coalesce and separate from the liquid buttermilk.

B. Ghee is butter that has had the milk solids and water removed through gentle heating.

C. Heavy cream contains a higher percentage of milk fat than half-and-half.

D. Butter contains no water at all.

E. Whipped cream relies on air being trapped in a network formed by partially coalesced fat globules.

7. Ghee is produced by gently heating butter to remove which two components, leaving behind purified milk fat?

A. Sugar and salt

B. Milk solids and water

C. Vitamins and minerals

D. Casein and rennet

8. Refer to Image 2, a photograph of a traditional butter churn. Churning cream in a device like this causes which physical change to occur?



Image 2

A. Milk proteins are hydrolyzed into individual amino acids

B. Fat globule membranes are disrupted, allowing fat globules to clump together (coalesce) and separate from the liquid
C. Lactose is converted into glucose and galactose
D. The cream is pasteurized

9. When cream is whipped into whipped cream, what physically happens to the milk fat globules?

A. They dissolve completely into the surrounding liquid
B. They partially coalesce and form a network that traps air bubbles
C. They are chemically converted into protein
D. They evaporate

10. Explain, at the physical/chemical level, why cream can be whipped into a stable foam (whipped cream) while skim milk cannot.

11. Commercial dairies typically separate cream from whole milk using which process?

A. Filtration through cheesecloth
B. Centrifugation in a cream separator
C. Freezing and thawing
D. Adding rennet

12. Ranking from HIGHEST to LOWEST milk fat percentage, which of the following orderings is correct?

A. Whole milk > half-and-half > heavy cream
B. Heavy cream > half-and-half > whole milk
C. Half-and-half > heavy cream > whole milk
D. Whole milk > heavy cream > half-and-half

13. Select ALL statements that are TRUE about cheese categories. (Select ALL that apply.)

A. Soft cheeses generally have higher moisture content than hard, aged cheeses.
B. Hard, aged cheeses typically have LESS moisture than fresh soft cheeses.
C. All cheeses are made using rennet coagulation exclusively.
D. Aging (ripening) cheese generally increases the intensity of its flavor.
E. Cottage cheese is an example of a hard, aged cheese.

14. During cheese aging (ripening), bacterial and enzymatic activity primarily does which of the following?

A. Adds new fat and protein to the cheese
B. Breaks down proteins and fats into smaller flavor and aroma compounds
C. Converts all the cheese's protein into lactose
D. Sterilizes the cheese, halting all chemical activity

15. Refer to Image 3, a micrograph of Lactobacillus bacteria. This genus of bacteria is commonly used in dairy fermentation and cheese aging because it primarily produces which compound from lactose?

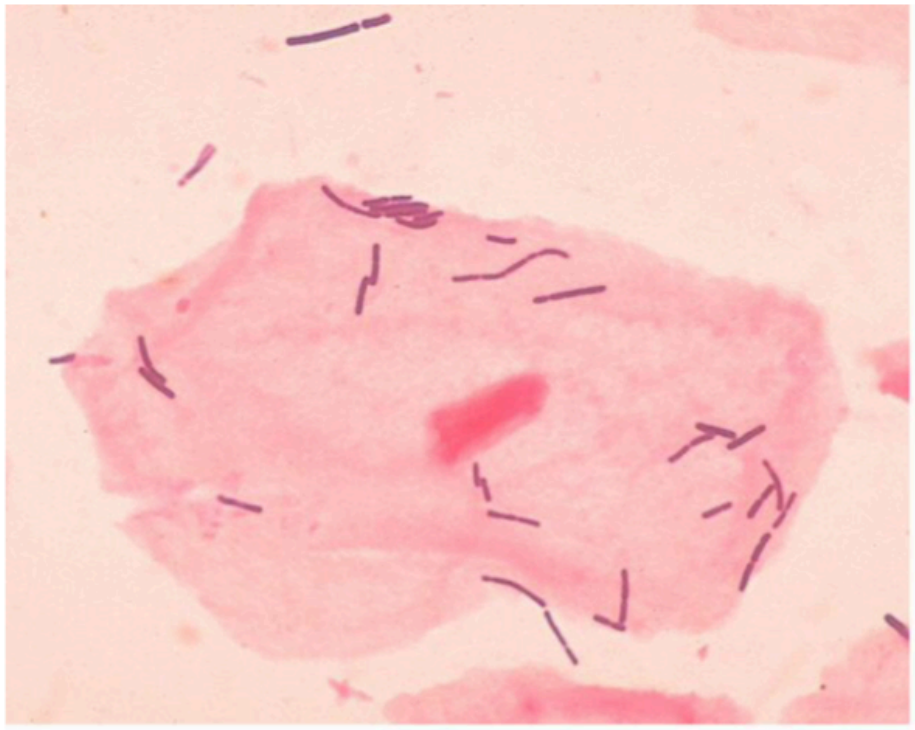


Image 3

A. Ethanol
B. Lactic acid
C. Carbon dioxide gas only
D. Acetone

16. Describe the general chemical process of cheese ripening (aging), and explain how this process develops the cheese's characteristic flavor.

17. Commercial cheesemakers today may use rennet obtained from which of the following sources?

A. Only from calf stomachs
B. Animal (calf stomach), microbial (fungal/bacterial), or plant-derived sources
C. Only from bacterial fermentation
D. Rennet cannot be sourced commercially; it must be made in a lab from scratch each time

18. Which type of casein is located primarily on the surface of the casein micelle and plays the key role in keeping micelles stable and suspended in milk?

A. Alpha-s1-casein
B. Beta-casein
C. Kappa-casein
D. Whey protein

19. Refer to Image 4, a schematic diagram of the casein sub-micelle model. According to this model, what holds the individual casein sub-units together within the micelle?

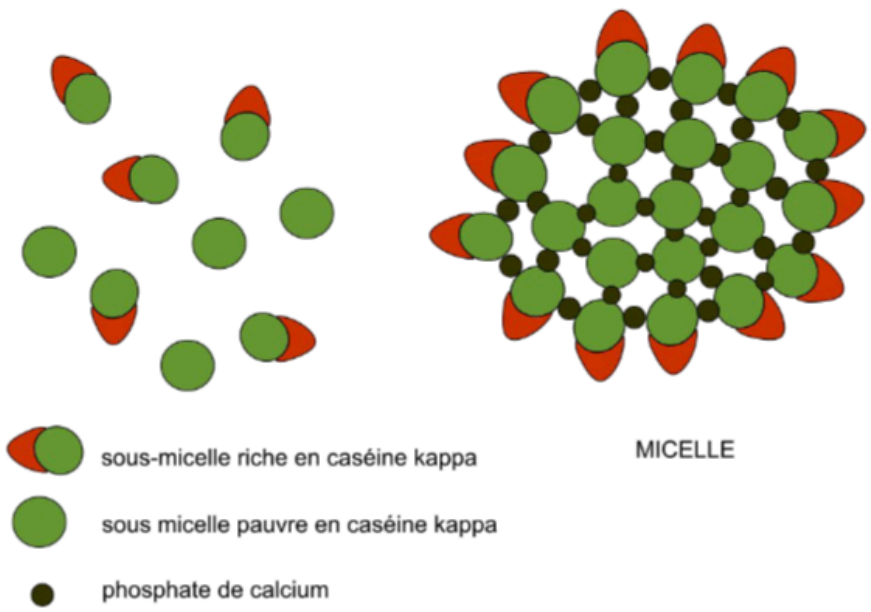


Image 4

A. Covalent peptide bonds between sub-units
B. Phospho-calcium (calcium phosphate) bridges linking the sub-units
C. Hydrogen bonds with lactose molecules
D. Disulfide bonds with whey proteins

20. Select ALL statements that are TRUE about kappa-casein and casein micelle stability. (Select ALL that apply.)

A. Kappa-casein is concentrated on the outer surface of the casein micelle.
B. Rennet enzymatically cleaves kappa-casein, destabilizing the micelle and causing coagulation.
C. Kappa-casein has no role in keeping casein micelles suspended in solution.
D. After rennet cleaves kappa-casein, casein micelles can clump together and form curds.
E. Kappa-casein content in milk varies depending on the species and breed of the animal.

21. Which two proteins make up the majority of whey protein in cow's milk?

A. Alpha-lactalbumin and beta-lactoglobulin
B. Kappa-casein and beta-casein
C. Collagen and elastin
D. Myosin and actin

22. Explain the difference between whey protein concentrate and whey protein isolate in terms of processing and protein purity.

23. Which best describes the difference between a Recommended Dietary Allowance (RDA) and a Percent Daily Value (%DV) shown on a Nutrition Facts label?

A. They are exactly the same thing, just with different names

B. RDA is a nutrient intake target set by age/sex group; %DV shows how much a serving contributes toward a single, standardized daily reference value used on food labels

C. %DV changes for every individual person based on their exact age and weight printed on the label

D. RDA only applies to vitamins, while %DV only applies to minerals

24. According to U.S. dietary guidelines, what is the RDA for calcium for teens aged 14-18?

A. 700 mg/day

B. 1,000 mg/day

C. 1,300 mg/day

D. 2,500 mg/day

25. Explain ONE specific health consequence that can result from consistently low calcium intake during adolescence, and why this life stage is particularly important for calcium consumption.

26. Refer to Image 5, an NIH chart of recommended daily calcium intake by life stage. According to the chart, which age group has the HIGHEST calcium RDA?

Recommended Dietary Allowance (RDA) for Calcium by Life Stage
(Source: NIH Office of Dietary Supplements)

Life Stage	Calcium RDA (mg/day)
1–3 years	700
4–8 years	1,000
9–13 years	1,300
14–18 years	1,300
19–50 years	1,000
51–70 years (male)	1,000
51–70 years (female)	1,200
71+ years	1,200

Image 5

A. Children 4-8 years
B. Children/teens 9-18 years
C. Adults 19-50 years
D. Adults 71 years and older

27. How does "ultra-pasteurized" milk differ from standard HTST-pasteurized milk?

A. Ultra-pasteurized milk is heated to a higher temperature than standard pasteurization, extending shelf life further
B. Ultra-pasteurized milk is not heated at all
C. Ultra-pasteurized milk has all of its lactose removed
D. Ultra-pasteurized and standard pasteurized milk are processed identically

28. The Percent Daily Value (%DV) shown on a Nutrition Facts label is based on a reference diet of how many calories per day?

A. 1,000 calories
B. 1,500 calories
C. 2,000 calories
D. 2,500 calories

29. Select ALL nutrients that U.S. federal regulations REQUIRE to be listed on a packaged food's Nutrition Facts label. (Select ALL that apply.)

A. Total Fat
B. Sodium
C. Vitamin D
D. Beta-carotene
E. Total Carbohydrate

30. Refer to Image 6, an older-format (2006) FDA Nutrition Facts label. Compared to the current (2016-era) label format, which nutrient was NOT required to be listed on this older label?

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving

Calories 230	Calories from Fat 40
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	
Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Image 6

A. Total Fat
B. Added Sugars
C. Sodium
D. Total Carbohydrate

31. Which best distinguishes a "fortified" food from an "enriched" food?

A. Fortified foods have nutrients added that were not originally present (or present in only small amounts); enriched foods have nutrients added back that were lost during processing

B. Fortified and enriched mean exactly the same thing
C. Enriched foods always contain more calories than fortified foods
D. Only fortified foods can legally be sold in the United States

32. Using a dairy example, explain the difference between a fortified food and an enriched food.

33. Cultured buttermilk is produced by:

A. Adding lactic acid bacteria cultures to skim or low-fat milk, allowing fermentation to thicken and sour it
B. Removing all bacteria from milk using UHT processing
C. Whipping heavy cream until it becomes solid
D. Adding rennet to whole milk

34. How does kefir differ from yogurt in terms of the culture used to ferment it?

A. Kefir uses only a single bacterial species, while yogurt uses many species
B. Kefir is fermented using a more complex symbiotic culture of bacteria AND yeast, while yogurt is fermented using bacteria alone
C. Kefir contains no live cultures at all
D. Yogurt uses yeast exclusively, while kefir uses only bacteria

35. Refer to Image 7, a photograph of milk kefir grains. These "grains" are best described as:



Image 7

A. A pure crystal of milk sugar (lactose)
B. A symbiotic culture of bacteria and yeast held together in a polysaccharide matrix
C. A type of hardened cheese curd
D. A synthetic starter powder

36. Select ALL statements that are TRUE about fermented dairy products in general. (Select ALL that apply.)

A. Fermentation typically lowers the pH of milk through the production of lactic acid.
B. Fermented dairy products such as yogurt and kefir often contain live probiotic cultures.
C. Fermentation always destroys all of the protein in milk.
D. Fermented dairy products can have a longer shelf life than fresh milk due to their lower pH.
E. All fermented dairy products use identical bacterial cultures.

37. The Maillard reaction is best defined as:

A. A reaction between amino acids/proteins and reducing sugars that produces browning and flavor compounds when heated
B. The freezing of a liquid due to added solute
C. The coagulation of casein by acid
D. The separation of cream from milk by centrifugation

38. How does the Maillard reaction differ from caramelization?

A. The Maillard reaction involves both amino acids/proteins and sugars, while caramelization involves the browning of sugars alone
B. Caramelization requires amino acids while the Maillard reaction does not
C. The Maillard reaction only occurs in dairy products
D. Caramelization and the Maillard reaction are the same chemical process

39. Explain, at the chemical level, what happens when sweetened milk is slowly heated to make dulce de leche (a browned, caramel-flavored milk product).

40. Refer to Image 8, a photograph of dulce de leche. The characteristic brown color and rich flavor of this product develop primarily through which chemical process?



Image 8

A. Emulsification
B. The Maillard reaction (non-enzymatic browning)
C. Pasteurization alone, with no chemical reaction
D. Freezing point depression

41. In ice cream production, "overrun" refers to:

A. The percentage increase in volume of the ice cream mix due to air incorporated during churning
B. The amount of time it takes ice cream to melt at room temperature
C. The percentage of milk fat in the final product
D. The temperature at which the ice cream mix freezes

42. Stabilizers and emulsifiers are commonly added to commercial ice cream primarily to:

A. Increase the fat content dramatically
B. Help control ice crystal size and improve texture/smoothness during storage
C. Replace the need for sugar entirely
D. Eliminate the need for pasteurization

43. Which food additive commonly used as a stabilizer in commercial ice cream is derived from seaweed?

A. Carrageenan
B. Aspartame
C. Sodium benzoate
D. Citric acid

44. Explain the role that fat, sugar, and stabilizers each play in preventing the formation of large, gritty ice crystals in ice cream during freezing and storage.

45. Adding sugar to an ice cream mix lowers its freezing point primarily because of which principle?

A. Sugar reacts chemically with water to form a new compound
B. Sugar is a solute that depresses the freezing point of the water-based mix, a colligative property
C. Sugar increases the mix's density, which has no effect on freezing point
D. Sugar evaporates during freezing, concentrating the remaining liquid

46. If a solute fully dissociates into two particles per molecule in solution (such as NaCl into Na+ and Cl-), how does this affect the magnitude of freezing point depression compared to a solute that does not dissociate (such as sucrose)?

A. Dissociating solutes cause LESS freezing point depression per mole added
B. Dissociating solutes cause roughly TWICE the freezing point depression per mole added, due to the increased number of dissolved particles
C. Dissociation has no effect on freezing point depression
D. Only non-dissociating solutes can lower the freezing point at all

47. At approximately what pH does casein reach its isoelectric point, and explain why this pH value is significant for dairy processing (such as cheese and yogurt production).

48. Cottage cheese is typically made using acid coagulation, while many aged, hard cheeses use rennet coagulation. Describe ONE difference between acid-set and rennet-set curds in terms of texture or moisture content, and briefly explain the chemistry behind acid coagulation of casein.

49. Which coagulation method is typically used to produce firm, aged cheeses that can be pressed, shaped, and stored for extended ripening?

A. Acid coagulation
B. Rennet coagulation
C. Homogenization
D. Ultra-pasteurization

50. The Food Science event's lab tasks involve making ice cream, measuring curd mass, and measuring milk fat mass from cream. Choose ONE of these three lab tasks and explain the underlying food chemistry (involving fats, proteins, and/or carbohydrates) that makes the task work, and why understanding that chemistry helps a team predict or interpret their lab results.

ANSWER KEY

FOOD SCIENCE – DIVISION B – STATE EXAM

1. **Correct Answer: C**

   Cow's milk is roughly 87% water by weight, with the remaining ~13% made up of fat, protein, lactose, and minerals.

2. **Correct Answer: B**

   Milk is a colloid: fat globules and casein micelles are dispersed throughout the water-based liquid without fully dissolving or settling out.

3. **Correct Answer: A**

   Colloidal particles, like milk fat globules, are larger than dissolved molecules (so they scatter light and don't fully dissolve) but small enough to stay dispersed rather than settle out.

4. **Correct Answer: B**

   The kink in oleic acid's chain comes from a cis carbon-carbon double bond, which prevents the chain from packing tightly and is characteristic of unsaturated fatty acids.

5. **Correct Answer: B**

   Straight, saturated fatty acid chains can pack closely together and solidify more easily, while the kinks caused by double bonds in unsaturated fats prevent tight packing, keeping them liquid at room temperature.

6. **Correct Answers: A, B, C, E**

   Butter forms when churning coalesces fat globules, separating them from buttermilk. Ghee is clarified butter with milk solids and water removed. Heavy cream has a higher fat percentage than half-and-half. Butter does contain a small amount of water (commonly ~16-18%), so that statement is false. Whipped cream's structure comes from air trapped in a network of partially coalesced fat globules.

7. **Correct Answer: B**

   Ghee (clarified butter) is made by heating butter until the water evaporates and the milk solids (proteins, lactose) separate out and are removed, leaving nearly pure milk fat.

8. **Correct Answer: B**

   Churning agitates cream enough to damage the membranes surrounding fat globules, causing the fat to coalesce into solid butter and separate from the remaining liquid (buttermilk).

9. **Correct Answer: B**

   Whipping partially disrupts the fat globule membranes, causing the globules to partially coalesce and form a structural network around trapped air bubbles, giving whipped cream its light, foamy texture.

10. **Sample/Acceptable Answer:**

    Whipping incorporates air into the liquid while agitation partially disrupts the membranes surrounding the milk fat globules. The partially coalesced fat globules then link together around the air bubbles, forming a stable network that holds the foam's structure. Skim milk lacks sufficient fat globules to form this supporting network, so it cannot hold a stable foam the way cream does.

11. **Correct Answer: B**

    A centrifugal cream separator spins milk at high speed; because fat is less dense than the surrounding liquid, it collects toward the center and can be drawn off as cream.

12. **Correct Answer: B**

    Heavy cream has the highest fat content (about 36% or more), half-and-half is a mix of milk and cream (about 10-18% fat), and whole milk has the lowest fat percentage of the three (about 3.25%).

13. **Correct Answers: A, B, D**

Soft cheeses have higher moisture than hard, aged cheeses, and aging generally intensifies flavor as enzymes and bacteria break down proteins and fats. Not all cheeses use rennet (some use acid coagulation), and cottage cheese is a soft, fresh (unaged) cheese, not a hard, aged one.

14. Correct Answer: B

During aging, enzymes and bacteria gradually break down (via proteolysis and lipolysis) the cheese's proteins and fats into smaller compounds that create the characteristic flavors and aromas of aged cheese.

15. Correct Answer: B

Lactobacillus species are lactic acid bacteria; they ferment lactose into lactic acid, which lowers pH and contributes to flavor development in cheese and other fermented dairy products.

16. Sample/Acceptable Answer:

During ripening, bacterial cultures and enzymes (naturally present or added, such as from rennet) gradually break down the cheese's proteins (proteolysis) and fats (lipolysis) into smaller peptides, free amino acids, fatty acids, and other flavor/aroma compounds. Continued microbial fermentation of residual lactose also produces lactic acid. Over weeks to months, this breakdown produces the complex flavors, aromas, and textures associated with aged cheeses, which differ from the milder flavor of fresh, unaged cheese.

17. Correct Answer: B

Modern rennet can come from several sources: traditional animal rennet (from calf stomachs), microbial rennet (produced by fungi or genetically engineered microorganisms), or plant-derived coagulating enzymes.

18. Correct Answer: C

Kappa-casein sits on the outer surface of the casein micelle and provides steric and electrostatic stabilization that keeps micelles suspended and prevents them from clumping together.

19. Correct Answer: B

In the sub-micelle model, individual casein sub-units are linked together by phospho-calcium (calcium phosphate) bridges, forming the larger colloidal casein micelle structure.

20. Correct Answers: A, B, D, E

Kappa-casein sits on the micelle surface and stabilizes it; rennet's enzymatic action cleaves kappa-casein, removing that stabilization so micelles can aggregate and form curds. Kappa-casein content does vary by species/breed. The statement that kappa-casein has no stabilizing role is false.

21. Correct Answer: A

Alpha-lactalbumin and beta-lactoglobulin are the two major whey proteins found in cow's milk.

22. Sample/Acceptable Answer:

Whey protein concentrate is processed less extensively and retains more lactose, fat, and other milk components, resulting in a lower overall protein percentage (commonly around 70-80% protein by weight). Whey protein isolate undergoes additional filtration/processing to remove nearly all of the fat and lactose, resulting in a higher, more purified protein content (commonly 90% or more protein by weight).

23. Correct Answer: B

The RDA is a nutrient-specific intake recommendation based on age and sex groups, while %DV on food labels is based on a single standardized reference value (Daily Value) used for labeling purposes across the general population, not tailored to the individual.

24. Correct Answer: C

Teens aged 14-18 have a calcium RDA of 1,300 mg/day, the same as children aged 9-13, reflecting the high calcium demands of adolescent bone growth.

25. Sample/Acceptable Answer:

Consistently low calcium intake during adolescence can result in lower peak bone mass, increasing the risk of osteoporosis and bone fractures later in life. Adolescence is a particularly important time for calcium intake because this is when the body builds the majority of its lifetime peak bone mass; bones absorb and accumulate calcium most efficiently during these growth years, so insufficient intake during this window cannot be easily made up for later in life.

26. Correct Answer: B

Children and teens aged 9-18 have the highest calcium RDA (1,300 mg/day) of the groups shown, reflecting the intense bone growth that occurs during these years.

27. Correct Answer: A

Ultra-pasteurization heats milk to a higher temperature (commonly around 138°C, similar to UHT) for a short time, destroying more microorganisms than standard HTST pasteurization and extending refrigerated shelf life.

28. Correct Answer: C

%DV values on U.S. Nutrition Facts labels are calculated based on a standard 2,000-calorie daily reference diet.

29. Correct Answers: A, B, C, E

Total Fat, Sodium, Vitamin D, and Total Carbohydrate are all required nutrients on the current Nutrition Facts label. Beta-carotene specifically is not a required label entry.

30. Correct Answer: B

The requirement to separately declare "Added Sugars" was introduced in the FDA's 2016 label update and was not present on the older (2006-era) label format shown.

31. Correct Answer: A

Fortification adds nutrients not naturally present in significant amounts (such as adding Vitamin D to milk); enrichment adds back nutrients that were removed or lost during processing (such as adding B vitamins back to refined grain products).

32. Sample/Acceptable Answer:

A fortified dairy food has a nutrient added that was not originally present in significant amounts, such as milk fortified with Vitamin D, which milk does not naturally contain in meaningful amounts. An enriched food has nutrients added back that were lost during processing; while less common with dairy, this is more typical of foods like enriched refined flour, which has B vitamins and iron added back after processing removes them from the whole grain.

33. Correct Answer: A

Cultured buttermilk is made by adding lactic acid bacteria cultures to skim or low-fat milk; fermentation thickens the milk and gives it a tangy flavor, unlike traditional buttermilk, which was originally the liquid left over from churning butter.

34. Correct Answer: B

Kefir grains contain a complex symbiotic community of both lactic acid bacteria and yeast, while yogurt is typically fermented using specific bacterial strains alone (commonly Lactobacillus and Streptococcus species).

35. Correct Answer: B

Kefir grains are gelatinous clusters made up of a symbiotic community of bacteria and yeast embedded in a polysaccharide (kefiran) matrix, used to ferment milk into kefir.

36. Correct Answers: A, B, D

Fermentation lowers pH via lactic acid production, often leaves behind live probiotic cultures, and the resulting lower pH can extend shelf life by inhibiting spoilage organisms. Fermentation does not destroy all protein (it often coagulates/modifies it), and different fermented products use different specific cultures.

37. Correct Answer: A

The Maillard reaction is a non-enzymatic chemical reaction between amino acids (from proteins) and reducing sugars that occurs with heat, producing browning and a range of flavor and aroma compounds.

38. Correct Answer: A

The Maillard reaction requires both an amino acid/protein source and a reducing sugar, while caramelization is the browning of sugars alone (without amino acids) under heat.

39. Sample/Acceptable Answer:

As sweetened milk is heated over time, the reducing sugars (from lactose and any added sugar) react with the amino groups of milk proteins in the Maillard reaction. This non-enzymatic browning reaction produces melanoidins (brown pigments) and a wide range of new flavor and aroma compounds, giving dulce de leche its characteristic caramel-brown color and rich, toasted flavor. The slow evaporation of water also concentrates the sugars and proteins, further promoting the reaction and thickening the mixture.

40. Correct Answer: B

Dulce de leche's brown color and deep caramelized flavor develop primarily through the Maillard reaction, as milk proteins and sugars react under prolonged heating.

41. Correct Answer: A

Overrun is the percentage increase in volume that results from air being whipped into the ice cream mix during freezing/churning; higher overrun means more air (and typically a lighter texture).

42. Correct Answer: B

Stabilizers and emulsifiers help control ice crystal formation, improve texture and smoothness, and help the ice cream resist melting and texture changes during storage.

43. Correct Answer: A

Carrageenan is a stabilizer/thickener extracted from red seaweed, commonly used in ice cream and other dairy products to improve texture and stability.

44. Sample/Acceptable Answer:

Fat globules coat and interrupt the growth of ice crystals, helping keep them small and contributing to a smooth, creamy texture. Dissolved sugar lowers the freezing point of the mix (a colligative property) and increases the viscosity of the unfrozen liquid portion, slowing the rate of ice crystal growth. Stabilizers (such as guar gum or carrageenan) bind water and increase the mix's viscosity, which physically restricts water molecules from migrating to and enlarging existing ice crystals, especially during temperature fluctuations in storage.

45. Correct Answer: B

Dissolved sugar acts as a solute that lowers the freezing point of the water-based ice cream mix -- a colligative property that depends on the number of dissolved particles, not their identity.

46. Correct Answer: B

Freezing point depression depends on the total number of dissolved particles (the van't Hoff factor). A solute like NaCl that dissociates into two ions per formula unit produces roughly double the freezing point depression, per mole dissolved, compared to a non-dissociating solute like sucrose.

47. Sample/Acceptable Answer:

Casein's isoelectric point is approximately pH 4.6. This pH is significant because at this point, casein molecules have no net electrical charge, so they no longer repel one another and can clump (coagulate) together. This is the underlying chemistry behind acid-based coagulation used to make products such as cottage cheese, cream cheese, and yogurt.

48. Sample/Acceptable Answer:

Acid-set curds (such as cottage cheese) tend to be softer, more crumbly, and retain more moisture than rennet-set curds, which tend to form a firmer, more elastic gel structure that can be pressed and aged. Acid coagulation works by lowering milk's pH toward casein's isoelectric point (~pH 4.6), at which point

casein molecules lose their net charge and precipitate out of solution as soft curds, rather than being enzymatically cross-linked the way rennet-coagulated curds are.

49. Correct Answer: B

Rennet coagulation produces a firmer, more elastic curd structure (compared to the softer curd from acid coagulation), which is better suited to being pressed, shaped, and aged into firm cheeses.

50. Sample/Acceptable Answer:

Answers will vary depending on the task chosen; award full credit for a correct, complete chemical explanation. Sample answer (Ice Cream): Making ice cream relies on freezing point depression -- dissolved salt in the ice bath lowers the freezing point of the surrounding ice/water mixture below 0°C, allowing it to draw heat from and freeze the milk/cream/sugar mixture inside the bag. Understanding this helps a team predict that adding more salt (up to a point) or using a colder starting temperature will freeze the mixture faster and potentially yield a taller, firmer ice cream sample, improving their lab score. (Equivalent credit for a correct explanation of curd mass, based on acid coagulation of casein near its isoelectric point, or milk fat mass from cream, based on physically disrupting fat globule membranes through agitation/churning to coalesce milk fat into butter.)

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
State Exam

Team Name: _____ Team Number: _____

- This exam contains 50 questions: 35 multiple choice, 5 multiselect (select ALL correct answers), and 10 short answer.
- Eight questions (Q2, Q8, Q11, Q12, Q16, Q18, Q24, Q30) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write your response in the space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; State Tournament teams complete one or two Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which of the following is closest to whole milk's typical specific gravity (density relative to water)?

A. 0.85
B. 1.03
C. 1.50
D. 2.00

2. Refer to Image 1, a photograph of a lactometer. This instrument is used to quickly screen raw milk for:



Image 1

A. Bacterial contamination
B. Possible dilution with added water, based on milk's density
C. Fat percentage exclusively
D. Vitamin content

3. A lactometer's reading is based on which physical principle?

A. Archimedes' principle of buoyancy
B. Newton's third law
C. Osmosis
D. Capillary action

4. Explain why adding water to raw milk lowers its measured density, and describe how a lactometer reading could indicate this form of adulteration.

5. Because added water measurably raises milk's freezing point (bringing it closer to 0°C, water's freezing point), a laboratory cryoscope test that measures a milk sample's freezing point can be used to detect:

A. Fat content
B. Possible addition of water
C. Vitamin fortification levels
D. Bacterial count

6. The original, slower method of pasteurization, sometimes called batch or vat pasteurization (LTLT, "Low Temperature Long Time"), typically heats milk to approximately:

A. 63°C for 30 minutes
B. 72°C for 15 seconds
C. 138°C for 2 seconds
D. 100°C for 1 hour

7. Select ALL statements that are TRUE about batch (vat/LTLT) pasteurization compared to HTST pasteurization. (Select ALL that apply.)

A. Batch pasteurization uses a lower temperature held for a longer time.
B. Batch pasteurization is generally slower and less suited to high-volume continuous processing.
C. Batch pasteurization uses a higher temperature than HTST.
D. Both methods are legally recognized ways of achieving pasteurization.
E. Batch pasteurization cannot ever adequately destroy pathogens.

8. Refer to Image 2, a photograph of cottage cheese. Cottage cheese curd is traditionally formed using which coagulation method?

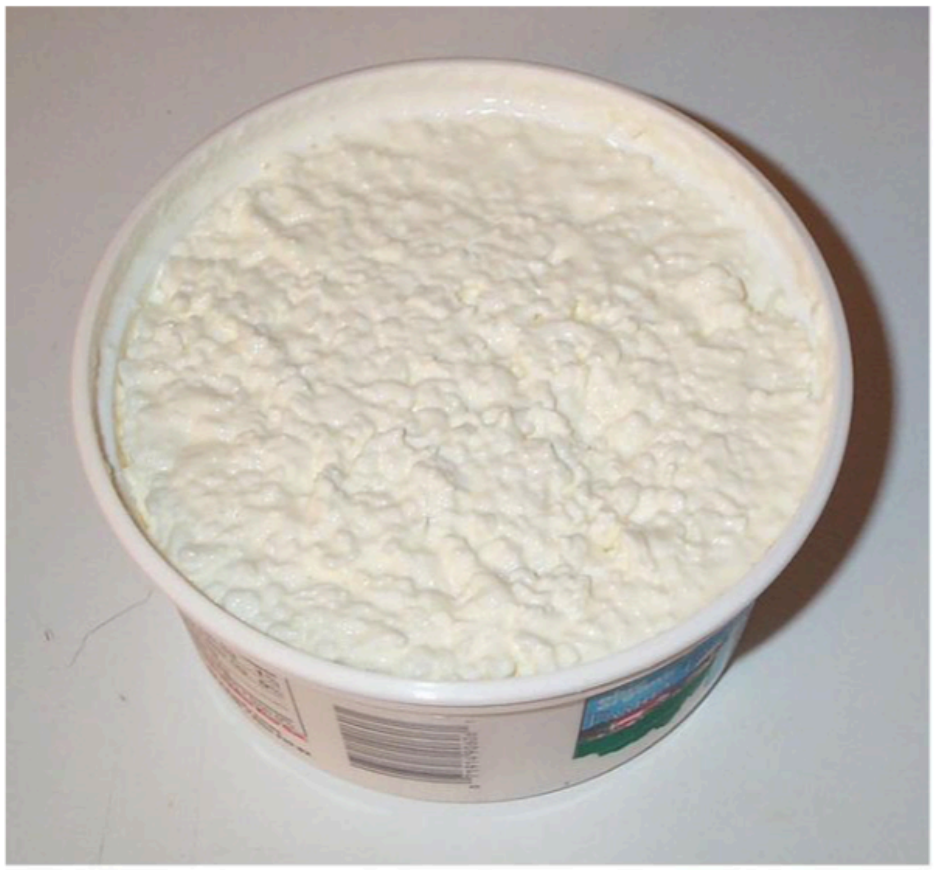


Image 2

A. Acid coagulation
B. Rennet coagulation only
C. Ultra-filtration
D. Reverse osmosis

9. Cottage cheese is commonly sold in "small curd" and "large curd" varieties, which primarily differ in:

A. The size the curd is cut into before cooking, affecting the final texture
B. The type of milk used
C. The amount of salt added
D. The cooking temperature only

10. Describe the general process used to make cottage cheese, from acid coagulation through the addition of "creaming" (dressing), and explain why cottage cheese is classified as an unaged (fresh) cheese.

11. Refer to Image 3, a photograph of cream cheese. Under FDA Standards of Identity, the primary difference between cream cheese and Neufchâtel cheese is that Neufchâtel:



Image 3

A. Contains significantly less milkfat than cream cheese
B. Contains no dairy ingredients
C. Is always aged for 60 days
D. Is made exclusively from goat milk

12. Refer to Image 4, the chemical structure of retinol. Retinol is the chemical name for which fat-soluble vitamin naturally found in milk fat?

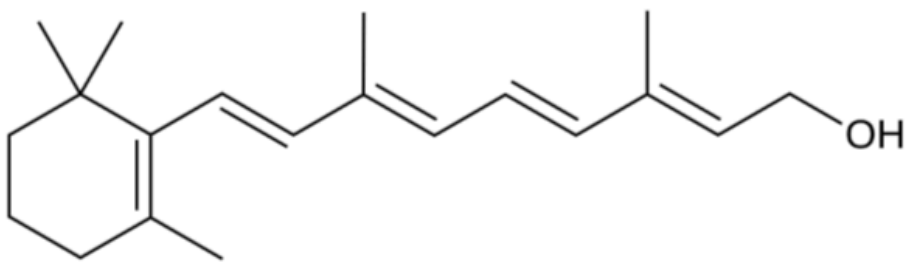


Image 4

A. Vitamin A
B. Vitamin B12
C. Vitamin C
D. Vitamin K

13. Because Vitamin A is fat-soluble and travels with milk fat, why must skim and low-fat milk be fortified with Vitamin A during processing?

A. Removing fat during processing also removes most of the milk's naturally occurring Vitamin A
B. Skim milk naturally contains too much Vitamin A
C. Vitamin A is water-soluble and washes out during pasteurization
D. Fortification is required by law purely for flavor reasons

14. Select ALL statements that are TRUE about Vitamin A in dairy products. (Select ALL that apply.)

A. Vitamin A is fat-soluble and associated with milk fat.
B. Whole milk naturally contains more Vitamin A than skim milk before fortification.
C. A severe, prolonged Vitamin A deficiency can contribute to vision problems such as night blindness.
D. Vitamin A is added to skim and low-fat milk to compensate for fat removal.
E. Vitamin A is a water-soluble vitamin, like Vitamin C.

15. Beta-carotene, a plant pigment sometimes discussed alongside Vitamin A, is significant in dairy science because it:

A. Is a precursor the body can convert into Vitamin A, and contributes to the yellow-orange color of butter/cheese from grass-fed cows
B. Has no relationship to Vitamin A
C. Is only found in skim milk
D. Destroys Vitamin A on contact

16. Refer to Image 5, a photograph of latte art created in steamed milk microfoam. Explain, at the protein level, how steaming and frothing milk creates a stable microfoam, and identify which class of milk protein is primarily responsible for stabilizing the tiny air bubbles.



Image 5

17. Which milk type generally produces the most voluminous foam when steamed, due to its lower fat content interfering less with protein's ability to stabilize air bubbles?

A. Whole milk
B. Skim (nonfat) milk
C. Heavy cream
D. Half-and-half

18. Refer to Image 6, a photograph of the cardoon (Cynara cardunculus) thistle in bloom. Extracts from this plant have historically been used as a source of:



Image 6

A. Plant-based (vegetable) rennet, providing an alternative coagulating enzyme for cheesemaking
B. Artificial food coloring
C. Lactase enzyme
D. Casein protein

19. Cheese made using a plant-based (vegetable) rennet, such as one derived from cardoon thistle, is often favored for:

A. Vegetarian cheesemaking, since no animal-derived coagulating enzyme is used
B. Producing lactose-free cheese
C. Eliminating the need for salt
D. Making cheese without any milk at all

20. Compared to cheese made with traditional animal or microbial rennet, cheese made with certain plant-based rennets, such as thistle rennet, is sometimes noted for developing a:

A. Identical flavor profile in every case
B. Slightly more bitter or distinctively different flavor profile during aging
C. Complete lack of any flavor
D. Sweeter flavor than added sugar

21. Select ALL statements that are TRUE about rennet sources used in cheesemaking. (Select ALL that apply.)

A. Traditional rennet is extracted from the stomach lining of young ruminant animals.
B. Fermentation-produced chymosin (FPC) is produced by genetically engineered microorganisms.
C. Vegetable rennet can be extracted from certain plants, such as cardoon thistle.
D. All rennet, regardless of source, is chemically identical with no functional differences.
E. The rennet source used can affect whether a cheese is considered vegetarian.

22. Explain what a "colloidal calcium phosphate" (CCP) bridge is within a casein micelle, and describe its role in holding the micelle's structure together.

23. If colloidal calcium phosphate is removed from a casein micelle (for example, by adding a calcium-chelating agent), the micelle structure generally:

A. Becomes more stable and rigid
B. Becomes destabilized and can partially disintegrate
C. Is completely unaffected
D. Converts entirely into whey protein

24. Refer to Image 7, a photograph of a whole wheel of soft-ripened cheese with a natural rind, sliced open to show the rind and interior paste. Cheeses aged this way, developing a hard, dry, unwaxed "natural rind" directly from their own surface, generally require which of the following during aging?



Image 7

A. No maintenance whatsoever

B. Regular turning, brushing, and humidity/temperature control to manage surface mold and moisture loss

C. Constant storage below freezing

D. Complete submersion in brine for the entire aging period

25. Compared to a wax-coated cheese, a cheese aged with a natural (unwaxed) rind will generally:

A. Lose more moisture through its surface over time, requiring more careful humidity control during aging

B. Never lose any moisture

C. Age at an uncontrollably fast rate regardless of conditions

D. Require identical care to a wax-coated cheese

26. The specific combination of temperature and humidity maintained in a cheese aging cellar or cave primarily affects:

A. Nothing measurable about the cheese

B. The rate of moisture loss, microbial activity, and enzymatic ripening reactions within the cheese

C. Only the cheese's color, with no effect on flavor or texture

D. The cheese's lactose content exclusively

27. Homogenization is typically achieved by forcing warm milk at high pressure through a narrow valve gap. This process breaks fat globules into smaller sizes primarily through:

A. Intense shear and turbulence forces as the milk is forced through the narrow gap
B. Freezing the fat globules solid
C. Chemical dissolution of the fat
D. Adding extra water to dilute the fat

28. Explain why reducing the size of fat globules during homogenization helps prevent cream from separating out of milk during storage, referencing the physical principle involved.

29. Homogenized milk, compared to non-homogenized (cream-line) milk, has fat globules that are:

A. Much larger on average
B. Much smaller and more uniform in size
C. Completely removed
D. Chemically converted into protein

30. Refer to Image 8, a photograph of Greek yogurt. Compared to regular (unstrained) yogurt, Greek yogurt has undergone an additional straining step that:



Image 8

A. Removes much of the liquid whey, concentrating the remaining protein and creating a thicker texture
B. Adds extra lactose
C. Adds extra water
D. Removes all protein from the yogurt

31. Select ALL statements that are TRUE about Greek yogurt compared to regular (unstrained) yogurt. (Select ALL that apply.)

A. Greek yogurt generally has a higher protein concentration per serving.
B. Greek yogurt is produced by straining out much of the liquid whey.
C. Straining removes some lactose along with the whey.
D. Greek yogurt always contains added thickening gums instead of being strained.
E. Greek yogurt generally has a thicker, denser texture than regular yogurt.

32. One byproduct of Greek yogurt production at commercial scale is a large volume of acid whey, which presents a processing/environmental challenge similar to the byproduct whey generated during:

A. Butter churning
B. Cheesemaking
C. Homogenization
D. Pasteurization

33. Non-dairy coffee creamers, unlike real dairy cream, typically achieve a creamy mouthfeel using:

A. Milk fat exclusively
B. Vegetable oil, along with emulsifiers and stabilizers such as sodium caseinate or carrageenan
C. Only water and sugar
D. Casein protein extracted from cheese whey exclusively

34. Some non-dairy coffee creamers list "sodium caseinate" as an ingredient, even though the product is marketed as non-dairy or lactose-free. Explain why sodium caseinate is derived from milk, and why a product containing it may still be inappropriate for someone with a true milk protein allergy, despite being labeled lactose-free.

35. The term "non-dairy," as used on some U.S. food labels, is regulated more loosely than "dairy-free," and a product labeled "non-dairy" may still legally:

A. Contain a milk-derived ingredient such as sodium caseinate
B. Never contain any milk-derived ingredient under any circumstances
C. Only be sold in liquid form
D. Always be certified organic

36. Milk naturally contains a small amount of the enzyme lipase, which can break down milk fat into free fatty acids, contributing to rancid off-flavors if not properly inactivated. Lipase is primarily inactivated during milk processing by:

A. Homogenization
B. Pasteurization (heat treatment)
C. Refrigeration alone
D. Adding sugar

37. The alkaline phosphatase test, used in quality control at dairy processing plants, is significant because this naturally occurring milk enzyme is:

A. Destroyed by proper pasteurization, so a negative phosphatase test result helps confirm that pasteurization was correctly performed
B. Completely unaffected by any heat treatment
C. Only found in cheese, not milk
D. Added artificially to milk after pasteurization

38. Select ALL statements that are TRUE about the alkaline phosphatase test used in dairy quality control. (Select ALL that apply.)

A. It is used to verify that milk has been properly pasteurized.
B. Alkaline phosphatase is a naturally occurring enzyme in raw milk.
C. A positive phosphatase test (enzyme still active) can indicate under-pasteurization or contamination with raw milk.
D. The test measures milk's fat percentage.
E. Properly pasteurized milk should test negative for active alkaline phosphatase.

39. If a batch of milk labeled as pasteurized tests POSITIVE for active alkaline phosphatase, this most likely indicates:

A. The milk was properly and fully pasteurized
B. The milk may have been under-pasteurized or contaminated with raw milk after processing
C. The milk has an unusually high vitamin content
D. The test result has no food-safety significance

40. Lipase and alkaline phosphatase are both naturally occurring milk enzymes, but they serve very different practical purposes in dairy science: lipase mainly as a potential source of off-flavors, and alkaline phosphatase mainly as a quality-control indicator. Describe ONE practical use of each enzyme's behavior in the dairy industry.

41. Light cream (sometimes called coffee cream), as defined by FDA Standards of Identity, generally contains a minimum milkfat percentage of approximately:

A. 2%
B. 18%
C. 36%
D. 50%

42. Light whipping cream and heavy whipping cream both contain enough milkfat to whip into stable peaks, but heavy whipping cream contains:

A. Less milkfat than light whipping cream
B. More milkfat than light whipping cream, generally producing a more stable, stiffer whipped foam
C. Identical milkfat to light whipping cream
D. No milkfat at all

43. When cream is whipped, its "overrun" (percentage increase in volume from incorporated air) is generally:

A. Impossible to measure
B. Roughly double (about a 100% increase) for well-whipped cream, meaning the whipped volume is about twice the original liquid volume
C. Always negative, meaning the volume decreases
D. Unrelated to the cream's fat content

44. Explain why heavy cream (with its higher fat content) generally whips into a more stable foam than light cream, referencing the role of fat globules in stabilizing whipped foam.

45. Leucine, a branched-chain amino acid particularly abundant in whey protein and often highlighted in sports nutrition marketing, is significant because it:

A. Plays a key role in stimulating muscle protein synthesis
B. Has no known biological function
C. Is only found in plant proteins
D. Causes lactose intolerance

46. The formation of a thin "skin" on the surface of milk that has been heated (such as when scalding milk on a stovetop) is primarily caused by:

A. Evaporation-driven concentration and denaturation of proteins at the milk's surface
B. Freezing of the milk's surface
C. A chemical reaction with the cooking pot's metal
D. Bacterial growth occurring on the surface during heating

47. Explain why heating milk on a stovetop (such as when scalding milk for a recipe) tends to form a thin protein "skin" on the surface, and suggest ONE practical technique, based on this chemical understanding, that could help reduce skin formation.

48. Milk's pH is typically around 6.6-6.8 (slightly acidic), while yogurt's pH is typically much lower, around 4.0-4.5. This drop in pH during yogurt fermentation is caused by:

A. Bacterial fermentation of lactose into lactic acid
B. Addition of citric acid from fruit
C. Removal of all protein from the milk
D. Addition of table salt

49. Aged cheeses can vary widely in pH depending on their production method. Compared to a fresh acid-set cheese like cottage cheese, a well-aged, rennet-set hard cheese like Parmesan generally has a pH that is:

A. Always identical to cottage cheese
B. Often somewhat higher (closer to neutral), because further ripening processes can raise pH back somewhat over time
C. Always far more acidic than fresh cottage cheese
D. Impossible to measure in a solid cheese

50. Compare the typical pH ranges of fresh milk, yogurt, and aged hard cheese, and explain in general terms why these dairy products differ so much in acidity despite all originating from the same starting ingredient (milk).

ANSWER KEY

FOOD SCIENCE – DIVISION B – STATE EXAM (FORM 2)

1. Correct Answer: B

Whole milk is slightly denser than water, with a typical specific gravity of approximately 1.03.

2. Correct Answer: B

A lactometer measures milk's density; because adding water lowers milk's density, a lactometer reading below the expected range can indicate possible water adulteration.

3. Correct Answer: A

A lactometer is a type of hydrometer that floats at a depth determined by the buoyant force acting on it, per Archimedes' principle, allowing density to be read from a calibrated scale.

4. Sample/Acceptable Answer:

Water has a lower density (specific gravity of exactly 1.00) than milk's naturally denser mixture of fat, protein, lactose, and minerals dissolved/suspended in water (specific gravity around 1.03). Diluting milk with added water shifts the overall mixture's density closer to that of pure water, lowering the measured specific gravity below the expected range for genuine, undiluted milk. Because a lactometer floats deeper in a less dense liquid, a lactometer reading noticeably lower than the expected value for milk can suggest that the sample has been diluted with water.

5. Correct Answer: B

Genuine milk has a slightly lower (more negative) freezing point than pure water due to dissolved solutes; added water raises (moves closer to 0°C) the measured freezing point, so cryoscope testing can help detect water adulteration.

6. Correct Answer: A

Batch (vat/LTLT) pasteurization typically heats milk to about 63°C (145°F) and holds it there for 30 minutes, a slower alternative to HTST or UHT methods.

7. Correct Answers: A, B, D

Batch pasteurization uses a lower temperature for a longer time and is slower/less suited to continuous high-volume processing, but is a legally recognized pasteurization method that does adequately destroy pathogens when properly performed.

8. Correct Answer: A

Cottage cheese is traditionally made by acid-coagulating skim milk, producing soft curds that are then cut, cooked, drained, and typically mixed with a creamy dressing.

9. Correct Answer: A

"Small curd" and "large curd" cottage cheese differ mainly in how finely the coagulated curd is cut before cooking, which affects the size and texture of the final curd pieces.

10. Sample/Acceptable Answer:

To make cottage cheese, skim milk is acidified (using a starter culture and/or direct acidification) until the casein coagulates into soft curds, which are then cut into pieces, gently cooked/heated to firm them, and drained to separate the curds from the whey. The drained curds are typically rinsed, then mixed with a "creaming" dressing (a light cream mixture) and salt to add flavor and richness. Cottage cheese is classified as an unaged (fresh) cheese because it is consumed shortly after production, without any extended ripening or aging period during which enzymes and bacteria would further transform its flavor and texture.

11. Correct Answer: A

Neufchâtel, as legally defined in the U.S., must contain significantly less milkfat than cream cheese, giving it a lighter texture and fewer calories per serving.

12. Correct Answer: A

Retinol is the chemical name for Vitamin A, a fat-soluble vitamin naturally associated with milk fat.

13. Correct Answer: A

Because Vitamin A is fat-soluble, removing milk fat (to make skim or low-fat milk) also removes most of the naturally associated Vitamin A, making fortification necessary to restore adequate levels.

14. Correct Answers: A, B, C, D

Vitamin A is fat-soluble (not water-soluble), naturally more abundant in whole milk than skim milk before fortification, linked to vision health with severe deficiency causing night blindness, and added to reduced-fat milks to compensate for fat removal.

15. Correct Answer: A

Beta-carotene, obtained from a cow's diet (especially fresh grass/forage), is a precursor the body can convert into Vitamin A, and it also contributes to the characteristic yellow-orange color seen in butter and cheese from grass-fed cows.

16. Sample/Acceptable Answer:

When milk is steamed, steam injects heat and tiny air bubbles into the milk while agitating it. The heat and mechanical agitation partially denature (unfold) whey proteins, exposing both hydrophilic and hydrophobic regions of the protein; these unfolded proteins migrate to and coat the surface of the tiny air bubbles, forming a stabilizing protein film around each bubble, similar to how proteins stabilize other foams like whipped egg whites. Whey proteins are primarily responsible for stabilizing this fine, stable "microfoam" texture, which is what allows a barista to hold and pour a defined pattern for latte art.

17. Correct Answer: B

Skim (nonfat) milk generally produces the largest volume of foam when steamed, since fat can interfere with the protein film's ability to fully stabilize air bubbles, though whole milk foam is often prized for a creamier, more stable microfoam texture.

18. Correct Answer: A

Extracts from cardoon thistle flowers contain plant-based coagulating enzymes that have traditionally been used as a vegetable rennet alternative in certain regional cheesemaking traditions, particularly in parts of Spain and Portugal.

19. Correct Answer: A

Because vegetable rennet comes from a plant source rather than an animal, cheese made with it can be marketed as vegetarian.

20. Correct Answer: B

Plant-based rennets can have somewhat different proteolytic activity than animal or microbial rennet, which can contribute to a distinctively different, sometimes slightly more bitter, flavor profile as the cheese ages.

21. Correct Answers: A, B, C, E

Traditional, microbial (FPC), and vegetable (plant-derived) rennets are all real sources used in cheesemaking, and the source used affects whether the resulting cheese can be marketed as vegetarian. Different rennet sources are not chemically identical and can behave somewhat differently.

22. Sample/Acceptable Answer:

Within a casein micelle, colloidal calcium phosphate refers to small clusters of calcium and phosphate ions embedded throughout the micelle's structure. These mineral clusters act as chemical bridges that help link individual casein sub-units (particularly alpha-s-casein and beta-casein) together, contributing to the overall structural integrity and stability of the micelle, in addition to the surface stabilization role provided by kappa-casein.

23. Correct Answer: B

Removing colloidal calcium phosphate disrupts the internal mineral bridges holding the casein micelle together, generally destabilizing the structure and causing it to partially disintegrate.

24. Correct Answer: B

Natural-rind cheeses require active management during aging -- including regular turning, brushing, and careful control of cellar humidity and temperature -- to manage surface mold growth and moisture loss as the rind develops.

25. Correct Answer: A

Because a natural rind is more porous/permeable than a sealed wax coating, natural-rind cheeses lose more moisture through the surface during aging, requiring more careful humidity management in the aging environment.

26. Correct Answer: B

Aging temperature and humidity directly influence how quickly moisture is lost from the cheese, how actively surface and internal microorganisms grow, and how quickly enzymatic ripening reactions proceed, all of which shape the final flavor and texture.

27. Correct Answer: A

Forcing milk at high pressure through a narrow homogenizer valve creates intense shear and turbulence forces that mechanically break large fat globules into much smaller, more uniform droplets.

28. Sample/Acceptable Answer:

Cream separation occurs because larger fat globules are more buoyant and rise more quickly through milk, since larger particle size increases the rate at which a less-dense particle rises through a denser fluid (related to Stokes' Law). By mechanically breaking fat globules into much smaller, more uniformly sized particles during homogenization, their rate of rise is dramatically slowed, allowing them to stay evenly dispersed throughout the milk for a much longer time rather than quickly separating into a visible cream layer at the top.

29. Correct Answer: B

Homogenization mechanically breaks fat globules into much smaller, more uniformly sized particles compared to non-homogenized milk, where larger fat globules remain and can rise to form a visible cream line.

30. Correct Answer: A

Straining removes much of the liquid whey from fermented yogurt, concentrating the remaining protein and solids and producing Greek yogurt's characteristically thick texture.

31. Correct Answers: A, B, C, E

Straining concentrates protein, removes whey (and some lactose along with it), and produces a thicker texture. True Greek yogurt is strained rather than thickened with added gums, though some "Greek-style" products do use added thickeners instead.

32. Correct Answer: B

Like traditional cheesemaking, straining yogurt to make Greek yogurt produces a large volume of leftover whey, presenting similar handling, utilization, or disposal challenges at commercial scale.

33. Correct Answer: B

Non-dairy creamers typically use vegetable oil in place of milk fat, along with emulsifiers and stabilizers (which may include milk-derived sodium caseinate or plant-derived carrageenan) to mimic cream's mouthfeel.

34. Sample/Acceptable Answer:

Sodium caseinate is a milk-derived ingredient made by treating casein protein to make it more water-soluble; it is often used as an emulsifier/whitener in non-dairy creamers. Even though such a product may be free of lactose (making it suitable for someone who is only lactose intolerant), sodium caseinate still contains milk protein. Because a true milk protein allergy is an immune reaction to milk proteins like casein, rather than an inability to digest lactose, a product containing sodium caseinate could still trigger an allergic reaction in someone with a genuine milk protein allergy, even if the product is labeled "non-dairy" or "lactose-free."

35. Correct Answer: A

Under U.S. labeling rules, "non-dairy" is not as strictly defined as "dairy-free," and products labeled "non-dairy" can still legally contain certain milk-derived ingredients such as sodium caseinate.

36. Correct Answer: B

The heat treatment used in pasteurization denatures and inactivates naturally occurring lipase enzyme, helping prevent the hydrolytic rancidity that unchecked lipase activity would otherwise cause.

37. Correct Answer: A

Alkaline phosphatase is reliably inactivated by proper pasteurization, so testing for its absence (a negative result) provides a simple, standardized way to confirm that milk has been adequately heat-treated.

38. Correct Answers: A, B, C, E

The phosphatase test verifies proper pasteurization; alkaline phosphatase occurs naturally in raw milk; a positive result can indicate under-pasteurization or raw-milk contamination; and properly pasteurized milk should test negative. The test does not measure fat percentage.

39. Correct Answer: B

A positive phosphatase result on milk labeled as pasteurized suggests it may not have been adequately heat-treated, or that it was contaminated with raw milk after pasteurization -- either way, a food-safety concern worth investigating.

40. Sample/Acceptable Answer:

Lipase, if not inactivated, breaks down milk fat into free fatty acids that can cause rancid off-flavors, so dairy processors rely on pasteurization's heat treatment to inactivate lipase and prevent this flavor defect from developing during storage and shelf life. Alkaline phosphatase, in contrast, is not itself a flavor or spoilage concern; instead, because it happens to be reliably destroyed by proper pasteurization heat treatment, dairy processors use a simple phosphatase test as a quality-control indicator: if the enzyme is inactive (test negative), that result helps confirm the milk was heated sufficiently to achieve proper pasteurization.

41. Correct Answer: B

Light cream is generally defined as containing at least about 18% milkfat, distinguishing it from lower-fat half-and-half and higher-fat whipping/heavy creams.

42. Correct Answer: B

Heavy whipping cream contains a higher milkfat percentage than light whipping cream, generally allowing it to whip into a more stable, stiffer foam.

43. Correct Answer: B

Well-whipped cream typically roughly doubles in volume (about 100% overrun) due to air incorporated during whipping, and this overrun is closely related to the cream's fat content and how it is whipped.

44. Sample/Acceptable Answer:

Heavy cream contains a higher concentration of milk fat globules than light cream. When whipped, these fat globules partially coalesce -- clumping together at their disrupted membrane surfaces -- and form a supportive, semi-solid network around the air bubbles being incorporated. Because heavy cream has more fat globules available to build this network, it can form a denser, more extensive, and more stable structural framework than light cream, resulting in stiffer peaks and a more stable whipped foam; light cream, lacking enough fat globules to build as strong a supporting structure, whips into a much less stable foam or may not hold stiff peaks at all.

45. Correct Answer: A

Leucine is a branched-chain amino acid found in relatively high concentration in whey protein and is recognized for its role in stimulating muscle protein synthesis, a key reason whey protein is popular in sports nutrition products.

46. Correct Answer: A

As milk heats, evaporation from the surface concentrates milk solids there, and heat-driven protein denaturation at that exposed, concentrated surface layer forms the characteristic thin "skin."

47. Sample/Acceptable Answer:

As milk heats, water evaporates from its surface, which concentrates the milk solids (proteins and minerals) there; combined with heat-driven denaturation of proteins at the exposed surface, this creates a thin, coagulated protein layer -- the "skin." A practical technique to reduce this, based on this understanding, is to stir the milk periodically as it heats (redistributing the concentrated surface layer back into the bulk milk) or to cover the pot to reduce surface evaporation, both of which limit the buildup of concentrated, denatured protein at the surface.

48. Correct Answer: A

Lactic acid bacteria ferment lactose into lactic acid during yogurt production, which is what lowers the product's pH from milk's near-neutral range down to yogurt's more acidic range.

49. Correct Answer: B

While rennet-set cheeses also acidify somewhat during production, extended aging/ripening (including microbial and enzymatic activity that metabolizes acids and produces buffering compounds) can raise a hard aged cheese's pH back somewhat closer to neutral compared to a fresh, unaged acid-set cheese like cottage cheese.

50. Sample/Acceptable Answer:

Fresh milk has a pH around 6.6-6.8 (only mildly acidic); yogurt is much more acidic, typically around pH 4.0-4.5, because bacterial fermentation converts much of milk's lactose into lactic acid, which accumulates since the product is not aged further after fermentation. Aged hard cheeses can vary but are often somewhat less acidic than fresh yogurt, because although initial lactic acid fermentation also lowers their pH during cheesemaking, further ripening/aging (including the activity of aging bacteria and enzymes that metabolize lactic acid and produce buffering compounds) can gradually raise the pH back somewhat closer to neutral over weeks or months of aging. These differences arise because each product undergoes a different combination of fermentation intensity, aging time, and microbial activity, even though they all start from the same base ingredient, milk.

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
National Exam

Team Name: _____ Team Number: _____

- This exam contains 80 questions: 60 multiple choice, 5 multiselect (select ALL correct answers), 10 short answer, and 5 long answer.
- Ten questions (Q2, Q14, Q20, Q26, Q38, Q40, Q48, Q50, Q60, Q62) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write a concise response in the space provided. For long answer questions, write a complete, multi-part response addressing every part of the prompt in the larger space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; National Tournament teams complete all Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Besides water, fat, protein, and lactose, what term describes the collective mineral content that remains after milk is completely combusted (burned off)?

A. Ash
B. Slag
C. Residue
D. Curd

2. Refer to Image 1, a photo of Holstein dairy cows, the most common dairy breed in the U.S. Compared to other common dairy breeds such as Jersey, Holstein milk is generally characterized by:



Image 1

A. Higher milk volume but relatively lower butterfat percentage
B. Lower milk volume and lower butterfat percentage
C. The highest butterfat percentage of any dairy breed
D. No measurable compositional difference from other breeds

3. Which term describes a genetic variant of beta-casein found in some cow's milk that has been marketed (though not conclusively proven scientifically) as easier to digest than conventional milk?

A. A2 beta-casein
B. Kappa-casein
C. Alpha-lactalbumin
D. Rennet casein

4. Explain what the term "A2 milk" refers to, and briefly describe why scientific evidence for its claimed digestive benefits is still considered limited or inconclusive.

5. The membrane that surrounds each milk fat globule, composed largely of phospholipids and proteins, is known as the:

A. Casein micelle
B. Milk fat globule membrane (MFGM)

C. Whey protein complex
D. Lactose shell

6. Phospholipids, a key component of the milk fat globule membrane, are unique among milk lipids because they:

A. Contain both hydrophilic and hydrophobic regions, allowing them to stabilize the fat-water interface
B. Are entirely hydrophobic, like triglycerides
C. Are a type of protein rather than a lipid
D. Are entirely water-soluble simple sugars

7. Oxidative rancidity in milk fat, which produces off-flavors, primarily occurs through a reaction between unsaturated fatty acids and:

A. Oxygen
B. Nitrogen gas
C. Carbon dioxide
D. Calcium

8. Select ALL factors that can accelerate oxidative rancidity (off-flavor development) in milk and dairy fats. (Select ALL that apply.)

A. Exposure to light
B. Exposure to oxygen
C. Presence of trace metal ions (e.g., copper, iron)
D. Consistent, proper refrigeration temperatures
E. Complete absence of unsaturated fatty acids

9. Milk's slightly yellow-green fluorescent pigment, riboflavin (Vitamin B2), is significant in dairy processing because it:

A. Is degraded by exposure to light, contributing to off-flavors in light-exposed milk
B. Has no sensitivity to light at all
C. Is entirely destroyed by pasteurization
D. Is only found in skim milk, not whole milk

10. Which packaging characteristic helps protect milk from light-induced riboflavin degradation and off-flavor development?

A. Clear glass bottles
B. Opaque or pigmented plastic or cardboard packaging
C. Thin, fully transparent plastic film
D. Milk does not need any light protection

11. According to FDA Standards of Identity, butter sold in the United States must contain at least what minimum percentage of milkfat?

A. 50%
B. 65%
C. 80%
D. 95%

12. Explain what a "Standard of Identity" is in U.S. food regulation, and give ONE example of how it applies to a dairy product.

13. Under FDA regulations, "heavy cream" or "heavy whipping cream" must contain a minimum milkfat percentage of approximately:

A. 10%
B. 18%
C. 30%
D. 36%

14. Refer to Image 2, a photo of a Jersey cow. Jersey cattle are widely known in the dairy industry for producing milk with a relatively:



Image 2

A. Lower fat and protein percentage than Holstein milk
B. Higher fat and protein percentage than Holstein milk
C. Composition identical to Holstein milk
D. Complete absence of milkfat

15. Somatic cell count (SCC) in raw milk is primarily used by the dairy industry as an indicator of:

A. Milk's calcium content
B. Udder health and potential mastitis infection
C. Milk's lactose content
D. The cow's breed

16. Discuss the importance of somatic cell count (SCC) testing in the dairy industry. In your answer: define what somatic cells are, explain what an elevated SCC indicates about herd health, and describe how a high SCC can affect milk quality and downstream dairy processing (such as cheese yield or shelf life).

17. Standard Plate Count (SPC) is a laboratory test used to estimate which of the following in raw milk?

A. Total bacterial count
B. Fat percentage
C. Lactose concentration
D. pH

18. The Grade "A" Pasteurized Milk Ordinance (PMO) is a model regulatory document primarily used to establish:

A. International trade tariffs on dairy products
B. Uniform sanitation and safety standards for Grade A milk production and processing in the U.S.
C. Genetic breeding standards for dairy cattle
D. Global milk pricing agreements

19. Which federal agency has primary regulatory authority over the safety and labeling of most fluid milk and dairy products in the United States?

A. USDA
B. FDA
C. EPA
D. CDC

20. Refer to Image 3, a photograph of blue cheese showing characteristic blue-green veining. Identify the genus of mold most commonly responsible for this veining, and briefly explain how it is typically introduced into the cheese during production.



Image 3

21. HACCP, a food safety management system used in dairy processing, stands for:

A. Hazard Analysis and Critical Control Points
B. High Acid Concentration Control Protocol
C. Health and Cleanliness Certification Process
D. Homogenization and Cream Control Procedure

22. Soft, unpasteurized, or improperly aged cheeses carry an elevated food safety risk primarily from which bacterium, of particular concern to pregnant women?

A. Lactobacillus
B. Listeria monocytogenes
C. Penicillium roqueforti
D. Streptococcus thermophilus

23. Mandatory milk pasteurization laws in the early-to-mid 20th century United States were adopted largely in response to public health concerns about which diseases historically transmitted through raw milk?

A. The common cold and influenza
B. Tuberculosis and brucellosis
C. Lactose intolerance
D. Adverse reactions to food coloring

24. Select ALL statements that are TRUE regarding raw (unpasteurized) milk. (Select ALL that apply.)

A. Raw milk carries a higher risk of harmful bacterial contamination than pasteurized milk.
B. Pasteurization destroys essentially all of milk's nutritional value.

C. Young children, older adults, pregnant women, and immunocompromised individuals face higher risk from raw milk consumption.

D. Sale of raw milk for direct human consumption is regulated differently across U.S. states.

E. Raw milk cannot legally be used to produce any cheese sold in the United States.

25. Bactofugation is a dairy processing technique that uses centrifugal force to:

A. Add bacterial cultures to milk for fermentation

B. Remove bacterial spores and somatic cells from raw milk

C. Whip air into cream

D. Measure milk's acidity

26. Refer to Image 4, a diagram of a titration setup. Titratable acidity testing, commonly used in dairy quality control for cultured products, measures milk's acidity by:

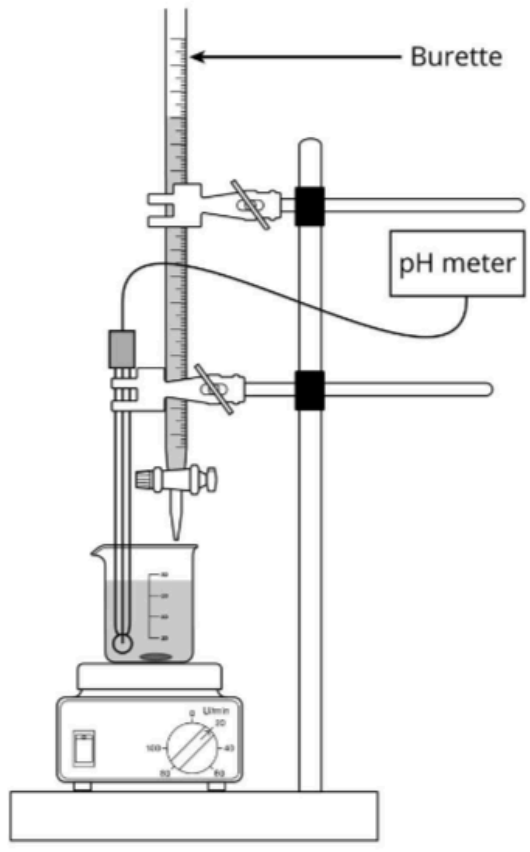


Image 4

A. Adding a measured base (such as NaOH) until a color-change endpoint is reached, then calculating acid content from the volume used

B. Measuring electrical conductivity only

C. Weighing the milk sample before and after heating

D. Observing the milk's color under UV light

27. Which best describes the difference between pH and titratable acidity (TA) when evaluating milk or cultured dairy products?

A. pH and TA measure exactly the same property and are interchangeable

B. pH measures the concentration of free hydrogen ions, while TA measures the total amount of acid (free and bound) that can be neutralized by a base

C. TA can only be measured electronically, while pH is only measured by titration

D. pH only applies to liquid samples, and TA only applies to solid samples

28. Explain why titratable acidity (TA), rather than pH alone, is often considered a more useful measurement for tracking fermentation progress in cultured dairy products like yogurt.

29. Most rennet used in commercial cheesemaking today is produced by which method?

A. Extracted exclusively from calf stomachs
B. Fermentation-produced chymosin (FPC) from genetically engineered microorganisms
C. Synthesized entirely from plant cellulose
D. Extracted directly from milk itself

30. Cheese made using fermentation-produced chymosin (FPC) instead of traditional animal rennet is often marketed as:

A. Non-dairy
B. Vegetarian
C. Lactose-free
D. Organic

31. Conjugated linoleic acid (CLA), a fatty acid naturally found in dairy fat, is of research interest primarily because it:

A. Has no known biological activity
B. Has been studied for potential health effects, including anti-inflammatory properties
C. Causes milk to spoil more quickly
D. Is only found in plant oils, not dairy

32. Milk fat contains a complex mixture of fatty acids, including saturated fats, unsaturated fats, and minor bioactive compounds like conjugated linoleic acid (CLA). Explain the general structural difference between saturated and unsaturated fatty acids, describe what makes CLA structurally unique among unsaturated fatty acids, and discuss why milk fat's fatty acid profile can vary based on a cow's diet.

33. Compared to grain-fed dairy cows, grass-fed dairy cows generally produce milk with:

A. A lower omega-3 fatty acid content
B. A higher omega-3 fatty acid content

C. No measurable difference in fatty acid profile
D. Higher lactose content only

34. In milk processing, "standardization" refers to the process of:

A. Adjusting milk's fat content to a specific target percentage by adding or removing cream
B. Adding vitamins to milk
C. Pasteurizing milk at a standardized temperature
D. Testing milk for bacterial contamination

35. Milk "clarification," typically performed early in processing, uses centrifugal force to remove:

A. Lactose
B. Sediment, somatic cells, and other solid debris
C. Water
D. All milk fat

36. Describe, in order, at least FOUR major steps that raw milk typically undergoes to become pasteurized, homogenized, fortified whole milk ready for retail sale, and briefly explain the purpose of each step.

37. Extended Shelf Life (ESL) milk achieves a longer refrigerated shelf life than standard HTST-pasteurized milk primarily by using:

A. Lower pasteurization temperatures than standard milk
B. Higher heat treatment and/or advanced microfiltration to remove more microorganisms
C. Artificial chemical preservatives
D. No heat treatment at all

38. Refer to Image 5, a photograph of ricotta cheese. Ricotta is traditionally made by heating and slightly acidifying which dairy processing byproduct?



Image 5

A. Cream
B. Whey
C. Buttermilk
D. Casein curd

39. Because most casein has already been removed as curds before ricotta production, the proteins that coagulate to form ricotta when whey is reheated and acidified are primarily:

A. Casein proteins
B. Whey proteins (such as beta-lactoglobulin), which denature and aggregate with heat and acid
C. Collagen
D. Amylase

40. Refer to Image 6, a photograph of powdered milk. Select ALL statements that are TRUE about spray-dried milk powder. (Select ALL that apply.)



Image 6

A. Milk is first concentrated by evaporation before spray drying.

B. Spray drying rapidly evaporates moisture from fine milk droplets in a heated chamber.

C. Milk powder generally has a SHORTER shelf life than liquid milk.

D. Powdered milk does not require refrigeration before opening, due to its low moisture content.

E. Nonfat dry milk, whole milk powder, and dry whey are all examples of powdered dairy products.

41. Compared to spray drying, freeze-drying (lyophilization) of dairy products generally:

A. Uses much higher heat, damaging more nutrients
B. Better preserves heat-sensitive nutrients and flavor compounds, but is more costly and slower
C. Is identical in process and cost to spray drying
D. Cannot be used for dairy products at all

42. Microfiltration, increasingly used in dairy processing, separates components primarily based on:

A. Their electrical charge
B. Their particle or molecular size, using a fine membrane
C. Their color
D. Their temperature sensitivity

43. Lactoferrin, a minor iron-binding protein found in milk (in higher concentration in colostrum), is of interest in food science primarily for its:

A. Antimicrobial and immune-supporting properties
B. Role as milk's primary energy source
C. Function as an artificial sweetener
D. Use as a synthetic preservative

44. Colostrum, the first milk produced by mammals after giving birth, differs chemically from mature milk in several ways. Describe TWO chemical or compositional differences between colostrum and mature milk, and explain the biological purpose of at least one of these differences.

45. Compared to cow's milk, human breast milk generally contains:

A. A higher percentage of casein protein
B. A lower percentage of casein protein relative to whey protein
C. Identical casein content to cow's milk
D. No casein protein at all

46. Compared to cow's milk, goat's milk generally contains lower levels of which specific casein protein, which some research suggests may make it easier for some individuals to digest?

A. Alpha-s1-casein
B. Kappa-casein exclusively
C. Beta-lactoglobulin
D. Lactose

47. Compared to cow's milk, sheep's milk generally has a:

A. Lower fat and protein content
B. Higher fat and protein content
C. Composition identical to cow's milk
D. Complete absence of lactose

48. Refer to Image 7, a photograph of whey protein powder. Whey, once considered primarily a low-value byproduct of cheesemaking, is now processed into a range of valuable dairy ingredients. Describe the general process used to separate and concentrate whey proteins into whey protein concentrate or isolate, explain at least TWO different commercial uses of whey-derived ingredients, and discuss why using whey this way is considered more sustainable than discarding it as waste.



Image 7

49. Historically, before modern processing technology made whey protein products commercially valuable, large volumes of cheese whey were often:

A. Used exclusively for premium cheese production
B. Disposed of as agricultural waste/animal feed, or discharged as wastewater
C. Converted directly into butter
D. Sold as bottled drinking water

50. Refer to Image 8, a photograph of goat's milk cheese. Compared to cow's milk cheese, goat's milk cheese is often reported to be easier to digest for some people, in part because goat milk fat globules are generally:



Image 8

A. Larger than cow milk fat globules
B. Smaller than cow milk fat globules, providing more surface area for enzymatic digestion
C. Identical in size to cow milk fat globules
D. Entirely absent of fat

51. Which of the following best distinguishes sherbet from sorbet?

A. Sherbet contains a small amount of dairy (milk or cream), while sorbet contains no dairy at all
B. Sherbet is entirely fruit-based with no dairy, while sorbet contains dairy
C. They are identical products marketed under different names
D. Sherbet always contains eggs, while sorbet never does

52. Explain the FDA's compositional requirement that distinguishes sherbet from ice cream in terms of milkfat content, and describe how this difference affects sherbet's flavor and texture compared to ice cream.

53. Compared to traditional American ice cream, Italian-style gelato is generally characterized by:

A. Higher fat content and more air (overrun) than ice cream
B. Lower fat content, less air (overrun), and a denser, more intense flavor than ice cream
C. A composition identical to standard ice cream
D. No dairy content at all

54. The gradual growth of large, gritty ice crystals in ice cream that has been improperly stored (e.g., through temperature fluctuation, partial thawing, and refreezing) is primarily explained by which physical process?

A. Ostwald ripening, in which smaller ice crystals melt and redeposit onto larger crystals over time
B. The Maillard reaction
C. Esterification
D. Emulsification

55. Before freezing, commercial ice cream mix is typically "aged" (held cold, around 4°C, for several hours) primarily to:

A. Allow fat to crystallize and proteins/stabilizers to fully hydrate, improving final texture
B. Begin the freezing process early
C. Pasteurize the mix
D. Add flavoring ingredients

56. Select ALL factors that generally help minimize large ice crystal formation and improve the smooth texture of ice cream. (Select ALL that apply.)

A. Rapid freezing during initial manufacture
B. Consistent, cold storage temperature (avoiding fluctuation)
C. Higher total solids (fat, sugar, stabilizers) in the mix
D. Repeated partial thawing and refreezing during storage
E. Proper overrun (air incorporation) during freezing

57. Under FDA Standards of Identity, ice cream sold in the U.S. must contain a minimum milkfat percentage of at least:

A. 2%
B. 10%
C. 25%
D. 50%

58. On U.S. food labels, an ice cream product labeled "light" or "lite" must generally contain:

A. No fat or calorie reduction requirement at all
B. At least 50% less fat or 33% fewer calories than the reference regular product
C. More fat than regular ice cream
D. No dairy ingredients

59. A frozen dessert made with plant-based milk (such as oat or almond "ice cream") generally CANNOT legally be labeled simply "ice cream" in the U.S. because:

A. FDA Standards of Identity for ice cream require dairy milkfat as an ingredient
B. Plant-based desserts are always more expensive to produce

C. There is no regulation of frozen dessert labeling at all
D. Plant-based desserts cannot physically be frozen

60. Refer to Image 9, a historical photograph of a centrifugal cream separator. Explain the physical principle that allows a centrifugal separator to divide whole milk into cream and skim milk, and explain why cream ends up at the center of the device while skim milk moves toward the outside.



Image 9

61. The commercial centrifugal cream separator, which revolutionized dairy processing in the late 1800s, is most closely associated with which inventor?

A. Louis Pasteur
B. Gustaf de Laval
C. John Deere
D. Marco Polo

62. Refer to Image 10, a photograph of vanilla ice cream. The percentage increase in volume of an ice cream mix due to air whipped in during freezing is called:



Image 10

A. Standardization
B. Overrun
C. Homogenization
D. Pasteurization

63. If a fixed volume of ice cream mix yields a larger finished volume of ice cream due to air incorporation, a HIGHER overrun percentage generally results in a finished product that is:

A. Denser and heavier per unit volume
B. Lighter and less dense per unit volume
C. Unaffected in density
D. Always higher in fat content

64. Describe, using specific food-science concepts (colligative properties/freezing point depression, fat and protein structure, and air incorporation/overrun), how the ingredients and freezing process work together to produce ice cream's characteristic smooth, scoopable texture. Explain what can go wrong, in terms of ingredients or storage, to produce a final product that is icy/gritty, or one that is overly hard and dense.

65. Which food additive derived from soybeans is commonly used as an emulsifier in commercial ice cream and other dairy products?

A. Lecithin
B. Carrageenan
C. Guar gum
D. Pectin

66. Guar gum, a common stabilizer in ice cream and other dairy products, is derived from:

A. Seaweed
B. The seeds of the guar plant (a legume)
C. Animal collagen
D. Milk protein

67. Pectin, sometimes used as a stabilizer in cultured dairy products like yogurt drinks, is most commonly extracted from:

A. Citrus fruit peels and apple pomace
B. Animal bones
C. Seaweed
D. Milk whey

68. Compare carrageenan (from seaweed) and guar gum (from guar seeds) as dairy stabilizers: describe their biological source and explain ONE similarity in how they function to improve texture in dairy products.

69. The lactoperoxidase system, a natural antimicrobial system present in raw milk, helps to:

A. Naturally inhibit some bacterial growth before processing
B. Add flavor compounds to aged cheese
C. Increase milk's fat content
D. Break lactose down into glucose and galactose

70. Galactosemia is a rare genetic metabolic disorder in which an individual cannot properly metabolize which milk sugar component?

A. Sucrose
B. Galactose
C. Fructose
D. Maltose

71. How does galactosemia differ from common lactose intolerance?

A. They are the same condition with different names

B. Galactosemia is a rare, serious genetic enzyme deficiency present from birth requiring strict avoidance of galactose-containing foods, while lactose intolerance is a more common, often milder condition involving reduced lactase enzyme activity

C. Lactose intolerance is more dangerous than galactosemia

D. Galactosemia only affects adults, never infants

72. Select ALL statements that are TRUE about metabolic/digestive conditions related to milk sugar. (Select ALL that apply.)

A. Lactose intolerance results from reduced lactase enzyme activity in the small intestine.

B. Galactosemia is caused by reduced lactase enzyme activity.

C. Galactosemia requires strict dietary avoidance of galactose from birth.

D. Lactose intolerance symptoms are generally milder and more common than galactosemia symptoms.

E. Both conditions have identical treatment/dietary recommendations.

73. "Sandiness," a textural defect sometimes found in ice cream or overly aged sweetened condensed milk, is caused by the crystallization of:

A. Milk fat

B. Lactose, forming gritty lactose crystals

C. Casein protein

D. Salt

74. The key compositional difference between sweetened condensed milk and evaporated milk is that sweetened condensed milk:

A. Contains no milk at all

B. Has a large amount of added sugar, which along with water removal helps preserve it without sterilization

C. Is never heated during processing

D. Contains no lactose

75. Unlike sweetened condensed milk (which contains little to no added sugar), evaporated milk is preserved primarily through:

A. High sugar content alone

B. Sterilization via retort (canning) heat processing after being sealed in its container

C. Freezing

D. Fermentation

76. Compare sweetened condensed milk and evaporated milk: describe ONE compositional difference and explain how each product achieves shelf stability without refrigeration before opening.

77. In the modern U.S. dairy industry, farmers are often paid for raw milk based partly on a "multiple component pricing" system that accounts for the milk's:

A. Only its total volume in gallons, regardless of composition
B. Fat, protein, and sometimes other solids content, not just total volume
C. Color only
D. The cow's breed registration papers

78. The Babcock test, a classic laboratory method still referenced in dairy science, was developed to measure:

A. Milk's bacterial count
B. Milk's fat percentage, using sulfuric acid and centrifugation
C. Milk's pH
D. Milk's lactose content

79. The Gerber test, an alternative to the Babcock test still used in some countries for measuring milk fat content, uses which reagent to dissolve non-fat milk solids?

A. Sulfuric acid
B. Sodium hydroxide
C. Hydrochloric acid only
D. Distilled water only

80. Synthesize your understanding of dairy food science by choosing ONE of the following processing or quality-control methods discussed on this exam -- titratable acidity testing, the Babcock/Gerber fat test, somatic cell count testing, or pasteurization -- and explain in detail: (1) what the test/process measures or accomplishes, (2) the underlying chemical or physical principle involved, and (3) why this test/process is important to the overall quality, safety, or economic value of dairy products reaching consumers.

ANSWER KEY

FOOD SCIENCE – DIVISION B – NATIONAL EXAM

1. Correct Answer: A

The mineral content of milk (calcium, phosphorus, potassium, etc.) that remains after complete combustion of the organic components is referred to as ash content.

2. Correct Answer: A

Holsteins are bred primarily for high milk volume and tend to produce milk with a comparatively lower butterfat percentage than breeds like Jersey or Guernsey.

3. Correct Answer: A

"A2 milk" refers to milk containing only the A2 variant of beta-casein rather than the more common A1 variant; digestive benefit claims remain scientifically inconclusive.

4. Sample/Acceptable Answer:

"A2 milk" comes from cows that produce only the A2 genetic variant of beta-casein protein, rather than the more common A1 variant found in most conventional milk. Some marketing claims suggest A2 milk is easier to digest or causes less digestive discomfort than regular milk. However, scientific evidence for this claim is limited: existing studies are relatively few, often small in scale, sometimes funded by companies with a commercial interest in the outcome, and have produced mixed or inconclusive results, so the scientific and medical community does not consider the digestive-benefit claim well established.

5. Correct Answer: B

The milk fat globule membrane (MFGM) is a phospholipid- and protein-rich layer that surrounds and stabilizes each fat globule within milk's aqueous phase.

6. Correct Answer: A

Phospholipids are amphipathic (having both a hydrophilic head and hydrophobic tail), which allows them to orient at the fat-water interface and stabilize the emulsion.

7. Correct Answer: A

Oxidative rancidity occurs when double bonds in unsaturated fatty acids react with oxygen, producing off-flavor compounds such as aldehydes and ketones.

8. Correct Answers: A, B, C

Light, oxygen exposure, and trace metal ions (which act as catalysts) all accelerate oxidative rancidity. Proper refrigeration slows rather than accelerates rancidity, and a fat with no unsaturated fatty acids would not be susceptible to this particular oxidative pathway.

9. Correct Answer: A

Riboflavin is photosensitive; light exposure can degrade it and trigger light-oxidized off-flavors in milk, which is one reason milk is often sold in opaque packaging.

10. Correct Answer: B

Opaque or pigmented packaging blocks light exposure, helping protect light-sensitive nutrients like riboflavin and preventing light-oxidized off-flavors.

11. Correct Answer: C

FDA Standards of Identity require butter to contain at least 80% milkfat by weight.

12. Sample/Acceptable Answer:

A Standard of Identity is an FDA regulation that legally defines what a specific food product must contain (and in what proportions) in order to be labeled and sold under that product's common name. For example, FDA Standards of Identity require butter to contain at least 80% milkfat, and ice cream to contain at least 10% milkfat; a product that does not meet these requirements cannot legally be labeled "butter" or "ice cream" in the U.S.

13. Correct Answer: D

Heavy cream (heavy whipping cream) must legally contain at least 36% milkfat under FDA Standards of Identity.

14. Correct Answer: B

Jersey cattle are prized for producing milk with a higher butterfat and protein percentage than Holstein milk, making it especially valuable for butter and cheese production.

15. Correct Answer: B

Somatic cells are largely white blood cells; an elevated SCC generally indicates udder inflammation or infection (mastitis), making SCC a key milk-quality and herd-health indicator.

16. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Somatic cells are primarily white blood cells (with a small proportion of epithelial cells) naturally present in milk; they are part of the cow's immune response. A low SCC is normal and expected in healthy milk, but an elevated SCC generally signals udder inflammation or infection (mastitis), often caused by bacterial infection of the mammary gland. Beyond indicating animal health issues, milk with a high SCC tends to have altered composition -- for example, increased enzyme activity (such as proteases and lipases) that can break down milk proteins and fats prematurely, reducing shelf life, flavor quality, and cheese-making yield, since damaged casein does not form curds as efficiently. For these reasons, SCC is closely monitored and often directly tied to the price dairy farmers are paid for their milk.

17. Correct Answer: A

Standard Plate Count estimates the total number of viable bacteria present in a milk sample, an important microbiological quality indicator.

18. Correct Answer: B

The PMO, developed by the FDA in cooperation with states, provides model regulations that most U.S. states adopt to standardize sanitation and safety requirements for Grade A milk.

19. Correct Answer: B

The FDA holds primary authority over the safety and labeling of most dairy products, though USDA separately provides voluntary quality grading services for some products like butter and cheese.

20. Sample/Acceptable Answer:

The mold is Penicillium, most commonly the species Penicillium roqueforti. Mold spores are typically introduced by adding a powdered mold culture directly to the milk or curd during cheesemaking, or by inoculating the cheese after formation; the cheese is then pierced with needles or skewers to create air channels, allowing the mold (which requires oxygen) to grow along these channels through the interior of the cheese, producing the characteristic blue-green veining.

21. Correct Answer: A

HACCP (Hazard Analysis and Critical Control Points) is a systematic, preventive food safety approach that identifies and controls hazards at critical points in a production process.

22. Correct Answer: B

Listeria monocytogenes can survive and grow at refrigeration temperatures and poses a serious risk of miscarriage or severe illness, particularly from soft, unpasteurized, or improperly aged cheeses.

23. Correct Answer: B

Historically, raw milk was a significant vector for diseases such as bovine tuberculosis and brucellosis; pasteurization requirements were adopted largely to eliminate these serious public health risks.

24. Correct Answers: A, C, D

Raw milk does carry a higher contamination risk, vulnerable populations face higher risk, and state regulation of raw milk sale varies widely. Pasteurization does not destroy essentially all nutritional value

(only modestly affects some heat-sensitive nutrients), and federal rules do permit raw-milk cheeses that are aged at least 60 days.

25. Correct Answer: B

Bactofugation uses high-speed centrifugation to physically remove bacterial spores (and some somatic cells) from raw milk, particularly useful for milk destined for aged cheese production.

26. Correct Answer: A

Titratable acidity testing involves slowly adding a standardized base solution to a milk sample until a pH-indicator color-change endpoint is reached, then calculating total acid content from the volume of base used.

27. Correct Answer: B

pH reflects only the concentration of free hydrogen ions in solution at a given moment, while titratable acidity measures the total acid content, including acid that has not yet dissociated, giving a more complete picture of total acidity.

28. Sample/Acceptable Answer:

TA measures the total amount of acid developing in the product, including lactic acid molecules that have not yet fully dissociated into free hydrogen ions, which correlates more directly and sensitively with the total amount of lactic acid produced by bacterial fermentation. Because milk has natural buffering capacity, pH can change relatively little in the early stages of fermentation even as substantial acid is being produced, making pH alone a less sensitive early indicator of fermentation progress than TA.

29. Correct Answer: B

Most commercial rennet today is fermentation-produced chymosin (FPC), made by genetically engineered microorganisms (such as certain yeast or fungi) that produce the same coagulating enzyme found in traditional animal rennet.

30. Correct Answer: B

Because FPC is produced by microorganisms rather than extracted from animal stomachs, cheeses made with it can be marketed as vegetarian.

31. Correct Answer: B

CLA is a minor but biologically active fatty acid naturally present in ruminant dairy fat that has been studied for various potential health effects.

32. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Saturated fatty acids contain only single carbon-carbon bonds along their hydrocarbon chain, allowing them to pack tightly together and remain solid at room temperature, while unsaturated fatty acids contain one or more carbon-carbon double bonds, which introduce kinks in the chain that prevent tight packing, keeping them liquid at room temperature. CLA is structurally unique among unsaturated fatty acids because its double bonds are conjugated -- meaning they are directly adjacent to one another (separated by only one single bond) rather than separated by an intervening methylene (-CH2-) group, as in most naturally occurring polyunsaturated fatty acids. Milk fat's fatty acid profile, including its CLA content, varies with a cow's diet because rumen bacteria in the cow's digestive system biohydrogenate (partially saturate) dietary fats differently depending on the feed composition; cows on fresh pasture/grass diets tend to produce milk with higher levels of CLA and omega-3 fatty acids than cows fed primarily grain-based diets, because fresh forage contains more of the precursor fatty acids that rumen bacteria convert into CLA.

33. Correct Answer: B

Grass-fed cows generally produce milk with a higher omega-3 fatty acid content (and higher CLA) than grain-fed cows, due to differences in the fatty acid precursors present in their diet.

34. Correct Answer: A

Standardization adjusts milk's fat content (by adding cream or skim milk, or separating out fat) to reach a specific target percentage, such as whole, 2%, 1%, or skim milk.

35. Correct Answer: B

Clarification uses a centrifuge to remove sediment, somatic cells, and other undesirable solid particles from raw milk before further processing.

36. Sample/Acceptable Answer:

Accept any four correctly ordered and explained steps, such as: (1) Clarification -- centrifugal removal of sediment and somatic cells. (2) Standardization -- adjusting milk fat to the target percentage for the final product. (3) Pasteurization -- heat treatment (e.g., HTST) to destroy harmful pathogens and extend shelf life. (4) Homogenization -- mechanically breaking fat globules into smaller, evenly dispersed particles to prevent cream separation. (5) Fortification -- adding Vitamin D (and Vitamin A for reduced-fat/skim milks) since processing removes some naturally fat-soluble vitamins. (6) Packaging -- sealing milk in clean, often light-protective containers to prevent contamination and nutrient degradation.

37. Correct Answer: B

ESL milk typically uses higher-temperature heat treatment and/or microfiltration to remove or destroy more spoilage microorganisms than standard HTST pasteurization, extending refrigerated shelf life without reaching full UHT sterilization.

38. Correct Answer: B

Ricotta (meaning "recooked") is traditionally made from whey, the liquid byproduct left over after casein curds are removed during other cheesemaking.

39. Correct Answer: B

Ricotta production relies on the heat- and acid-induced denaturation and aggregation of remaining whey proteins, since most casein has already been removed in earlier cheesemaking steps.

40. Correct Answers: A, B, D, E

Milk is concentrated before spray drying, which rapidly evaporates moisture from atomized droplets; the resulting low-moisture powder does not require refrigeration and has a much LONGER shelf life than liquid milk (not shorter). Nonfat dry milk, whole milk powder, and dry whey are all real examples of powdered dairy products.

41. Correct Answer: B

Freeze-drying uses low temperatures and sublimation (rather than heat evaporation) to remove water, better preserving heat-sensitive nutrients and flavor, but it is a slower and more expensive process than spray drying.

42. Correct Answer: B

Microfiltration uses membranes with very small, precise pore sizes to physically separate particles (such as bacteria, somatic cells, or fat globules) based on size.

43. Correct Answer: A

Lactoferrin is studied for its antimicrobial and immune-supporting properties, partly related to its ability to bind and sequester iron that bacteria need to grow.

44. Sample/Acceptable Answer:

Accept any two correct differences, such as: colostrum is much higher in protein, especially immunoglobulins (antibodies), than mature milk; colostrum is generally lower in lactose than mature milk; colostrum often contains higher concentrations of certain bioactive compounds, such as lactoferrin, than mature milk. Biological purpose: the high immunoglobulin content in colostrum helps transfer passive immunity from mother to newborn, providing antibody protection before the newborn's own immune system is fully developed.

45. Correct Answer: B

Human breast milk has a much lower casein-to-whey ratio than cow's milk, with whey proteins making up a larger relative share, which is one reason infant formulas are often modified to be more digestible for infants.

46. Correct Answer: A

Goat's milk generally contains lower levels of alpha-s1-casein than cow's milk, which some research associates with a softer curd structure and easier digestibility for some individuals.

47. Correct Answer: B

Sheep's milk is notably richer than cow's milk, with significantly higher fat and protein content, which is part of why it is prized for cheesemaking (such as Roquefort and Pecorino).

48. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Whey protein concentrate and isolate are typically produced using membrane filtration: microfiltration first removes remaining fat and casein particles, and ultrafiltration then concentrates the protein while allowing lactose, minerals, and water to pass through; further processing (such as ion exchange or additional filtration) can be used to produce a more highly purified whey protein isolate with even less lactose and fat. The resulting liquid concentrate is typically spray-dried into a shelf-stable powder. Commercial uses include sports nutrition/protein supplements, infant formula (whey is often the primary protein source because its digestibility profile is closer to human breast milk than casein-dominant cow's milk), baked goods (for texture and browning), and as an ingredient in processed cheese or other dairy products, as well as being used to make ricotta cheese. Using whey this way is more sustainable than discarding it because raw whey disposed of as wastewater carries a very high biological oxygen demand (BOD), meaning it can severely deplete oxygen levels and harm aquatic ecosystems if released untreated into waterways; converting whey into valuable food ingredients instead reduces this environmental burden while creating economic value from what was previously treated as waste.

49. Correct Answer: B

Before modern filtration and drying technology made whey protein products commercially viable, whey was frequently treated as a low-value waste product, often disposed of as wastewater or used as low-value animal feed.

50. Correct Answer: B

Goat milk fat globules tend to be smaller on average than cow milk fat globules, which is thought to provide more relative surface area for digestive enzymes to act on, potentially contributing to easier digestibility for some individuals.

51. Correct Answer: A

Sherbet legally must contain a small percentage of milkfat, distinguishing it from sorbet, which by definition contains no dairy ingredients at all.

52. Sample/Acceptable Answer:

Sherbet must contain a small percentage of milkfat, generally between about 1% and 2%, far less than the FDA's minimum of at least 10% milkfat required for ice cream. Because sherbet contains much less fat, it has a lighter, less creamy texture that is more icy/granular than ice cream, and its lower fat content allows fruit flavors to come through more prominently and vividly than in the richer, fat-coated flavor profile typical of ice cream.

53. Correct Answer: B

Gelato is typically made with less fat and churned to incorporate less air (lower overrun) than American ice cream, resulting in a denser texture with a more concentrated, intense flavor.

54. Correct Answer: A

Ostwald ripening describes the thermodynamically favorable process by which smaller ice crystals melt and redeposit onto larger existing crystals during temperature fluctuations, causing crystal size to grow and texture to become gritty over time.

55. Correct Answer: A

Aging the mix at refrigeration temperature allows fat to begin crystallizing and gives proteins and stabilizers time to fully hydrate, which improves whipping properties and final texture during freezing.

56. Correct Answers: A, B, C, E

Rapid initial freezing, stable storage temperature, higher total solids, and proper overrun all help minimize large ice crystal formation. Repeated partial thawing and refreezing does the opposite, promoting Ostwald ripening and gritty texture.

57. Correct Answer: B

FDA Standards of Identity require ice cream to contain a minimum of 10% milkfat.

58. Correct Answer: B

FDA labeling rules require "light" or "lite" versions of a food to contain at least 50% less fat or at least 33% fewer calories than the standard reference version of that product.

59. Correct Answer: A

Because FDA's Standard of Identity for "ice cream" specifically requires dairy milkfat, plant-based frozen desserts must instead use alternate labeling, such as "frozen dessert" or a plant-specific term.

60. Sample/Acceptable Answer:

A centrifugal separator spins milk at very high speed, generating centrifugal force. Because milk fat is less dense than the surrounding aqueous (skim milk) portion of milk, the denser skim milk is thrown outward toward the spinning bowl's edge, while the lighter fat globules are displaced toward the center of rotation. This density-based separation allows the cream (concentrated fat) to be collected from the center outlet and the skim milk from the outer outlet, achieving rapid separation without needing to wait for gravity settling.

61. Correct Answer: B

Gustaf de Laval developed and popularized the centrifugal cream separator in the 1870s-1880s, dramatically speeding up cream separation compared to older gravity-settling methods.

62. Correct Answer: B

Overrun is the percentage increase in volume from air incorporated into the mix during freezing/churning.

63. Correct Answer: B

Higher overrun means more air has been incorporated per unit volume, resulting in a lighter, less dense finished product.

64. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Dissolved sugar in the ice cream mix lowers the freezing point of the water-based portion (freezing point depression, a colligative property), which means the mix never freezes completely solid at typical freezer temperatures -- a portion of unfrozen, syrupy liquid always remains between ice crystals, contributing to a soft, scoopable texture rather than a solid block of ice. As the mix freezes and is simultaneously churned, milk fat globules partially coalesce and, along with emulsifiers/stabilizers, form a structural network that traps small air bubbles (overrun), which lightens the texture and interrupts the growth of large ice crystals. Stabilizers (such as guar gum or carrageenan) bind water and increase viscosity, further slowing ice crystal growth. A gritty, icy final product typically results from large ice crystals forming due to slow initial freezing, insufficient stabilizers/sugar, or -- most commonly -- temperature fluctuation during storage that triggers Ostwald ripening (smaller crystals melting and redepositing onto larger ones). An overly hard, dense product can result from too little overrun (not enough air incorporated during freezing), too little sugar (insufficient freezing point depression, so more of the mix freezes solid), or excessively cold storage temperatures that solidify the remaining unfrozen liquid phase.

65. Correct Answer: A

Soy lecithin is a phospholipid-based emulsifier commonly extracted from soybeans and used to help stabilize fat-water emulsions in products like ice cream.

66. Correct Answer: B

Guar gum is extracted from the ground endosperm of guar plant seeds (a legume) and is valued as a strong thickener even at low concentrations.

67. Correct Answer: A

Pectin is a plant-derived polysaccharide most commonly extracted commercially from citrus peels and apple pomace (a byproduct of juice production).

68. Sample/Acceptable Answer:

Carrageenan is a polysaccharide extracted from red seaweed, while guar gum is a polysaccharide extracted from the ground endosperm of guar plant seeds (a legume). Despite their different biological sources, both function similarly as hydrocolloids: they dissolve or disperse in the water phase of a dairy product, bind water, and increase viscosity, which slows the movement of water molecules and helps prevent large ice crystal growth (in frozen products) or ingredient separation/settling (in liquid or semi-solid products), improving overall texture and stability.

69. Correct Answer: A

The lactoperoxidase system is a naturally occurring enzymatic antimicrobial system in raw milk that provides some inherent, limited protection against bacterial growth before processing.

70. Correct Answer: B

Galactosemia is caused by a deficiency in enzymes needed to metabolize galactose (one of the two monosaccharides that make up lactose), requiring strict dietary avoidance of galactose from birth.

71. Correct Answer: B

Galactosemia is a rare, serious genetic disorder present from birth requiring strict galactose avoidance, while lactose intolerance is a far more common and generally milder condition caused by reduced (not absent) lactase enzyme activity, usually developing later in childhood or adulthood.

72. Correct Answers: A, C, D

Lactose intolerance results from reduced lactase; galactosemia requires strict lifelong galactose avoidance from birth; and lactose intolerance is far more common and generally milder than galactosemia. Galactosemia is not caused by lactase deficiency (it is a downstream metabolic enzyme deficiency), and the two conditions do not have identical treatment recommendations.

73. Correct Answer: B

Sandiness results from the crystallization of lactose into large, gritty crystals, which can occur when lactose concentration exceeds its solubility limit, particularly in products like sweetened condensed milk or improperly processed ice cream.

74. Correct Answer: B

Sweetened condensed milk contains a large amount of added sugar; combined with water removal, the resulting high sugar concentration (low water activity) inhibits microbial growth, allowing shelf stability without full sterilization.

75. Correct Answer: B

Evaporated milk, which contains little or no added sugar, achieves shelf stability through sterilization: it is sealed in its can and then heat-processed (retorted) to destroy microorganisms and enzymes.

76. Sample/Acceptable Answer:

Sweetened condensed milk contains a large amount of added sugar along with water removed by evaporation, while evaporated milk contains little to no added sugar. Sweetened condensed milk achieves shelf stability through its high sugar concentration, which creates a low-water-activity environment that inhibits microbial growth, without requiring full sterilization. Evaporated milk, lacking this high sugar content, instead achieves shelf stability through sterilization: after being concentrated and sealed in its can, it is heat-processed (retorted) to destroy microorganisms and enzymes that would otherwise cause spoilage.

77. Correct Answer: B

Multiple component pricing pays farmers based on the actual fat, protein, and other solids content of their milk, not simply its total volume, reflecting the differing processing value of milk components.

78. Correct Answer: B

The Babcock test uses sulfuric acid to digest non-fat milk solids and centrifugation to separate and measure the resulting fat layer, providing a standardized measurement of milk fat percentage.

79. Correct Answer: A

Like the Babcock test, the Gerber test uses sulfuric acid (along with amyl alcohol and centrifugation) to dissolve non-fat solids and isolate milk fat for measurement.

80. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Answers will vary depending on the method chosen; award full credit for an accurate, detailed explanation covering all three required parts. Sample answer (Pasteurization): (1) Pasteurization heats raw milk to a specific temperature for a specific time (e.g., 72°C for 15 seconds, HTST) to accomplish destruction of pathogenic microorganisms. (2) The underlying principle is thermal inactivation of proteins in microbial cells -- heat denatures essential enzymes and structural proteins in bacteria, killing or inactivating them, while the carefully chosen time/temperature combination is selected to achieve this pathogen reduction while minimizing damage to milk's own proteins, flavor, and nutrients. (3) Pasteurization is critically important because it prevents transmission of dangerous milk-borne diseases (historically including tuberculosis and brucellosis, and today pathogens like Salmonella, E. coli, and Listeria), extends shelf life, and gives consumers confidence in the safety of a widely consumed staple food; without it, milk-borne illness would be far more common, and milk's economic value and marketability as a safe food product would be significantly reduced. (Equivalent full credit applies for well-developed answers on titratable acidity, the Babcock/Gerber test, or SCC testing, covering the same three required components.)

SCIENCE OLYMPIAD
FOOD SCIENCE – DIVISION B
National Tournament Written Exam – Honors Level

Team Name: _____ Team Number: _____

- This exam contains 80 questions: 60 multiple choice, 5 multiselect (select ALL correct answers), 10 short answer, and 5 long answer.
- Ten questions (Q2, Q14, Q20, Q26, Q38, Q40, Q48, Q50, Q60, Q62) require you to analyze an image or graph. These images are provided in a separate Image Packet handed out with this exam - refer to the numbered image indicated in each question.
- For multiple choice questions, circle the ONE best answer. For multiselect questions, circle ALL letters that apply - there may be more than one correct answer. For short answer questions, write a concise response in the space provided. For long answer questions, write a complete, multi-part response addressing every part of the prompt in the larger space provided.
- This exam covers ONLY the dairy food science test topics identified in Section 3 of the event rules (the same test-topic list used at Regional, State, and National tournaments per the 2027 Rules).
- Total Time: 50 minutes (shared with lab tasks per event rules; National Tournament teams complete all Lab Tasks). No resource sheet permitted on this portion unless otherwise instructed by the Event Supervisor.

1. Which classic dairy laboratory test uses infrared (Mid-IR) spectroscopy to rapidly measure a milk sample's fat, protein, and lactose content simultaneously?

A. Babcock test
B. Gerber test
C. Mid-infrared (Mid-IR) spectroscopic analysis
D. Standard Plate Count

2. Refer to Image 1, a photograph of Emmental (Swiss) cheese. The characteristic round holes ("eyes") in this cheese are traditionally attributed to carbon dioxide gas produced by which type of bacteria during ripening?



Image 1

A. Lactobacillus acidophilus
B. Propionibacterium (propionic acid bacteria)
C. Penicillium roqueforti
D. Streptococcus thermophilus alone

3. The propionic acid fermentation responsible for Swiss cheese eyes also contributes to the cheese's flavor by producing which two byproducts, in addition to CO_2 gas?

A. Propionic acid and acetic acid
B. Ethanol and methane
C. Citric acid and butter
D. Casein and whey

4. Explain, at a basic level, why Swiss-type cheeses like Emmental develop characteristic round holes ("eyes") during aging, and why cheese without these holes is sometimes called "blind."

5. Which term describes a cheese rind formed primarily by surface mold growth, giving cheeses like Brie and Camembert their characteristic soft white exterior?

A. Washed rind
B. Bloomy rind
C. Natural rind
D. Waxed rind

6. Which mold species is primarily responsible for the white, velvety bloomy rind on cheeses like Brie and Camembert?

A. Penicillium roqueforti
B. Penicillium camemberti
C. Aspergillus niger
D. Rhizopus oryzae

7. As a bloomy-rind cheese like Brie ripens, enzymes produced by the surface mold break down proteins and fats primarily from the:

A. Center of the cheese inward, evenly throughout
B. Outside (rind) toward the center, giving Brie its characteristic gradient of ripeness
C. Bottom of the cheese only
D. Nowhere; bloomy-rind cheeses do not ripen at all

8. Select ALL statements that are TRUE about bloomy-rind cheeses such as Brie and Camembert. (Select ALL that apply.)

A. They ripen from the outside (rind) inward.
B. Their rind is edible and is intentionally cultivated as part of the cheesemaking process.
C. Penicillium camemberti is typically responsible for their characteristic white rind.
D. They become firmer and less creamy the longer they ripen past peak ripeness.
E. They are hard, aged cheeses with very low moisture content.

9. "Washed rind" cheeses are periodically rinsed during aging with brine, wine, or other liquid, which encourages the growth of a bacterium responsible for their strong aroma and orange-tinted rind. This bacterium is:

A. Lactobacillus bulgaricus
B. Brevibacterium linens
C. Propionibacterium freudenreichii
D. Penicillium camemberti

10. Cheddaring, a step unique to cheddar-style cheesemaking, involves repeatedly cutting, stacking, and turning slabs of curd. The primary purpose of this process is to:

A. Add flavoring ingredients
B. Mechanically expel additional whey and develop the cheese's characteristic fibrous texture
C. Introduce mold spores
D. Pasteurize the curd a second time

11. Under FDA regulations, which product category allows manufacturers to use emulsifying salts and a broader range of ingredients not permitted in natural cheese, resulting in products like American cheese singles?

A. Aged cheddar
B. Pasteurized process cheese (cheese food/cheese product)
C. Raw milk cheese
D. Farmstead cheese

12. Explain the general difference between "natural cheese" and "pasteurized process cheese" (such as American cheese singles) in terms of ingredients and production, and describe ONE practical advantage of process cheese.

13. Salt added during cheesemaking serves several functions. Which of the following is NOT a typical function of salt in cheese?

A. Controlling moisture content by drawing out whey
B. Slowing the growth of unwanted spoilage bacteria
C. Contributing to flavor
D. Increasing the cheese's lactose content

14. Refer to Image 2, a photograph of Brie cheese showing its soft white bloomy rind. Which enzyme-producing organism is primarily responsible for creating this rind and contributing to Brie's characteristic ripening?



Image 2

A. Penicillium roqueforti
B. Penicillium camemberti
C. Lactobacillus casei
D. Saccharomyces cerevisiae

15. Compared to fresh, unripened Brie, fully ripened Brie is generally:

A. Firmer and drier
B. Softer, creamier, and more pungent in flavor
C. Identical in texture and flavor
D. Higher in lactose content

16. Compare and contrast bloomy-rind cheeses (such as Brie, ripened by Penicillium camemberti) and blue cheeses (such as Roquefort, ripened by Penicillium roqueforti). In your answer: describe how each type of mold is introduced and where it grows in/on the cheese, explain how each affects the direction and pattern of ripening, and describe ONE difference in the resulting flavor or texture between the two cheese types.

17. "Farmstead cheese" is a marketing/production term referring to cheese made:

A. Using only imported milk from other countries
B. On the same farm where the milk-producing animals are raised, using that farm's own milk
C. Exclusively from goat's milk
D. Using entirely synthetic ingredients

18. A cheese labeled with a Protected Designation of Origin (PDO), such as Parmigiano-Reggiano, legally means:

A. The cheese can be produced anywhere in the world using the same recipe
B. The cheese must be produced in a specific geographic region following defined traditional methods to use that name
C. The cheese contains no animal products
D. The cheese has no minimum aging requirement

19. Which of the following cheeses is an example of a PDO-protected cheese that must be produced in a specific region of Italy using traditional methods?

A. American cheese
B. Parmigiano-Reggiano
C. Generic mozzarella string cheese
D. Processed cheese spread

20. Refer to Image 3, a photograph of the mozzarella stretching (pasta filata) process. Describe what physically happens to the cheese curd's protein structure during this hot-water stretching process, and explain how this creates mozzarella's characteristic fibrous, stringy texture.



Image 3

21. Which of the following is an example of a "pasta filata" (stretched-curd) cheese, made using the same hot-water stretching technique as mozzarella?

A. Cheddar
B. Provolone
C. Brie
D. Roquefort

22. String cheese, a popular snack product, exploits mozzarella's aligned protein fiber structure because this structure allows the cheese to:

A. Melt instantly at room temperature
B. Be peeled apart into strings along the direction the fibers were stretched
C. Dissolve completely in water
D. Never be sliced or cut

23. Which of the following best describes "ultra-filtered" milk, a newer dairy product marketed for its higher protein and lower sugar content compared to regular milk?

A. Milk that has been filtered to remove all fat
B. Milk processed through a membrane filtration system that concentrates protein while reducing lactose (sugar) content
C. Milk boiled to remove water
D. Milk with artificial protein powder added

24. Select ALL statements that are TRUE about ultra-filtration as applied to milk processing. (Select ALL that apply.)

A. It uses a membrane to separate milk components based largely on molecular size.
B. It can be used to increase a milk product's protein concentration relative to its lactose content.
C. It requires boiling the milk at high temperatures.

D. It is a type of membrane filtration technology, related to microfiltration and reverse osmosis.

E. It destroys all protein in the milk.

25. Reverse osmosis (RO), sometimes used in dairy processing, differs from ultra-filtration primarily in that RO membranes:

A. Have larger pores that let protein and lactose pass through freely

B. Have extremely small pores that block nearly all dissolved solutes, allowing mostly only water to pass through

C. Cannot be used with any liquid other than milk

D. Only filter out bacteria, not dissolved solids

26. Refer to Image 4, a photograph of milk being pasteurized at a dairy using industrial heat-exchange equipment. This type of equipment (a plate heat exchanger) heats milk efficiently by:



Image 4

A. Submerging milk directly in an open flame

B. Passing milk and a hot fluid through separate, closely spaced thin metal plates, maximizing surface area for rapid heat transfer

C. Freezing the milk first, then thawing it

D. Adding chemical preservatives instead of heat

27. A key advantage of plate heat exchangers over older batch (vat) pasteurization methods is that plate heat exchangers:

A. Allow continuous, high-volume, energy-efficient processing of milk

B. Cannot achieve the temperatures required for pasteurization

C. Require far more time to process the same volume of milk

D. Eliminate the need for any temperature monitoring

28. Explain why a large surface area between milk and the heating medium (such as in a plate heat exchanger) allows for faster, more efficient pasteurization compared to heating milk in a single large batch tank.

29. UHT aseptic packaging technology (such as Tetra Pak cartons) allows shelf-stable milk to be stored without refrigeration primarily because the process combines UHT sterilization with:

A. Packaging the sterilized milk into a sterile, airtight container under sterile conditions, preventing recontamination
B. Adding chemical preservatives to the carton
C. Leaving the package open to air
D. Freezing the package after filling

30. Which of the following best explains why aseptically packaged UHT milk can be stored unrefrigerated for months, while HTST-pasteurized milk in a normal carton cannot?

A. UHT milk contains added preservatives that HTST milk lacks
B. The combination of higher heat treatment AND aseptic (sterile) packaging prevents any microbial recontamination after processing, unlike standard HTST packaging
C. UHT milk contains no lactose
D. There is no real difference between the two

31. Cultured (or "ripened") butter differs from standard sweet cream butter in that cultured butter is made by:

A. Adding artificial butter flavoring
B. Fermenting the cream with lactic acid bacteria before churning, developing a more complex, tangy flavor
C. Using only skim milk
D. Omitting the churning step entirely

32. Compare sweet cream butter and cultured butter: describe the key difference in how each is produced, explain how this difference affects flavor, and discuss why cultured butter has historically been more common in parts of Europe while sweet cream butter has been more common in the United States.

33. Traditional buttermilk was historically defined as:

A. Milk with butter blended into it
B. The liquid left over after churning cream into butter

C. A synthetic dairy substitute
D. Milk with baking soda added

34. Modern "cultured buttermilk" sold in stores today is produced differently from traditional buttermilk. Modern cultured buttermilk is made by:

A. Collecting the leftover liquid from butter churning, as in the traditional method
B. Adding lactic acid bacteria cultures directly to pasteurized skim or low-fat milk to ferment and thicken it
C. Removing all bacteria from traditional buttermilk
D. Mixing butter directly into whole milk

35. In baking, buttermilk (or buttermilk powder) is often used because its acidity reacts with baking soda to:

A. Prevent the batter from rising at all
B. Produce carbon dioxide gas, which helps leaven (raise) baked goods
C. Turn the batter a different color only
D. Destroy the gluten structure completely

36. Explain the chemical reaction that occurs when buttermilk (or another acidic dairy ingredient) is combined with baking soda in a baking recipe, and describe the practical effect this reaction has on the finished baked good.

37. Crème fraîche, a soured cream product popular in French cooking, differs from American-style sour cream primarily in its:

A. Complete absence of dairy ingredients
B. Higher fat content and slightly less tangy flavor
C. Bright blue color
D. Use of only skim milk

38. Refer to Image 5, a photograph of buttons made from Galalith, an early 20th-century plastic. Galalith is produced through a chemical reaction between casein and which compound, which cross-links and hardens the protein into a durable plastic material?



Image 5

A. Formaldehyde
B. Sulfuric acid
C. Sodium hydroxide
D. Rennet

39. Before the widespread availability of modern petroleum-based plastics, casein-based plastics like Galalith were commonly used to manufacture small items such as buttons, buckles, and knitting needles because casein plastic is:

A. Extremely flammable and unstable
B. Hard, durable, and can be dyed in a wide range of colors
C. Edible and intended to be eaten
D. Only available in a single color, black

40. Refer to Image 6, a photograph of sour cream. Select ALL statements that are TRUE about sour cream production and composition. (Select ALL that apply.)



Image 6

A. Sour cream is produced by fermenting cream with lactic acid bacteria cultures.
B. The fermentation process lowers the cream's pH and thickens its texture.
C. Sour cream typically has a higher fat content than fat-free milk.
D. Sour cream is produced without any bacterial culture at all.
E. The tangy flavor of sour cream comes primarily from lactic acid produced during fermentation.

41. Which of the following distinguishes "ice milk," a legacy dairy dessert category, from standard ice cream?

A. Ice milk contains a higher percentage of milkfat than ice cream
B. Ice milk contains a lower percentage of milkfat than ice cream
C. Ice milk contains no dairy ingredients at all
D. There is no compositional difference

42. In the U.S., the historical "ice milk" labeling category has largely been replaced by which modern labeling term for lower-fat frozen dairy desserts?

A. "Light" or "low-fat" ice cream
B. "Non-dairy" ice cream
C. "Raw" ice cream
D. "Organic" ice cream exclusively

43. Which of the following dairy products generally has the LEAST regulatory milkfat requirement among the options listed?

A. Butter
B. Ice cream
C. Milkshake/soft-serve mix
D. Heavy cream

44. Explain why cheese labeled "imitation cheese" or a "cheese analog" might use vegetable oil in place of some or all of the milkfat found in natural cheese, and describe ONE reason a food manufacturer might choose to use a cheese analog instead of natural cheese in a product.

45. Shredded cheese sold in bags is often coated with a small amount of cellulose powder (or similar anti-caking agent) primarily to:

A. Add flavor
B. Prevent the shredded pieces from clumping together in the bag
C. Increase the cheese's fat content
D. Replace the need for refrigeration

46. Shredded cheese packages are often flushed with nitrogen gas (modified atmosphere packaging) instead of leaving normal air inside primarily to:

A. Add flavor compounds
B. Displace oxygen, slowing mold growth and oxidation to extend shelf life
C. Increase the cheese's moisture content
D. Speed up spoilage intentionally

47. Gouda and Edam cheeses are traditionally coated in a layer of colored wax primarily to:

A. Add flavor to the cheese
B. Create an airtight barrier that prevents moisture loss and protects the cheese from mold and contamination during aging/storage
C. Speed up the aging process
D. Replace the need for salt

48. Refer to Image 7, a photograph of fresh cheese curds. Fresh curds are famous for "squeaking" against the teeth when bitten, but this squeak fades within days. Explain, at the level of protein structure, why fresh curds squeak, describe what changes in the cheese over time that causes the squeak to disappear, and explain why this makes curd freshness difficult to preserve during shipping/storage.



Image 7

49. Which of the following dairy starter culture types grow and ferment optimally at warmer temperatures (around 40-45°C), such as those used in yogurt production?

A. Mesophilic cultures
B. Thermophilic cultures
C. Psychrophilic cultures
D. Rennet cultures (not a bacterial culture type)

50. Refer to Image 8, a simplified schematic diagram of a reverse osmosis system. Applied to dairy processing (such as concentrating milk or whey before spray drying), reverse osmosis works by using pressure to:

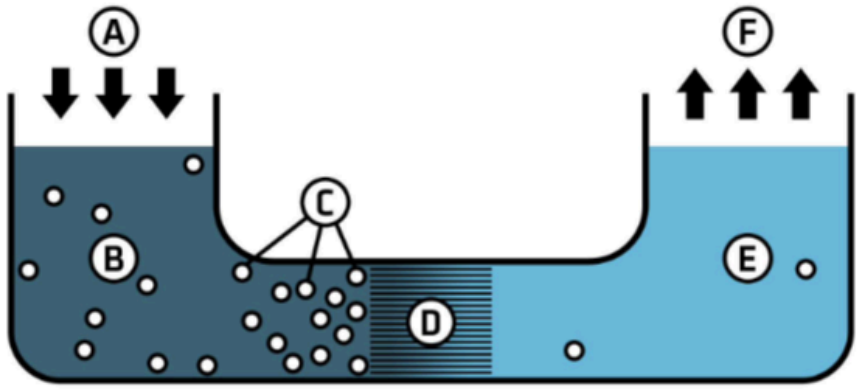


Image 8

A. Force water molecules through a semi-permeable membrane, leaving behind a more concentrated solution of milk solids

B. Add extra water to dilute the milk

C. Heat the milk until all water evaporates

D. Freeze the milk solid

51. Compared to evaporation (heat-based concentration), using reverse osmosis to pre-concentrate milk or whey before spray drying offers which advantage?

A. It requires much higher heat, improving flavor

B. It can concentrate the product with less heat exposure, helping preserve heat-sensitive nutrients and flavor

C. It cannot be used with any dairy liquid

D. It always produces a less concentrated final product

52. Explain the basic physical principle of osmosis, and describe how reverse osmosis "reverses" this natural process to concentrate a dairy liquid such as milk or whey.

53. The term "withdrawal period," relevant to antibiotic use in dairy cattle, refers to:

A. The time a farmer must wait after treating a cow with antibiotics before that cow's milk can legally be sold for human consumption

B. The time it takes to milk a cow

C. The shelf life of pasteurized milk

D. The time required to age a cheese

54. Maximum Residue Level (MRL), a term used in dairy food safety regulation, refers to:

A. The maximum amount of milk a single cow can produce per day

B. The legal upper limit for the concentration of a substance (such as an antibiotic) permitted to remain in a food product

C. The maximum number of cows allowed on a dairy farm

D. The maximum fat percentage allowed in whole milk

55. Why are dairy processors required to test raw milk for antibiotic residues before accepting it for processing?

A. Antibiotic residues improve milk's flavor

B. Antibiotic residues in milk can pose health risks to sensitive consumers and can interfere with the bacterial starter cultures needed to ferment cheese, yogurt, and other cultured products

C. Antibiotics increase milk's shelf life, so testing ensures enough is present

D. Federal law has no requirements regarding antibiotics in milk

56. Select ALL statements that are TRUE about antibiotic residue testing in the dairy industry. (Select ALL that apply.)

A. Rapid microbial inhibition tests (such as Delvotest) are commonly used to screen milk for antibiotic residues before processing.

B. Antibiotic residues in milk can inhibit the bacterial starter cultures used to make cheese and yogurt.

C. Dairy farmers have no legal obligation to observe a withdrawal period after treating a cow with antibiotics.

D. A positive antibiotic residue test can result in an entire tanker load of milk being rejected.

E. Antibiotic residues are never a food safety or regulatory concern in the dairy industry.

57. Which type of infant formula is designed for infants with an allergy or sensitivity to intact cow's milk protein, using protein that has been broken down into smaller fragments?

A. Standard cow's milk-based formula

B. Hydrolyzed (partially or extensively hydrolyzed) formula

C. Whole milk

D. Evaporated milk formula

58. Whey protein is often used as a primary protein source in standard infant formula (rather than casein-dominant cow's milk protein alone) because whey's amino acid profile and digestibility are considered:

A. Closer to that of human breast milk than cow's milk's natural casein-dominant profile

B. Identical to soy protein

C. Completely indigestible for infants

D. Irrelevant to infant nutrition

59. "Extensively hydrolyzed" infant formulas break down milk proteins into very small peptide fragments primarily to:

A. Increase the formula's fat content
B. Reduce the likelihood of triggering an allergic immune response to intact milk proteins
C. Add extra lactose
D. Make the formula taste sweeter

60. Refer to Image 9, a photograph of a container of infant formula. Explain why standard cow's-milk-based infant formula must be modified from ordinary cow's milk before it is considered safe and appropriate for young infants, describing at least TWO specific compositional changes typically made.



Image 9

61. Which of the following is a reason some Kosher dietary certification standards restrict the type of rennet that can be used in cheesemaking?

A. Rennet has no relevance to Kosher dietary law
B. Traditional animal rennet is derived from the stomach lining of animals, and Kosher law has specific requirements about the source and slaughter method of animal-derived ingredients
C. Kosher law forbids all dairy products entirely
D. Rennet always contains gluten

62. Refer to Image 10, an image related to antibiotic residue testing across the dairy value chain. Rapid antibiotic screening tests (such as Delvotest) work by observing whether a milk sample:

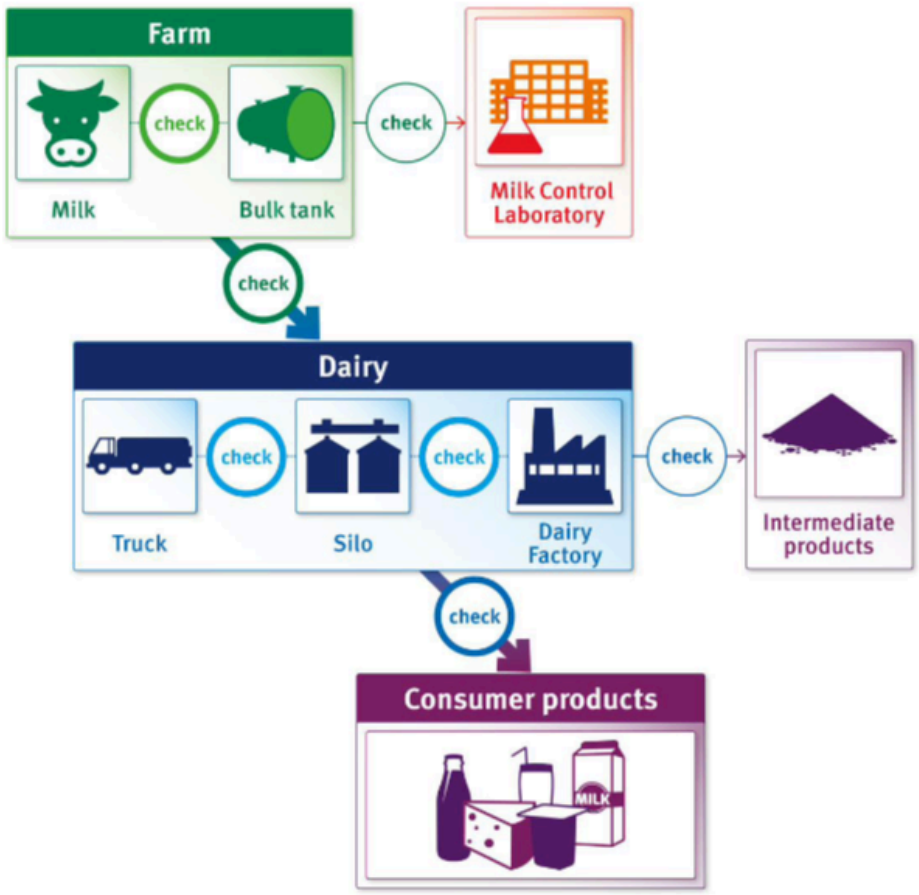


Image 10

A. Changes color when exposed to sunlight

B. Inhibits the growth of a standardized test bacterium, indicating the presence of antibiotic residues

C. Freezes at a different temperature than normal milk

D. Produces more cream than untreated milk

63. If a milk sample inhibits bacterial growth in a Delvotest-style microbial inhibition assay, this result suggests that the sample:

A. Is completely free of antibiotic residues

B. May contain antibiotic residues above a detectable threshold, warranting further testing or rejection

C. Has an unusually high fat content

D. Has been successfully pasteurized

64. Discuss the dairy industry's multi-layered approach to preventing antibiotic residues from reaching consumers. In your answer: explain the purpose of a withdrawal period, describe how rapid on-farm or receiving-dock screening tests (such as Delvotest) are used, and explain what happens (from both a food-safety and an economic standpoint) when a raw milk sample tests positive for antibiotic residues.

65. Cheese yield (the amount of finished cheese produced from a given volume of milk) is most directly influenced by the milk's:

A. Color and temperature only
B. Fat and protein (casein) content
C. Lactose content alone
D. Vitamin D content

66. All else being equal, milk with a HIGHER fat and casein protein content will generally produce:

A. A lower cheese yield per unit of milk
B. A higher cheese yield per unit of milk
C. No change in cheese yield
D. Only affects cheese color, not yield

67. Milk protein-based paint, an early form of paint used historically (including by some old master painters and in early American folk art), was made using:

A. Casein combined with lime or another alkaline binder
B. Whey combined with vegetable oil only
C. Pure lactose crystals
D. Rennet dissolved in water

68. Describe ONE historical, non-food application of milk proteins (such as casein), and briefly explain the chemical property of the protein that made it useful for that application.

69. Compared to natural cheese, imitation/analog cheese products made with vegetable oil generally lack which nutritionally significant dairy fat component naturally found in milkfat?

A. Conjugated linoleic acid (CLA)
B. Sucrose

C. Gluten
D. Vitamin C

70. A cheese labeled "raw milk cheese" that is legally sold at retail in the United States must, under federal law, generally be:

A. Aged for at least 60 days
B. Sold within 24 hours of production
C. Made without any bacterial culture
D. Frozen immediately after production

71. The 60-day aging requirement for raw-milk cheese sold in the U.S. is intended to:

A. Improve the cheese's color only
B. Allow time for the cheese's naturally developing acidity and other factors to reduce the risk of harmful pathogens surviving in the final product
C. Increase the cheese's lactose content
D. Have no food-safety purpose; it is purely a flavor preference

72. Select ALL statements that are TRUE about raw-milk (unpasteurized) cheese production in the United States. (Select ALL that apply.)

A. Federal law generally requires such cheese to be aged at least 60 days before retail sale.
B. Raw-milk cheese carries zero food safety risk compared to pasteurized-milk cheese.
C. The 60-day aging rule is intended to reduce (though not eliminate) the risk of pathogens surviving in the final product.
D. Some soft, high-moisture raw-milk cheeses are considered higher risk and are more strictly regulated or restricted.
E. All fifty U.S. states have identical raw-milk cheese regulations.

73. Which of the following organisms is commonly used to help produce lactase enzyme commercially, which is then added to milk to make lactose-free dairy products?

A. Kluyveromyces lactis (a yeast)
B. Penicillium roqueforti
C. Escherichia coli exclusively
D. Saccharomyces cerevisiae only, never other organisms

74. Commercially produced lactase enzyme, rennet (via fermentation-produced chymosin), and some cheese cultures are all examples of dairy processing aids that are:

A. Produced through industrial fermentation using selected, controlled microorganisms
B. Extracted exclusively from cow's milk itself
C. Entirely synthetic chemicals with no biological origin
D. Illegal for use in U.S. food production

75. Buttermilk powder, a dried dairy ingredient used in commercial baking, is valued in bread and cracker formulas partly because it:

A. Has no effect on dough or baked texture
B. Contributes to browning (via Maillard reaction with its lactose and protein) and can improve dough's water absorption and texture
C. Prevents any browning from occurring

D. Contains no lactose or protein at all

76. Explain why buttermilk powder (or nonfat dry milk) added to a bread dough formula can improve the crust's browning color during baking, referencing a specific chemical reaction.

77. "Recombined" or "reconstituted" milk, sometimes used in regions without a reliable fresh milk supply, is produced by:

A. Mixing milk powder, water, and sometimes milkfat back together to approximate fresh liquid milk

B. Never mixing any ingredients; it is only ever fresh raw milk

C. Adding artificial flavoring to soda water

D. Combining two different types of cheese

78. A key food-science advantage of recombined/reconstituted milk products in regions with limited refrigerated transport infrastructure is that:

A. Milk powder is shelf-stable and can be shipped and stored without refrigeration, then reconstituted with local water close to the point of consumption

B. Milk powder spoils faster than fresh milk

C. Milk powder cannot be safely reconstituted

D. There is no practical advantage compared to shipping fresh liquid milk

79. Nonfat dry milk added to bread dough (beyond its browning contribution) also improves dough structure primarily because its proteins:

A. Compete with wheat gluten and weaken dough structure

B. Help strengthen the dough's gas-holding capacity and improve water absorption, supporting a better texture and rise

C. Have no interaction with the dough's other ingredients

D. Convert gluten protein into starch

80. Synthesize your understanding of dairy food science by choosing ONE non-cheese dairy ingredient or process discussed on this exam -- such as buttermilk powder in baking, reverse osmosis concentration, UHT aseptic packaging, or recombined/reconstituted milk -- and explain: (1) the underlying food-science principle involved, (2) a specific practical application of this ingredient/process in the food industry, and (3) ONE advantage this ingredient/process provides compared to a simpler or more traditional alternative.

ANSWER KEY

FOOD SCIENCE – DIVISION B – NATIONAL EXAM (FORM 2)

1. Correct Answer: C

Modern Mid-IR spectroscopic analyzers can rapidly and simultaneously measure fat, protein, and lactose content in milk, largely replacing slower wet-chemistry methods like Babcock or Gerber for routine testing.

2. Correct Answer: B

Propionic acid bacteria, notably Propionibacterium freudenreichii, ferment compounds in the cheese and release CO2 gas, which slowly collects into the characteristic round "eyes" as the cheese ages.

3. Correct Answer: A

Propionic acid bacteria produce propionic acid and acetic acid as byproducts of fermentation, contributing to Swiss cheese's characteristic nutty, slightly sweet flavor.

4. Sample/Acceptable Answer:

Propionic acid bacteria added during cheesemaking ferment compounds in the cheese and release carbon dioxide gas as a byproduct during the cheese's warm aging/ripening period. Because the cheese's protein matrix is elastic enough to trap the gas without cracking, the CO2 slowly collects into pockets that form smooth, round eyes as the cheese ages. Cheese that lacks these characteristic holes (due to a different culture, gas escaping, or different processing conditions) is informally called "blind."

5. Correct Answer: B

A bloomy rind is a soft, white, fuzzy rind formed by surface mold growth, characteristic of cheeses like Brie and Camembert.

6. Correct Answer: B

Penicillium camemberti is the mold species cultivated on the surface of Brie and Camembert to create their characteristic bloomy white rind.

7. Correct Answer: B

Bloomy-rind cheeses ripen from the outside inward, since the mold and its enzymes are concentrated at the surface, creating a gradient from soft, ripe cheese near the rind to firmer, less-ripe cheese toward the center.

8. Correct Answers: A, B, C

Bloomy-rind cheeses ripen outside-in, have an intentionally cultivated edible rind, and rely on Penicillium camemberti. They generally become softer/runnier (not firmer) and can develop ammonia off-flavors past peak ripeness, and they are soft, high-moisture cheeses, not hard/low-moisture ones.

9. Correct Answer: B

Brevibacterium linens thrives on the moist, salty surface created by washing, producing the strong aroma and orange color characteristic of washed-rind cheeses.

10. Correct Answer: B

Cheddaring mechanically presses out additional whey and aligns/develops the curd's protein structure, giving cheddar its characteristic dense, fibrous texture.

11. Correct Answer: B

Pasteurized process cheese (and related categories like cheese food and cheese product) permits emulsifying salts and other ingredients not allowed in natural cheese, enabling smooth, consistent, shelf-stable products like American cheese singles.

12. Sample/Acceptable Answer:

Natural cheese is made directly from milk through fermentation, coagulation, and aging with minimal additional ingredients, while pasteurized process cheese is made by blending one or more natural cheeses

with emulsifying salts (and sometimes additional dairy ingredients, water, or flavorings), then heating the mixture until it melts into a smooth, homogeneous product. A practical advantage of process cheese is that it has a longer shelf life, melts more smoothly and consistently, and has a more uniform texture and flavor than many natural cheeses, making it well suited to food service and packaged product applications.

13. Correct Answer: D

Salt controls moisture, slows spoilage organisms, and contributes flavor, but it does not add lactose to cheese.

14. Correct Answer: B

Penicillium camemberti is cultivated on the surface of Brie to form its bloomy rind and drive its characteristic outside-in ripening.

15. Correct Answer: B

As bloomy-rind cheeses ripen, enzymatic breakdown of proteins and fats produces a softer, creamier texture and a more pungent, complex flavor.

16. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Bloomy-rind mold (Penicillium camemberti) is cultivated as a surface layer, typically sprayed onto or introduced at the exterior of the cheese after it is formed, and grows as a rind on the outside; this causes the cheese to ripen from the outside inward, creating a soft, gradually softening interior as ripening progresses. Blue cheese mold (Penicillium roqueforti) is mixed into the curd or injected into the cheese's interior, and grows along air channels created by piercing the cheese with needles or skewers (since the mold requires oxygen); this causes ripening to occur from the inside via these internal veins outward toward the surface. In terms of resulting differences, bloomy-rind cheeses develop a soft, creamy, spreadable texture with a mild, buttery, mushroom-like flavor, while blue cheeses develop a more crumbly texture with a sharp, tangy, pungent flavor, due in part to the breakdown of fats into free fatty acids by Penicillium roqueforti.

17. Correct Answer: B

Farmstead cheese is made on the same farm where the milk-producing animals are raised, using milk from that farm's own herd.

18. Correct Answer: B

PDO status legally restricts a cheese name to products made in a specific geographic region using defined traditional production methods.

19. Correct Answer: B

Parmigiano-Reggiano is a classic example of a PDO-protected cheese, legally restricted to production in a defined region of Italy using traditional methods.

20. Sample/Acceptable Answer:

During the pasta filata process, curd is submerged in very hot water (roughly 60-90°C) and repeatedly pulled, folded, and kneaded. The heat and mechanical working cause casein protein strands to align and stretch into long, parallel fibers, similar to how kneading aligns gluten strands in bread dough. This protein alignment is what gives mozzarella its characteristic stretchy, fibrous, stringy texture when pulled or melted, distinguishing it from cheeses made without this stretching step.

21. Correct Answer: B

Provolone is another well-known pasta filata (stretched-curd) cheese, produced using the same hot-water stretching technique as mozzarella.

22. Correct Answer: B

Because pasta filata stretching aligns casein fibers in one direction, string cheese can be peeled apart into long strings along that alignment.

23. Correct Answer: B

Ultra-filtered milk is produced using membrane filtration technology that separates and concentrates milk protein while allowing more of the lactose (and water) to be removed, resulting in a naturally higher-protein, lower-sugar product.

24. Correct Answers: A, B, D

Ultra-filtration is a membrane-based, size-selective filtration technology related to microfiltration and reverse osmosis that can concentrate protein relative to lactose. It does not require boiling, and it does not destroy the protein it concentrates.

25. Correct Answer: B

RO membranes have much smaller effective pore sizes than ultra-filtration membranes, blocking nearly all dissolved solutes (including lactose and minerals) and allowing mostly water to pass through, making RO useful for general concentration rather than selective protein separation.

26. Correct Answer: B

A plate heat exchanger passes milk and a heating (or cooling) fluid through alternating thin channels formed by closely spaced metal plates, maximizing surface area for fast, efficient heat transfer.

27. Correct Answer: A

Plate heat exchangers enable continuous-flow processing of large volumes of milk efficiently, unlike slower batch (vat) pasteurization.

28. Sample/Acceptable Answer:

Heat transfer rate depends on the surface area available for heat exchange, along with the temperature difference between the two fluids. A plate heat exchanger spreads milk into many thin layers across a large total plate surface area in contact with a heating fluid, dramatically increasing the rate of heat transfer compared to a single large batch of milk in a tank, where only the outer surface (and slow internal mixing/convection) transfers heat. This allows milk to reach pasteurization temperature very quickly and continuously, improving efficiency and consistency compared to slower batch heating.

29. Correct Answer: A

Aseptic UHT packaging combines high-heat sterilization with filling into a pre-sterilized, airtight container under sterile conditions, so no recontamination occurs after the sterilizing heat treatment, allowing long shelf-stable storage.

30. Correct Answer: B

It is the combination of more complete sterilization (UHT) and truly sterile, airtight packaging that prevents recontamination, not added preservatives, that allows extended unrefrigerated shelf life.

31. Correct Answer: B

Cultured butter is made by fermenting cream with lactic acid bacteria cultures before churning, developing more complex, tangy flavor compounds compared to sweet cream butter.

32. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Sweet cream butter is churned directly from fresh, unfermented cream, giving it a clean, mild, "sweet" dairy flavor, while cultured butter is made by first fermenting the cream with lactic acid bacteria cultures (similar to yogurt or sour cream cultures) for a period of time before churning, which produces lactic acid and aromatic compounds (such as diacetyl) that give cultured butter a more complex, tangy, slightly nutty flavor. Historically, before mechanical refrigeration was widely available, cream in many parts of Europe would naturally begin to sour/ferment during the time it took to collect enough cream for churning, making cultured butter the traditional style; in the United States, with earlier widespread adoption of refrigeration and centralized dairy processing, cream could be kept fresh and churned before natural souring occurred, making sweet cream butter the more common style.

33. Correct Answer: B

Traditional buttermilk was the liquid byproduct remaining after churning cream into butter.

34. Correct Answer: B

Modern cultured buttermilk is made by fermenting skim or low-fat milk with lactic acid bacteria cultures, rather than being a butter-churning byproduct.

35. Correct Answer: B

Buttermilk's acid reacts with the base baking soda to produce CO2 gas, which helps leaven baked goods.

36. Sample/Acceptable Answer:

Buttermilk's lactic acid reacts with baking soda (sodium bicarbonate, a base) in an acid-base neutralization reaction that produces carbon dioxide gas as a byproduct. As this CO2 gas forms and expands within the batter or dough, it creates small bubbles that help leaven (raise) the baked good, contributing to a lighter, more tender texture than would result without this reaction.

37. Correct Answer: B

Crème fraîche is generally made from a higher-fat cream than American sour cream, giving it a richer texture and a milder, less tangy flavor.

38. Correct Answer: A

Galalith is formed by reacting casein with formaldehyde, which cross-links the protein molecules into a hard, durable plastic material.

39. Correct Answer: B

Casein plastic is hard, durable, virtually nonflammable, and can be produced in a wide range of colors, making it well suited to manufacturing small decorative and functional objects.

40. Correct Answers: A, B, C, E

Sour cream is made by fermenting cream with lactic acid bacteria, which lowers pH, thickens the product, and produces its characteristic tangy lactic-acid flavor; it also has substantially more fat than fat-free milk. It is not produced without a bacterial culture.

41. Correct Answer: B

Ice milk historically contained a lower percentage of milkfat than standard ice cream.

42. Correct Answer: A

FDA labeling changes replaced the old "ice milk" category with "light" or "low-fat" ice cream terminology, which specifies the required fat/calorie reduction relative to regular ice cream.

43. Correct Answer: C

Milkshake and soft-serve mix products generally have far less stringent (or no specific) minimum milkfat requirements compared to the well-defined Standards of Identity for butter, ice cream, and heavy cream.

44. Sample/Acceptable Answer:

Cheese analogs substitute vegetable oil (such as palm or soybean oil) for some or all of the milkfat because vegetable oil is often less expensive than milkfat, has more consistent and controllable melting behavior, and does not require the same aging or dairy-specific processing that natural cheese does. A manufacturer might choose a cheese analog to reduce ingredient cost, achieve more predictable, uniform melting and stretch in a processed food product (such as frozen pizza), or extend shelf life, compared to using natural cheese.

45. Correct Answer: B

A light coating of cellulose or a similar anti-caking agent keeps shredded cheese pieces from sticking together in the package.

46. Correct Answer: B

Displacing oxygen with nitrogen slows aerobic mold growth and oxidative reactions, extending the shredded cheese's shelf life.

47. Correct Answer: B

A wax coating creates an airtight, moisture-retaining barrier that protects the cheese's rind from mold and contamination during aging and storage.

48. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Fresh cheese curds contain a still-intact, elastic protein matrix of casein strands that have not yet been broken down by aging enzymes or extensive proteolysis; when bitten, these elastic, fibrous protein strands rub against tooth enamel and vibrate, producing the characteristic squeaking sound. Over time (typically within days), naturally present enzymes and residual bacterial cultures continue to break down (proteolyze) this casein protein matrix, causing the structure to lose its elasticity and firmness; as the protein network relaxes and breaks down, the curd no longer vibrates against teeth in the same way, and the squeak fades. Because this protein breakdown begins immediately after the curd is formed and continues during storage and shipping (even under refrigeration), it is very difficult to preserve the fresh "squeak" for curds shipped any meaningful distance or held for more than a few days, which is why fresh squeaky curds are prized as a very locally sold, short-shelf-life specialty product.

49. Correct Answer: B

Thermophilic cultures (such as those used in yogurt) grow best at warmer temperatures, roughly 40-45°C, compared to mesophilic cultures, which prefer cooler temperatures around 20-30°C.

50. Correct Answer: A

Reverse osmosis applies pressure to force water molecules through a semi-permeable membrane, leaving a more concentrated milk or whey solution behind.

51. Correct Answer: B

Because reverse osmosis concentrates liquid using pressure rather than heat, it exposes the product to less thermal stress, helping preserve heat-sensitive nutrients and flavor compared to heat-based evaporation.

52. Sample/Acceptable Answer:

Osmosis is the natural movement of water molecules across a semi-permeable membrane from an area of lower solute concentration to an area of higher solute concentration, driven by the difference in osmotic pressure between the two sides, until concentrations equalize. Reverse osmosis "reverses" this natural direction by applying mechanical pressure greater than the natural osmotic pressure to the concentrated side (such as milk or whey), forcing water molecules to move backward through the membrane from the higher-concentration side to the lower-concentration (purified water) side, leaving behind a more concentrated milk or whey solution on the pressurized side.

53. Correct Answer: A

A withdrawal period is the required waiting time after antibiotic treatment before a treated animal's milk may legally re-enter the food supply, allowing residue levels to fall below regulatory limits.

54. Correct Answer: B

MRL is the legal upper limit for how much of a given substance (such as an antibiotic) may remain in a food product, including milk.

55. Correct Answer: B

Antibiotic residues can pose health risks (such as allergic reactions) to sensitive consumers, and can also inhibit the starter bacterial cultures needed for cheese and yogurt fermentation, making residue testing an important quality and safety control.

56. Correct Answers: A, B, D

Rapid screening tests are widely used, antibiotic residues can inhibit starter cultures, and a positive test can lead to an entire load being rejected. Farmers ARE legally required to observe withdrawal periods, and antibiotic residues ARE a genuine food safety/regulatory concern.

57. Correct Answer: B

Hydrolyzed infant formulas use milk protein broken down into smaller peptide fragments, reducing the likelihood of triggering an allergic response in sensitive infants.

58. Correct Answer: A

Whey protein's digestibility profile more closely resembles human breast milk than cow's milk's naturally casein-dominant protein profile, which is part of why formula manufacturers often adjust the whey-to-casein ratio.

59. Correct Answer: B

Breaking proteins into very small fragments reduces the chance that an infant's immune system will recognize and react to the larger, intact protein structures that typically trigger milk protein allergy.

60. Sample/Acceptable Answer:

Accept any two correct modifications, such as: whey protein is often added or the whey-to-casein ratio is adjusted to better resemble human breast milk's digestibility profile; lactose or other carbohydrates are adjusted to appropriate levels; the mineral content (such as sodium and potassium) is reduced compared to whole cow's milk, since infant kidneys cannot yet handle cow milk's naturally higher mineral load; and vitamins (such as Vitamin C, D, and iron) are added, since cow's milk alone does not provide adequate amounts of certain nutrients infants need. Ordinary cow's milk is not recommended for young infants because its unmodified protein, mineral, and nutrient profile is not well suited to an infant's immature digestive and kidney systems.

61. Correct Answer: B

Because traditional rennet is animal-derived, Kosher certification standards apply specific requirements about its source, which is part of why microbial or fermentation-produced chymosin is often preferred for certified Kosher cheese.

62. Correct Answer: B

Microbial inhibition tests like Delvotest expose a standardized bacterial culture to the milk sample; if the sample contains antibiotic residues, it will inhibit the bacteria's normal growth, producing a detectable result.

63. Correct Answer: B

Inhibited bacterial growth in this type of assay is a positive indicator that the milk sample may contain antibiotic residues, prompting further testing or rejection of the load.

64. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

A withdrawal period is the mandated waiting time after a cow is treated with antibiotics before her milk may legally be sold for human consumption, allowing antibiotic concentrations in the milk to fall below the legal Maximum Residue Level before that milk re-enters the food supply. As an additional safeguard beyond farmer compliance with withdrawal periods, rapid microbial inhibition screening tests (such as Delvotest) are run on every load or tanker of raw milk arriving at a processing plant before it is accepted; these tests expose a sample to a standardized bacterial culture and check whether antibiotic residues inhibit that culture's growth, providing a fast go/no-go result before the milk is mixed with other milk or processed further. If a raw milk sample tests positive, the load is typically rejected and cannot be used, protecting consumers from residues that could pose health risks or interfere with fermentation cultures used in downstream products like cheese and yogurt; economically, the farmer (or farmers, since a tanker often combines milk from multiple farms) who supplied the contaminated milk may bear significant financial loss from the rejected load, creating a strong incentive for strict adherence to withdrawal periods.

65. Correct Answer: B

Because cheese curd is primarily formed from coagulated casein protein with entrapped fat, milk's fat and casein protein content are the primary drivers of cheese yield.

66. Correct Answer: B

Milk richer in fat and casein protein generally yields more finished cheese per unit volume of milk processed, since these are the primary components retained in the curd.

67. Correct Answer: A

Historical casein paint was made by combining casein protein with an alkaline binder such as lime, which helps dissolve/activate the casein into a usable, durable paint medium.

68. Sample/Acceptable Answer:

Accept any correct historical application, such as: casein-based plastic (Galalith), made by reacting casein with formaldehyde to cross-link the protein into a hard, durable, moldable material used for buttons and small manufactured objects; or casein-based glue/adhesive, historically used in woodworking, which relies on casein's ability to form a strong, rigid bond as it dries; or casein-based paint, which uses casein (combined with an alkaline binder like lime) as a binder that hardens into a durable paint film as it dries. In each case, the useful property is casein's ability to denature/cross-link or harden into a strong, cohesive solid structure under the right chemical conditions.

69. Correct Answer: A

Because CLA is a bioactive fatty acid specific to ruminant dairy fat, cheese analogs made primarily with vegetable oil generally lack the CLA content naturally found in real dairy milkfat.

70. Correct Answer: A

Federal regulations generally require raw-milk cheese sold at retail to be aged at least 60 days, intended to reduce (though not eliminate) pathogen risk.

71. Correct Answer: B

The extended aging period allows natural acidification and other inhibitory conditions within the cheese to reduce (though not entirely eliminate) the survival of potentially harmful pathogens.

72. Correct Answers: A, C, D

The 60-day aging requirement exists and is meant to reduce (not eliminate) risk, and soft high-moisture raw-milk cheeses are considered higher risk. Raw-milk cheese does carry more risk than pasteurized-milk cheese, and state regulations on raw milk/raw-milk products vary rather than being identical nationwide.

73. Correct Answer: A

Kluyveromyces lactis, a yeast, is commonly used industrially to produce lactase enzyme for lactose-free dairy product manufacturing.

74. Correct Answer: A

Lactase, fermentation-produced chymosin, and many starter cultures are all produced through controlled industrial fermentation using selected microorganisms, rather than being extracted from milk or being synthetic chemicals.

75. Correct Answer: B

Buttermilk powder's lactose and protein support Maillard browning during baking and can improve dough's water absorption and texture.

76. Sample/Acceptable Answer:

Buttermilk powder (like other dried dairy ingredients) contains both protein (a source of amino acids) and lactose (a reducing sugar). During baking, these two components can react through the Maillard reaction -- a non-enzymatic browning reaction between amino acids and reducing sugars under heat -- which produces the golden-brown color and characteristic toasted flavor compounds seen on a well-browned crust.

77. Correct Answer: A

Recombined/reconstituted milk is made by mixing milk powder (and sometimes separately stored milkfat) with water to approximate the composition of fresh liquid milk.

78. Correct Answer: A

Because milk powder is shelf-stable without refrigeration, it can be transported and stored much more easily than fresh liquid milk, then reconstituted with local water near the point of consumption, which is especially valuable where cold-chain infrastructure is limited.

79. Correct Answer: B

Milk proteins added to dough can help strengthen the dough's structure and gas-holding capacity and improve water absorption, supporting better texture and rise, rather than weakening the gluten network.

80. Sample/Acceptable Answer (Long Answer – grade holistically for complete, accurate coverage of all parts):

Answers will vary depending on the ingredient/process chosen; award full credit for an accurate, detailed explanation covering all three required parts. Sample answer (UHT Aseptic Packaging): (1) UHT (Ultra-High-Temperature) processing sterilizes milk using very high heat for a very short time, and the milk is then filled into a package under sterile conditions so that no recontamination can occur after sterilization -- the underlying principle is complete microbial sterilization combined with an airtight barrier that prevents any new contamination. (2) A practical application is shelf-stable boxed milk (such as Tetra Pak cartons) sold unrefrigerated on grocery store shelves, widely used internationally and increasingly in the U.S. for extended-shelf-life dairy and plant-based beverages. (3) The key advantage compared to traditional HTST-pasteurized milk in a standard carton is that UHT aseptically packaged milk can be stored for months without refrigeration until opened, dramatically reducing cold-chain/refrigeration costs and food waste from spoilage, and making it far easier to distribute milk to regions or situations (such as emergency relief, school lunch programs, or areas with limited refrigerated transport) where consistent refrigeration is not guaranteed. (Equivalent full credit applies for well-developed answers on buttermilk powder in baking, reverse osmosis concentration, or recombined/reconstituted milk, covering the same three required components.)