
بسم الله الرحمن الرحيم
In The Name Of Allah, The Most Beneficent, The Most Merciful

رَبِّ زِدْنِي عِلْمًا

MY LORD! INCREASE ME IN KNOWLEDGE.

FOOD SAFETY AND QUALITY MANAGEMENT

DHND

YEAR-V

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L # 6. CHEMIICAL HAZARDS & FOOD SAFETY

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CHEMICAL HAZARDS: MYCOTOXINS

- Mycotoxins are **natural** toxins which are produced by **fungi** and can be **toxic** to humans and animals
- They are formed by **moulds** which grow on crops and foods under certain conditions
- There are number of **mycotoxins** present in the environment but only a few are found in foods and they are usually associated with particular field crops like **corn**

CHEMICAL HAZARDS: MYCOTOXINS

The most prominent mycotoxins which cause health concerns in humans are

- ***aflatoxin***
- ***deoxynivalenol***
- ***ochratoxin***
- ***fumonisin***
- ***patulin***

CHARACTERISTICS OF MYCOTOXINS

- Resistant to heat
- Produced by fungi as secondary metabolites in response to competitive pressures from other fungi/bacteria
- Can have antibiotic properties
- Can cause toxic damage to cells of humans and animals
- Can cause chronic effects such as various cancers, immunosuppression, growth retardation, birth defects, renal dysfunction
- Can have serious long-term effects even at small concentrations
- Usually associated with particular crops (i.e. corn, cereal crops, apples)

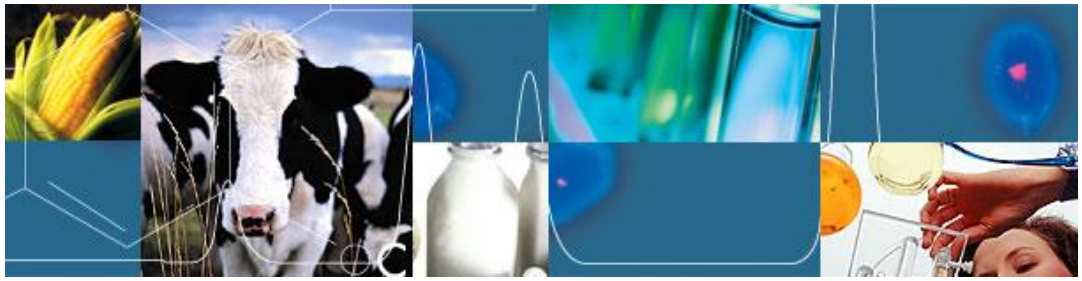
MYCOTOXINS STATISTICS

- **300-400 mycotoxins presently identified, with more becoming evident as new isolation techniques are used.**
- **Most frequent toxins present are aflatoxin, DON, ZEN, fumonisin, and T-2 toxin, to name a few.**

http://www.ars.usda.gov/incme/images/sitelogos/66120507/66120507.jpg

MYCOTOXIN HEALTH HAZARDS

- **Generally lower risk in well developed countries due to improved standards of living.**
- **High intake of affected product, usually in conjunction with limited amounts of other food sources.**
- **Greatest threat comes from long term exposure due to eating spoiled food or meat from animals fed contaminated feed.**



http://www.weber.hu/images/Vicam/products.jpg

SYMPTOMS OF MYCOTOXICOSIS

- Drugs and antibiotics are not effective in treatment
- The symptoms can be traced to foodstuffs or feed
- Testing of said foodstuffs or feed reveals fungal contamination
- The symptoms are not transmissable person to person
- The degree of toxicity is subject to persons age (more often in very young and very old), sex (more often in females than males)and nutritional status
- Outbreaks of symptoms appear seasonally

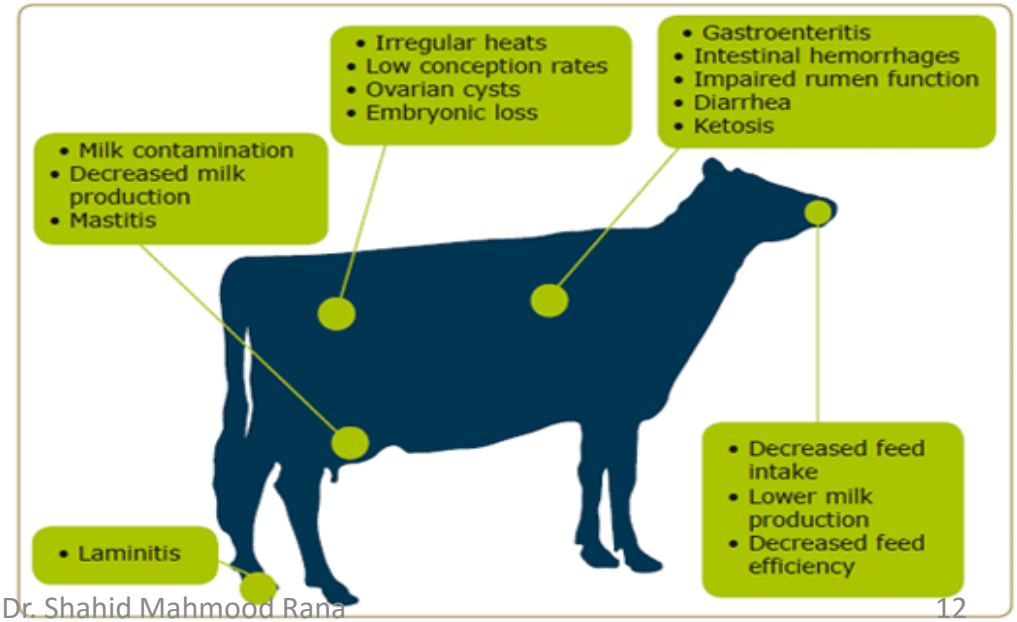
MYCOTOXIN EFFECTS ON HUMANS

- **Economic loss due to impaired health of stock animals**
- **Illness: symptoms can include cold/flu-like symptoms, sore throats, headaches, nose bleeds, fatigue, diarrhea, dermatitis, and immune suppression, and vary by species**
- **Death**

http://toxicblackmold.info/images/moldsickenschildren.jpg

MYCOTOXIN EFFECTS ON ANIMALS

- Feed refusal
- Impaired animal health, resulting in reduced production of eggs, milk, weight gain, etc.
- Metabolites are passed through the milk in cheese, dry milk, yogurt
- Disease
- Death in animals



http://www.thecattlesite.com/articles/contents/09-02-24Mytotoxin.gif

http://www.inoxpa.com/upload/Image/fda.jpg

REGULATORY CONTROL

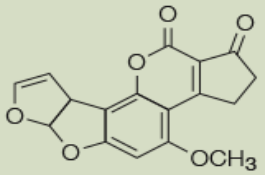
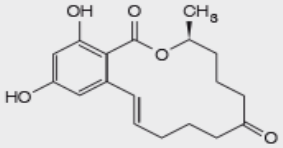
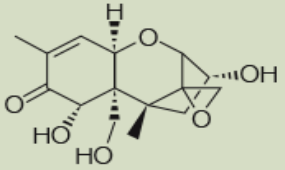
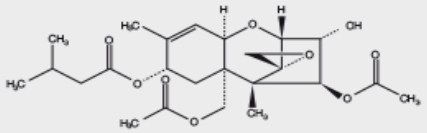
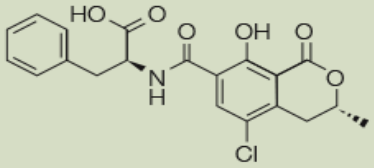
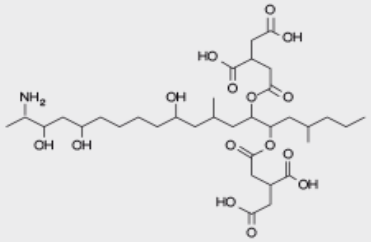
- In 1965, the Food and Drug Administration (FDA) set the first mycotoxin limit of 20 parts per billion (ppb) for aflatoxin in all foods and feed.
- But, this toxin can appear at varying levels of food production, so multiple testing at different points in the food chain is necessary.
- Using ELISA (enzyme-linked immunosorbent assay) technology, testing can be done cheaper and faster than previously.
- The FDA does not do the testing, various other agencies do, such as the Grain Inspection Packers and Stockyards Administration; but, toxic levels must be reported to the FDA.

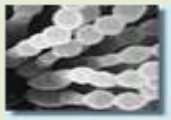
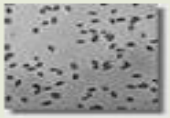
L # 7. QUICK TOXIN REVIEW

QUICK TOXIN REVIEW

Organ System Affected	Toxin(s)
Vascular	Aflatoxin
Digestive	Aflatoxin, T-2toxin, Vomitotoxin
Respiratory	Trichothecenes
Nervous	Trichothecenes
Cutaneous	Tricothecenes
Urinary	Ochratoxin A, Citrinin
Reproductive	Zearalenone, T-2 toxin
Immune	Many

Mycotoxin	Producing fungi	Commodities affected
Aflatoxin	*Aspergillus flavus*	
	Aspergillus parasiticus	Corn, cotton seed, peanuts, soy
Ochratoxin A	*Aspergillus ochraceus*	
	Aspergillus nigri	
	Penicillium verrucosum	Wheat, barley, oats, corn, others
Trichothecenes	*Fusarium graminearum*	
	Fusarium culmorum	Corn, wheat, barley
Zearalenone	*Fusarium graminearum*	Corn, wheat, barley
Fumonisin	*Fusarium verticillioides*	
	Fusarium proliferatum	Corn
Moniliformin	*Fusarium moniliforme*	Corn

Mycotoxins	Chemical structure	Productivity loss	Immuno toxicity	Frequently related clinical signs	Main affected organ/system
Aflatoxins		+++++	+++++	Hepatitis, poor response to vaccination, unspecific infections, increased susceptibility to diseases	Liver, kidney, immune system
Zearalenone		+++++	++	Hyperestrogenism, reproductive disorders	Reproductive tract - mainly female.
Deoxynivalenol		+++++	++++	Feed refusal, vomiting	Central nervous system, GUT epithelium, liver, immune system
T-2 toxin		+++++	+++++	Oral and epithelial lesions, loss of apetite	GUT epithelium, liver, immune system
Ochratoxin A		+++++	+++++	Nefritis (kidney damage - enlarged kidney), hepatitis	Kidney, liver, immune system
Fumonisins		+++++	+++	Porcine Pulmonary Edema (PPE), Equine Leukoencephalomalacia (ELEM)	Lungs and heart (pig), central nervous system (horse), liver, immune system

Major classes of mycotoxin-producing fungi	Fungi species	Mycotoxins
Aspergillus 	*A. flavus* *A. parasiticus* *A. nomius* *A. pseudotamarii*	Aflatoxin (B_1, B_2, G_1, G_2)
	A. ochraceus	Ochratoxin (Ochratoxin A)
	A. clavatus *A. terreus*	Patulin
	A. flavus *A. versicolor*	Cyclopiazonic acid (CPA)
Claviceps 	*C. purpurea* *C. fusiformis* *C. paspali* *C. africana*	Penitrem A Ergot alkaloids: Clavines (Argroclavine) Lysergic acids Lysergic acid amids (Ergin) Ergopeptines (Ergotamine, Ergovaline)
Fusarium 	*F. verticillioides* *(syn. F. moniliforme)* *F. proliferatum*	Fumonisin (B_1, B_2, B_3) Fusaric acid
	F. graminearum *F. avenaceum* *F. culmorum*	Type A Trichothecenes T-2 toxin, HT-2 toxin, diacetoxyscirpenol
	F. poae *F. equiseti* *F. crookwellense* *F. acuminatum* *F. sambucinum* *F. sporotrichioides*	Type B Trichothecenes Nivalenol, deoxynivalenol, fusarenon-X
	F. graminearum *F. culmorum* *F. sporotrichioides*	Zearalenone
Penicillium 	*P. verrucosum* *P. viridicatum*	Ochratoxin (Ochratoxin A)
	P. citrinum *P. verrucosum*	Citrinin
	P. roqueforti	Roquefortine PR toxin Pentirem A
	P. cyclopium *P. camemberti*	Cyclopiazonic acid (CPA) Pentirem A
	P. expansum *P. claviforme* *P. roquefortii*	Patulin
Neotyphodium (formerly Acremonium)	*N. coenophialum*	Tall fescue toxins: Ergot alkaloids, lolines, peramine
	N. lolii	Tall fescue toxins: Lolitrems, peramine, ergot alkaloid (ergovaline)
Pithomyces	*P. chartarum*	Sporidesmin

MYCOTOXINS ABSORPTION

	% absorbed	
	Swine	Poultry
Aflatoxins	>80%	>80%
Ochratoxin A	65%	40%
DON	55%	5-20%
Fumonisins	3-6%	1%

Main mycotoxins occurring in corn produced in the northeastern U.S.

Mycotoxin:	Predominant toxigenic mold:	Lowest level of concern:	Common effects on animals:
Deoxynivalenol (vomitoxin)	*Fusarium graminearum*	1-3 ppm*	Feed refusal in monogastric animals; severity increases with level. Swine and dogs are the most sensitive species; adult cattle and poultry tolerate > 10 ppm.
Zearalenone	*Fusarium graminearum (Gibberella zeae)*	1-5 ppm	Hyperestrogenism and infertility. graminearum Swine (gilts) are most sensitive; adult cattle tolerate 50 ppm.
Fumonisins	*Fusarium verticilloides; F. proliferatum*	5-10 ppm	Brain deterioration, death (horses); verticilloides; liver damage (horses, swine, cattle, poultry, others).
		>100 ppm	Lung damage in swine

*USDA recommends less than 1 ppm deoxynivalenol in finished food products and less than 2 ppm in unmilled grain destined for human consumption.

L # 8. MYCOTOXINS AND HEALTH

MYCOTOXINS: HEALTH EFFECTS

Mycotoxin	Effect
Fumonisins	Oesophageal cancer in humans, pulmonary oedema, in pigs, neurotoxic disease in horses, liver cancer in rats.
Zearalenone	Infertility, abortion and other breeding problems especially in swine.
Trichothecenes	Feed refusal, degeneration of bone marrow cells, diarrhoea, bleeding and death in pigs.
Aflatoxins	Acute toxicity in humans (over 100 deaths recorded in Kenya in 2005).
Diplonine	Ataxia, paresis, and paralysis in cattle and sheep, as well as stillbirths and nervous disorders in livestock.

FOODS HIGHEST IN MYCOTOXINS

SOME MINIMUM a_w VALUES REQUIRED GROWTH OF TOXIGENIC MOULD SPECIES (WHO, 2000)

Mould Species	Minimum a_w value
Aspergillus ochraceus	0.78
Penicillium verrucosum	0.79
Aspergillus flavus	0.80
Fusarium moniliforme	0.87

Contaminants	Foods
PCBs, dioxins, dieldrin, aldrin, DDT…	Milk, butter, eggs, animal and vegetable fats and oils, fish, cereals, drinking-water…
Lead	Milk, canned/fresh meat, kidney, fish, molluscs, crustaceans, cereals, legumes, fruits, spices, drinking-water...
Cadmium	Kidney, molluscs, crustaceans, cereals, vegetables…
Mercury	Fish, fish products, mushrooms…
Aflatoxins	Milk, milk products, cereals, nuts, spices, cocoa, coffee...
Ochratoxin A	Wheat, cereals, wine
DON	Wheat, cereals
Fumonisins	Maize, wheat
Chlorpyrifos, diazinon, melathion, parathion, aldicarb, captan, dithiocarbamate…	Cereals, vegetables, fruits, drinking-water…
Nitrate/nitrite	Meat, drinking-water…
Inorganic arsenic	Wheat, drinking-water…

L # 9. WATER AND FOOD SAFETY

THE MOST CRITICAL & DETRIMENTAL COMPONENT RELATED TO FOOD SAFETY

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WATER

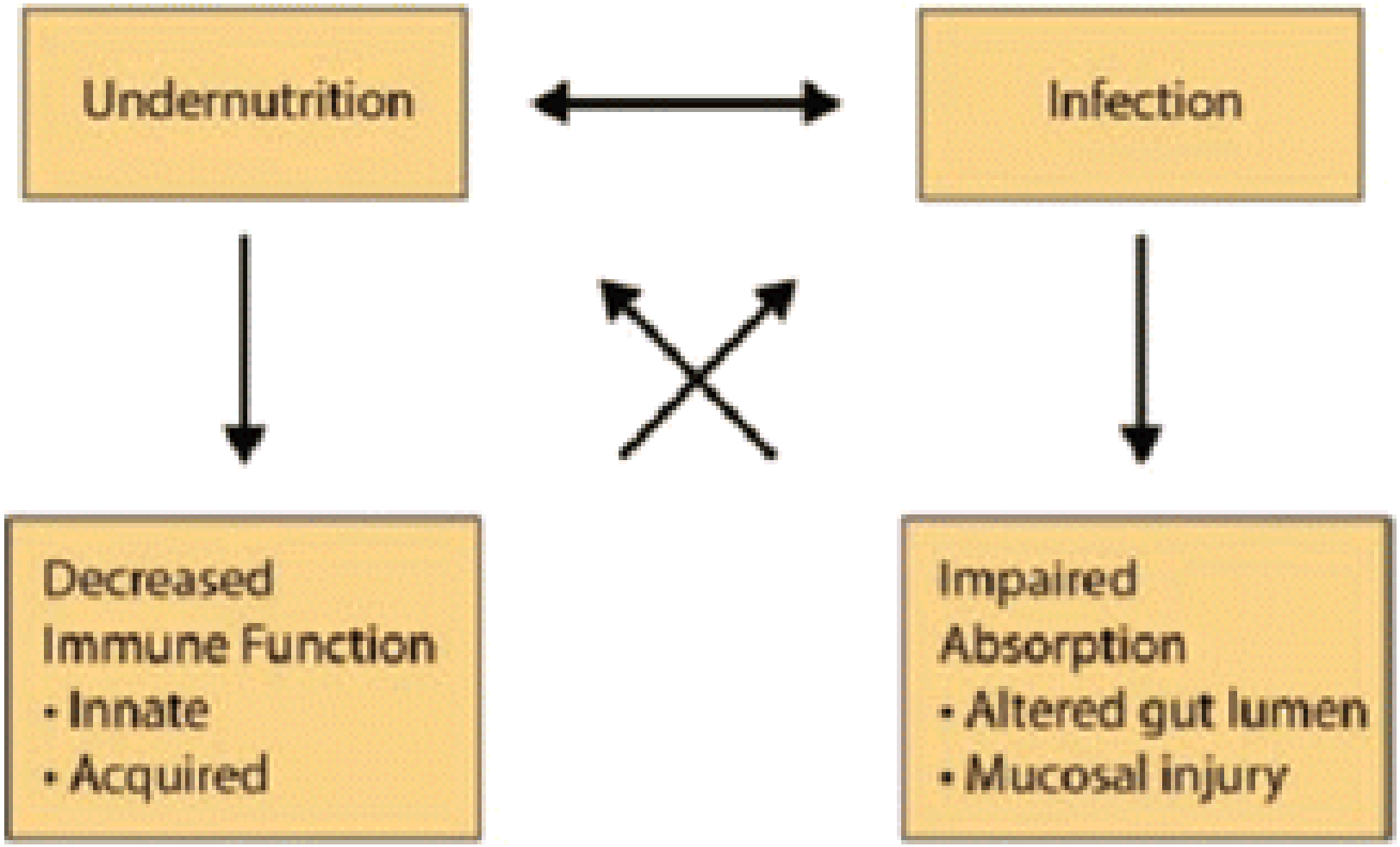
WHO: FOOD SAFETY-KEY FACTS

- Access to sufficient amounts of **SAFE and NUTRITIOUS** food is key to sustaining life and promoting good health.
- **Unsafe food** containing harmful **bacteria**, viruses, parasites or chemical substances, causes more than **200** diseases-ranging from DIARRHEA to CANCERS.
- An estimated **600** million-almost **1 in 10** people in the world-fall ill after eating contaminated food and **420 000** die every year, resulting in the loss of **33 million** healthy life years.
- Children **under 5** years of age carry **40 %** of the foodborne disease burden, with **125 000** deaths every year.

WHO: FOOD SAFETY-KEY FACTS

- **Diarrhoeal** diseases are the most common illnesses resulting from the consumption of contaminated food, causing **550 million** people to fall ill and **230 000** deaths every year.
- Food safety, nutrition and food security are inextricably (impossible to separate) linked.
- Unsafe food creates a vicious cycle of disease and malnutrition, particularly affecting infants, young children, elderly and the sick.

VICIOUS CYCLE: MALNUTRITION AND INFECTION



L # 10. WATER AND FOOD SAFETY-II

CRITICAL & DETRIMENTAL

?

WATER ACTIVITY

a_w

WATER ACTIVITY (a_w) IN FOODS

" The ratio of the partial pressure of water in the atmosphere in equilibrium with the substrate (e.g. a food) to that of the atmosphere in equilibrium with pure water at the same temperature, and is expressed on a scale of **0 -1** where **1** is for pure water".

WATER ACTIVITY (a_w)

$$a_w = \frac{p}{^\circ p}$$

- Partial pressure of water above the solution normalized to the partial pressure above pure water

WATER ACTIVITY (a_w) IN FOODS

- The water activity (**a_w**) of a food is the ratio between the vapor pressure of the food itself, when in a completely undisturbed balance with the surrounding air media, and the vapor pressure of distilled water under identical conditions.
- **a_w** of **0.80** means the vapor pressure is **80 %** of that of pure water. The water activity increases with temperature.
- The **moisture** condition of a product can be measured as the **equilibrium relative humidity (ERH)** expressed in **%** or as the **a_w** expressed as a decimal.

WATER ACTIVITY (a_w) IN FOODS

- Most foods have a a_w above **0.95** and that will provide sufficient moisture to support the growth of bacteria, yeasts, and mold.
- The amount of available moisture can be reduced to a point which will inhibit the growth of the organisms.

WATER ACTIVITY (a_w)

- Water in food which is not **bound** to food molecules can support the growth of bacteria, yeasts and molds (fungi)
- **a_w** refers to this **unbound** water
- **a_w** of a food is not the same thing as its moisture content
- Although **moist foods** are likely to have greater **a_w** than are dry foods, this is not always so; in fact a variety of foods may have exactly the same moisture content and yet have quite different water activities.

Foods	Water Activity (a_w)
Fresh Meat & Fish	0.99
Bread	0.95
Aged Cheddar	0.85
Jams & Jellies	0.80
Plum Pudding	0.80
Dried Fruit	0.60
Biscuits	0.30
Milk Powder	0.20
Instant coffee	0.20

WATER ACTIVITY OF SOME FOOD PRODUCTS

Food Product	Water activity (a_w)
Raw meat and milk	0.99- 1.0
Luncheon meat	0.95
Boiled ham, sliced bacon	0.90
Dried grains	0.80

MINIMUM a_w THAT SUPPORTS GROWTH OF SOME MICROORGANISMS

Microorganism	Water activity (a_w)
Clostridium botulinum,	0.95
Bacillus cereus,	0.95
Pseudmonas aeroginosa,	0.95
Salmonella spp.	0.95
Staphylococcus aureus (anaerobic)	0.90
Candida spp., Saccharomyces	
Staphylococcus aureus (aerobic)	0.86
Penicillium spp.	0.82
Most spoilage yeast	0.88
Most spoilage molds	0.80
Osmotic yeast	0.70

L # 11. FACTORS FOR MICROBIAL CONTROL

Minimum water activities at which active growth can occur

Group of micro-organism	Minimum aw
Most Gram-negative bacteria	0.97
Most Gram-positive bacteria	0.90
Most yeasts	0.88
Most filamentous fungi	0.80
Halophilic bacteria	0.75
Xerophilic fungi	0.61
Osmophilic yeasts	0.60

Table 5: Minimum water activity that supports growth of some microorganisms

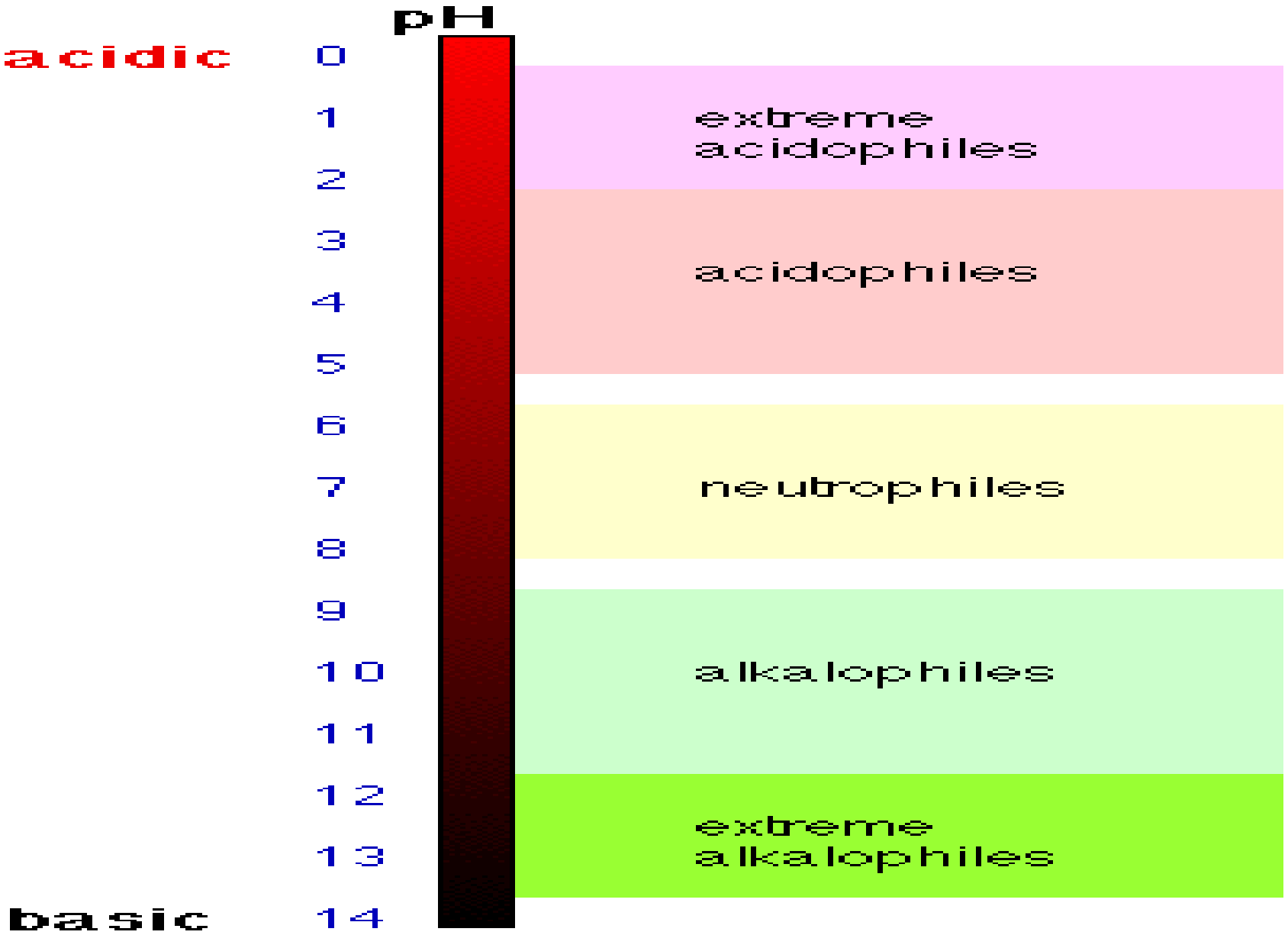
Microorganism	Water activity
Clostridium botulinum,	0.95
Bacillus cereus,	0.95
Pseudmonas aeroginosa,	0.95
Salmonella spp.	0.95
Staphylococcus aureus (anaerobic), Candida spp., Saccharomyces	0.90
Staphylococcus aureus (aerobic)	0.86
Penicillium spp.	0.82
Most spoilage yeast	0.88
Most spoilage molds	0.80
Osmotic yeast	0.70

Minimum Permitting M/O Growth

Group	Minimum A_w	
Bacteria	0.91	
Yeasts	0.88	
Molds	0.80	
Halophilic Bacteria	0.75	
Xerophilic Fungi	0.65	
Osmophilic Yeasts	0.60	
Staphylococcus aureus (Survive but No Growth)	0.86	*Lowest Aw for Pathogen Growth
Pseudomonas	0.97	
Vibrio parahaemolyticus	0.94	
Escherichai coli	0.96	

Microbial Growth Ability in Different pH

M/O	pH Range
Molds	0.2-11
Yeasts	1.5-8.5
Salmonella	3.6-9.5
Listeria monocytogenes	4.2-9.6
Yersinia enterocolitica	4.2-9.0
Escherichia coli	4.3-9.0
Clostridium botulinum	4.3-8.5
Bacillus cereus	5.0-9.5
Campylobacter	5.0-9.0
Shigella	5.0-9.2
Vibrio parahaemolyticus	5.0-11
V. Cholerae	5.0-9.5
Cl. perfringens	5.0-8.5


pH
acidic
0
1
2
3
4
5
6
7
8
9
10
11
12
13
basic
14
extreme acidophiles
acidophiles
neutrophiles
alkalophiles
extreme alkalophiles

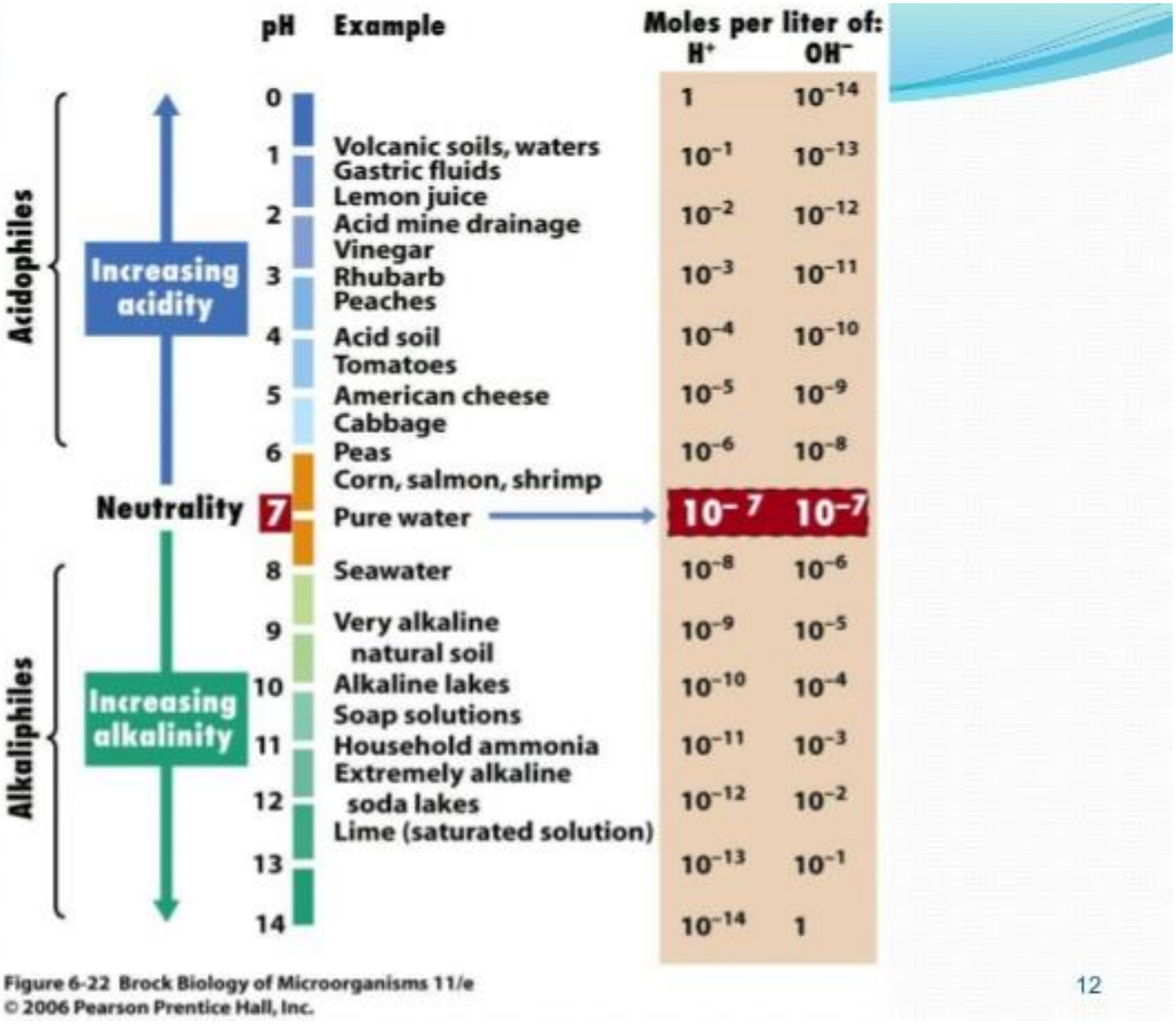
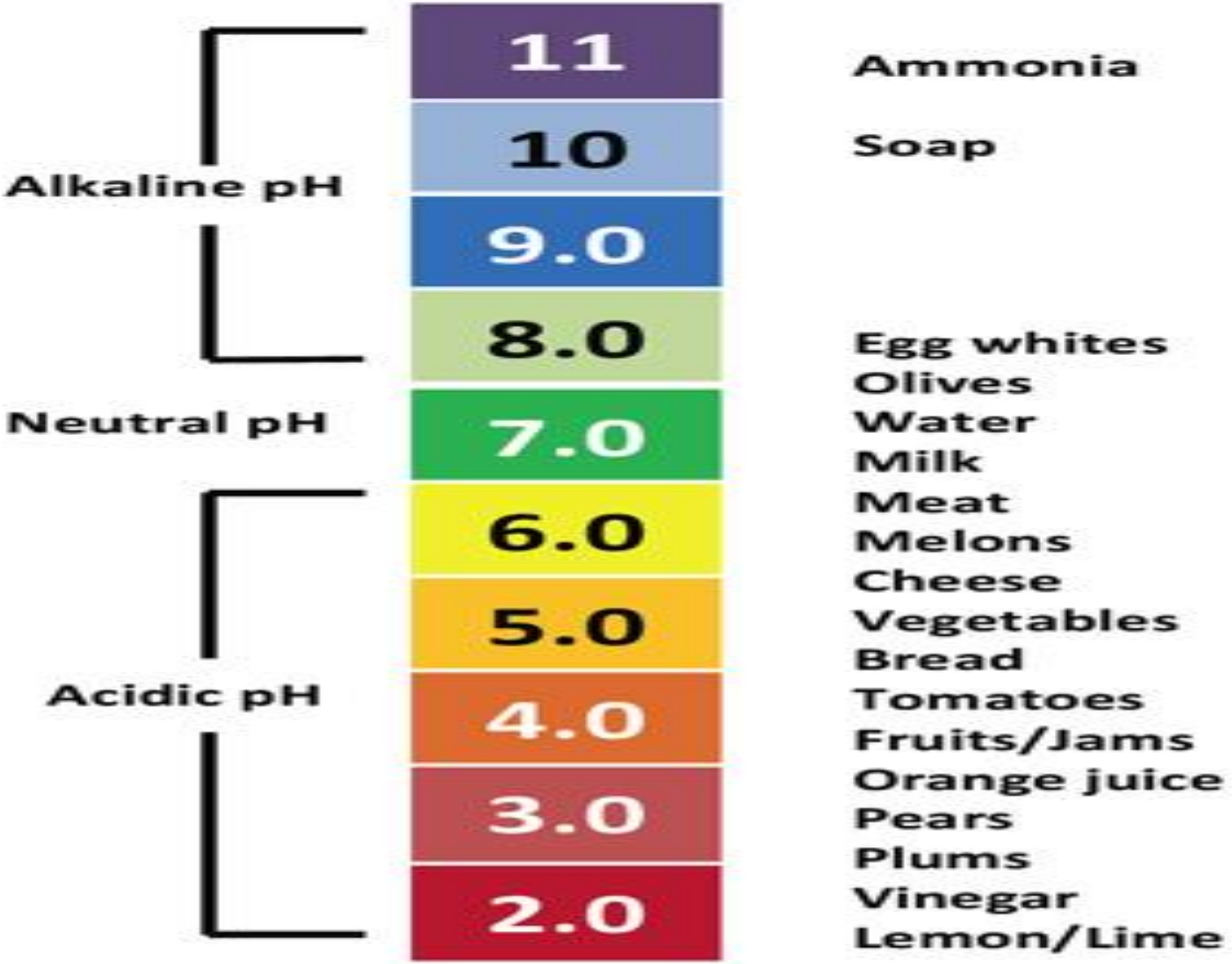
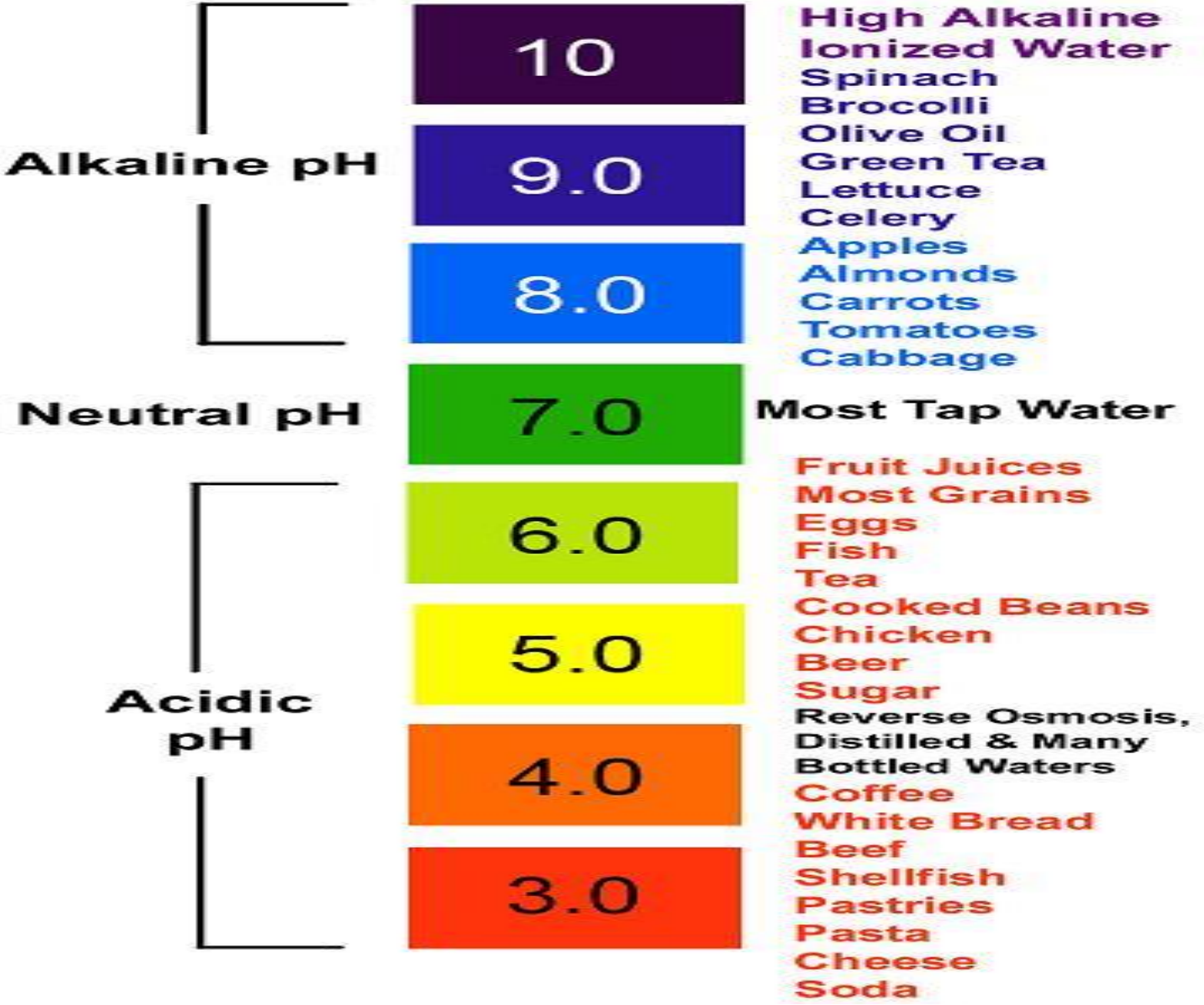
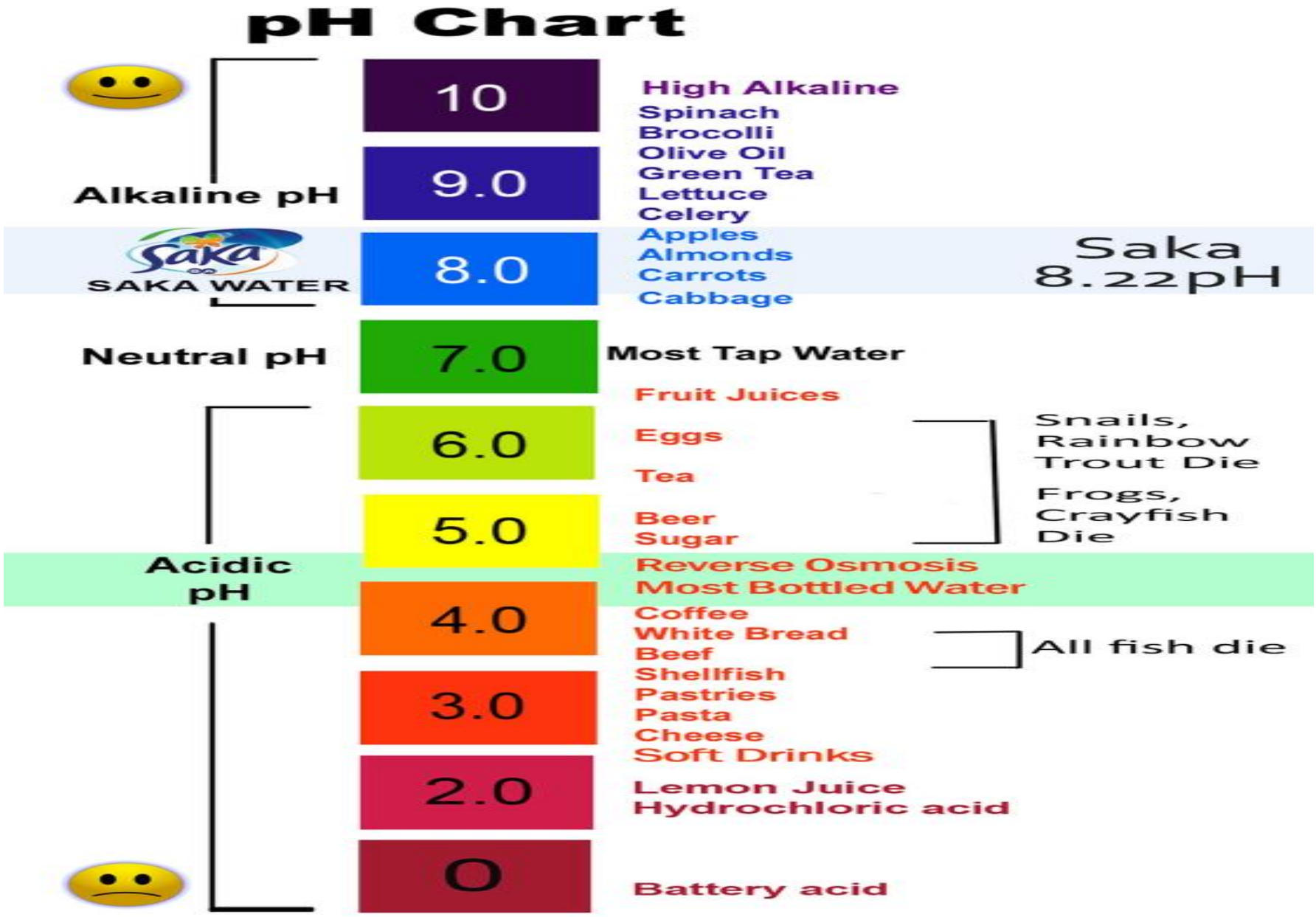


Figure 6-22 Brock Biology of Microorganisms 11/e


Alkaline pH
Neutral pH
Acidic pH
11
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
Ammonia
Soap
Egg whites
Olives
Water
Milk
Meat
Melons
Cheese
Vegetables
Bread
Tomatoes
Fruits/Jams
Orange juice
Pears
Plums
Vinegar
Lemon/Lime


Alkaline pH
Neutral pH
Acidic pH
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
High Alkaline Ionized Water
Spinach
Brocolli
Olive Oil
Green Tea
Lettuce
Celery
Apples
Almonds
Carrots
Tomatoes
Cabbage
Most Tap Water
Fruit Juices
Most Grains
Eggs
Fish
Tea
Cooked Beans
Chicken
Beer
Sugar
Reverse Osmosis, Distilled & Many Bottled Waters
Coffee
White Bread
Beef
Shellfish
Pastries
Pasta
Cheese
Soda


pH Chart
Alkaline pH
SAKA WATER
Neutral pH
Acidic pH
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
0
High Alkaline
Spinach
Brocolli
Olive Oil
Green Tea
Lettuce
Celery
Apples
Almonds
Carrots
Cabbage
Saka 8.22pH
Most Tap Water
Fruit Juices
Eggs
Tea
Beer
Sugar
Snails, Rainbow Trout Die
Frogs, Crayfish Die
Reverse Osmosis
Most Bottled Water
Coffee
White Bread
Beef
Shellfish
Pastries
Pasta
Cheese
Soft Drinks
All fish die
Lemon Juice
Hydrochloric acid
Battery acid