Введение в LINQ

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Составляющие LINQ

- Автоматические свойства
- Инициализаторы объектов и коллекций
- Анонимные типы
- Методы расширения
- Лямбда-выражения

Автоматические свойства

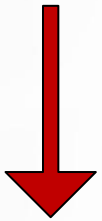
```
private string _firstName;

public string firstName
{
   get { return _firstName; }
   set { _firstName = value; }
}
```

Автоматические свойства

```
private string _firstName;

public string firstName
{
   get { return _firstName; }
   set { _firstName = value; }
}
```



```
public string FirstName { get; set; }
```

Неявно типизированные локальные переменные

```
var i = 5;
var s = "Hello";
var d = 1.0;
var numbers = new int[] { 1, 2, 3 };
```

Правила неявно типизированных локальных переменных

- var x; // Ошибка
- var y = {1, 2, 3}; // Ошибка
- var z = null; // Ошибка
- var не может использоваться в полях в области действия класса.
- int i = (i = 20); // ОК
- var i = (i = 20); // Ошибка
- var a = 5, b = 10; // Ошибка
- Если тип с именем var находится в области действия, то ключевое слово var будет преобразовано в это имя типа и не будет обрабатываться как часть неявно типизированного объявления локальной переменной.

Инициализаторы объектов

```
public class Car
{
    public string VIN { get; set; }
    public string Make { get; set; }
    public string Model { get; set; }
    public int Year { get; set; }
    public string Color { get; set; }
}
```

Инициализаторы объектов

```
Car c = new Car();
c.VIN = "ABC123";
c.Make = "Ford";
c.Model = "F-250";
c.Year = 2000;
```

Инициализаторы объектов

```
Car c = new Car();
c.VIN = "ABC123";
c.Make = "Ford";
c.Model = "F-250";
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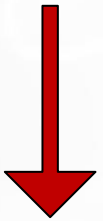


```
Car c = new Car()
{
   VIN = "ABC123",
   Make = "Ford",
   Model = "F-250",
   Year = 2000
};
```

Инициализаторы коллекций

```
private List<Car> GetCars()
{
   return new List<Car>
          {
             new Car { VIN = "ABC123", Make = "Ford",
                   Model = "F-250", Year = 2000 },
             new Car { VIN = "DEF123", Make = "BMW",
                   Model = "Z-3", Year = 2005 },
             new Car { VIN = "ABC456", Make = "Audi",
                   Model = "TT", Year = 2008 },
             new Car { VIN = "HIJ123", Make = "VW",
                   Model = "Bug",  Year = 1956  },
             new Car { VIN = "DEF456", Make = "Ford",
                   Model = "F-150", Year = 1998 }
          };
}
```

Анонимные типы

```
var car = new { Make = "VW", Model = "Bug" };
```

Методы расширения

```
public static class MyExtensions
{
    public static bool IsValidEmailAddress(this string s)
    {
        Regex regex = new Regex(@"^[\w-\.]+@([\w-]+\.)+[\w-]{2,4}$");
        return regex.IsMatch(s);
    }
}


string s = "my_mail@domen.com";
bool result = s.IsValidEmailAddress();
```

Правила методов расширений

- Метод расширения и класс, в котором он объявлен, должны быть статическими с модификатором public
- Первый параметр определяет, с каким типом оперирует метод, и перед параметром идет модификатор this
- Методы расширения не могут получить доступ к закрытым переменным типа, для расширения которого они используются
- Методы расширения находятся в области действия, только если пространство имен было явно импортировано в исходный код с помощью директивы using
- Методы расширения не могут переопределить методы класса

Анонимные методы

```
List<Car> cars = GetCars();
List<Car> filtered = new List<Car>();
foreach (Car car in cars)
{
    if (car.Year > 2000 && car.Model.StartsWith("F"))
    {
        filtered.Add(car);
    }
}
```

Анонимные методы

```
List<Car> cars = GetCars();
List<Car> filtered = new List<Car>();
foreach (Car car in cars)
{
   if (FilterYear(car) && FilterModel(car))
   {
      filtered.Add(car);
   }
}

public bool FilterYear(Car car) { return car.Year > 2000; }
public bool FilterModel(Car car) { return car.Model.StartsWith("F"); }
```

Анонимные методы

```
public delegate bool FilterPredicate(Car car);

public bool CheckPredicates(Car car, IList<FilterPredicate> predicates)
{
   foreach (FilterPredicate p in predicates)
   {
      if (!p(car)) { return false; }
   }

   return true;
}
```

Анонимные методы

```
List<Car> cars = GetCars();

List<FilterPredicate> predicates = new List<FilterPredicate>();
predicates.Add(delegate(Car car) { return car.Year > 2000; });
predicates.Add(delegate(Car car) { return car.Model.StartsWith("F"); });

List<Car> filtered = new List<Car>();
foreach (Car car in cars)
{
    if (CheckPredicates(car, predicates)) { filtered.Add(car); }
}
```

Анонимные методы

```
List<Car> cars = GetCars();

List<FilterPredicate> predicates = new List<FilterPredicate>();
predicates.Add ((Car car) => car.Year > 2000);
predicates.Add((Car car) => car.Model.StartsWith("F"));

List<Car> filtered = new List<Car>();
foreach (Car car in cars)
{
    if (CheckPredicates(car, predicates)) { filtered.Add(car); }
}
```

Анонимные методы

```
List<Car> cars = GetCars();

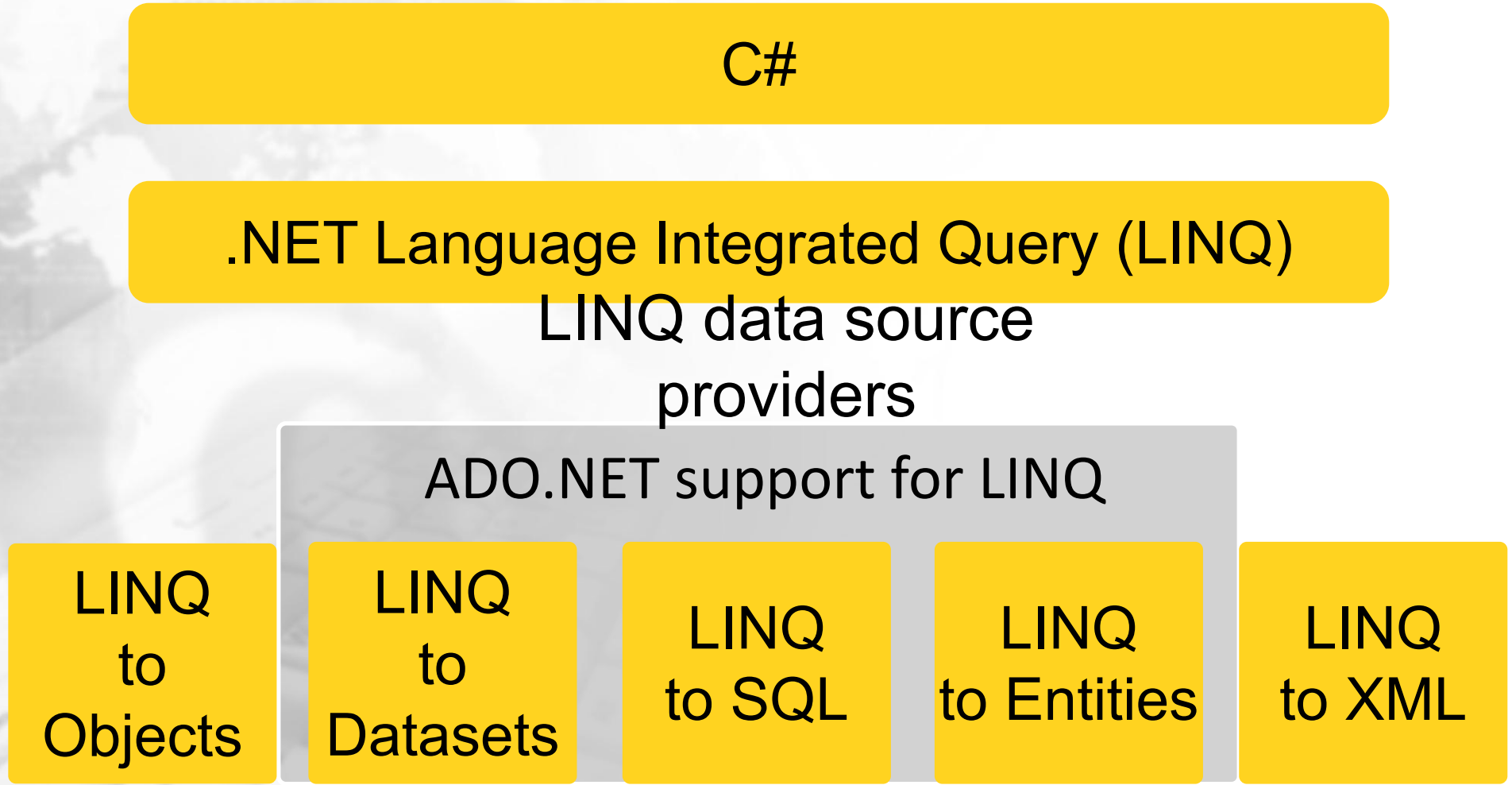
List<FilterPredicate> predicates = new List<FilterPredicate>();
predicates.Add (car => car.Year > 2000);
predicates.Add(car => car.Model.StartsWith("F"));

List<Car> filtered = new List<Car>();
foreach (Car car in cars)
{
   if (CheckPredicates(car, predicates)) { filtered.Add(car); }
}
```

Лямбда-выражения

- (string s) => { return s.Length; }
  (s) => { return s.Length; }
- () => {/* statement(s) */ }
- (s) => { return s.Length; }
  s => { return s.Length; }
- (x,y) => { return x < y; }

Архитектура



LINQ-примеры (Query-синтаксис)

```
var query = from book in list
where book.Category == ".NET"
orderby book.NumberOfCopies
select new { book.Title, book.Author};
```

LINQ-примеры (Query-синтаксис)

Источник данных

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LINQ-примеры (Query-синтаксис)

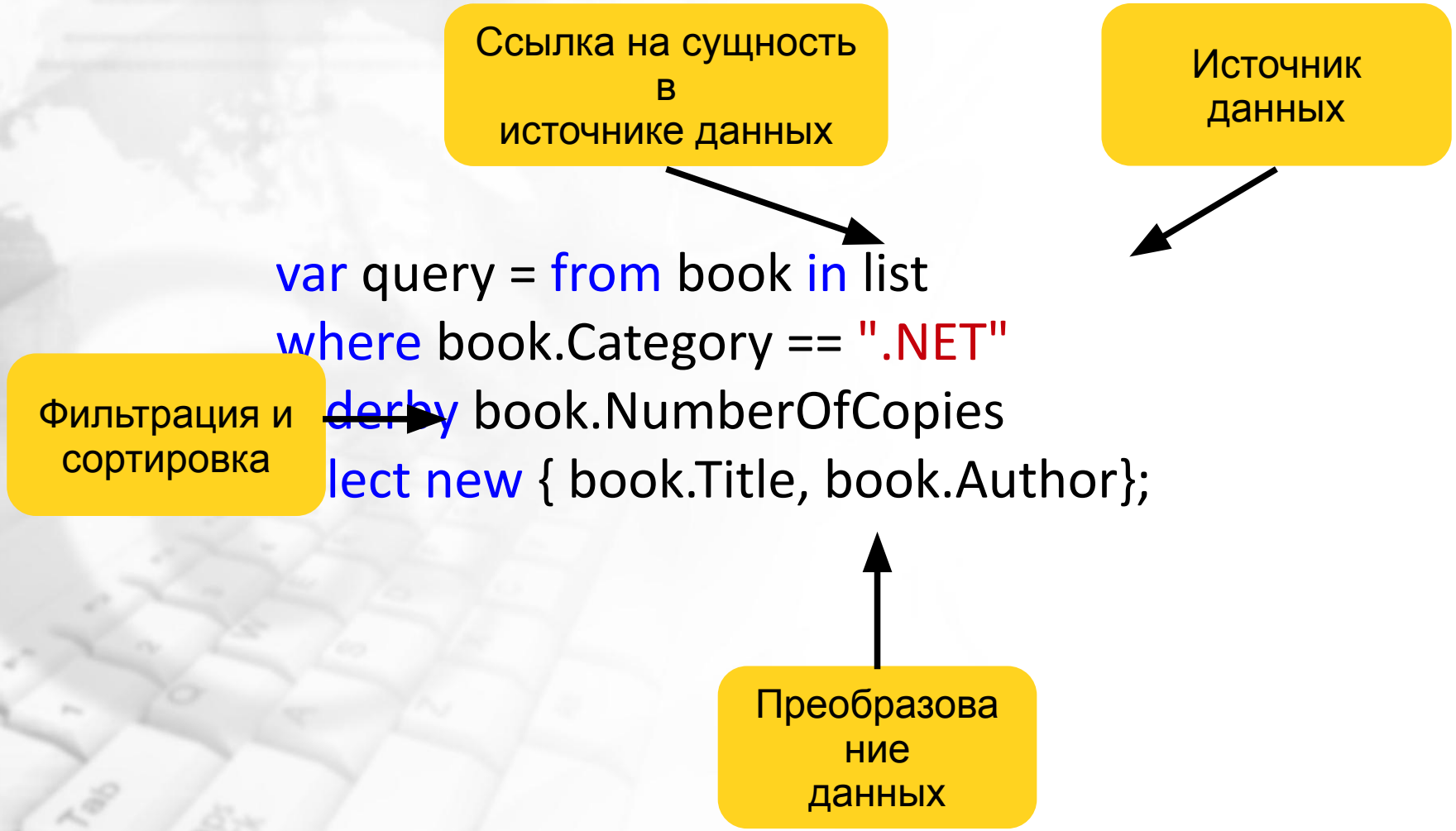
Ссылка на сущность в источнике данных

Источник данных

```
var query = from book in list
where book.Category == ".NET"
orderby book.NumberOfCopies
select new { book.Title, book.Author};
```

Фильтрация и сортировка

LINQ-примеры (Query-синтаксис)



Синтаксис

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var query = from book in list
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Синтаксис

Обязательное начало запроса

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var query = from book in list
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Синтаксис

Обязательное начало запроса

```
var query = from book in list
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Обязательный конец запроса

Синтаксис

Обязательное начало запроса

```
query = from book in list
ere book.Category == ".NET"
erby book.NumberOfCopies
ct new { book.Title, book.Author};
```

В середине запроса могут содержаться одно или более условий:

- where
- orderby
- join
- let
- from
- into

Обязательный конец запроса

Ключевые слова

C# LINQ	ANSI SQL
from	FROM
select	SELECT
where	WHERE
orderby	ORDER BY
join	JOIN
group	GROUP BY
Distinct()	DISTINCT
into	INTO
let	AS
Count(), Sum(),...	COUNT, SUM,...
Skip(), SkipWhile()	N/A
Take(), TakeWhile()	N/A

Отложенное выполение

```
string[] colors = { "Red", "Brown", "Orange", "Yellow", "Black", "Green", "White", "Violet",
"Blue" };

IEnumerable<string> results = from c in colors
                              where c.StartsWith("B")
                              orderby c
                              select c;

foreach (var color in results)
{
   txtLog.AppendText(color + ",");
}
```

Output: Brown, Black, Blue

Отложенное выполение

```
string[] colors = { "Red", "Brown", "Orange", "Yellow", "Black", "Green", "White", "Violet",
"Blue" };

IEnumerable<string> results = from c in colors
                              where c.StartsWith("B")
                              orderby c
                              select c;

colors[4] = "Slate";

foreach (var color in results)
{
   txtLog.AppendText(color + ",");
}
```

Output: Brown, Blue

Query Extension Methods
Enumerable static methods

Empty

```
var numbers = Enumerable.Empty<long>();
```

Range

```
var numbers = Enumerable.Range(1, 5);
```

Output: 1, 2, 3, 4, 5

Repeat

```
var numbers = Enumerable.Repeat(10, 5);
```

Output: 10, 10, 10, 10, 10

Query Extension Methods
All, Any

All

```
bool result = GetCars().All(c => c.Year > 1960);
```

Any

```
bool result = GetCars().Any(c => c.Year <= 1960);
```

Query Extension Methods AsEnumerable

```
public class MyStringList : List<string>
{
   public IEnumerable<string> Where(Predicate<string> filter)
   {
      return this.Select(s => filter(s) ? s.ToUpper() : s);
   }
}

var strings = new MyStringList {"orange", "apple", "grape", "pear"};
foreach (var item in strings.Where(s => s.Length == 5))
{
   txtLog.Write(item);
}
```

Output: orange, APPLE, GRAPE, pear

Query Extension Methods AsEnumerable

```
public class MyStringList : List<string>
{
   public IEnumerable<string> Where(Predicate<string> filter)
   {
      return this.Select(s => filter(s) ? s.ToUpper() : s);
   }
}

var strings = new MyStringList {"orange", "apple", "grape", "pear"};
foreach (var item in strings.AsEnumerable().Where(s => s.Length == 5))
{
   txtLog.Write(item);
}
```

Output: apple, grape

Query Extension Methods AsQueryable

```
IEnumerable<string> strings = new MyStringList {"orange", "apple", "grape", "pear"};
var querable = strings.AsQueryable();
txtLog.WriteLine("Element Type: {0}", querable.ElementType);
txtLog.WriteLine("Expression: {0}", querable.Expression);
txtLog.WriteLine("Provider: {0}", querable.Provider);
```

Output:

Element Type: System.String

Expression: MyStringList

Provider: MyStringList

Query Extension Methods ToArray, ToList

```
int[] scores = { 88, 56, 23, 99, 65, 93, 78, 23, 99, 90 };
var evenScores = scores.Where(s => s % 2 == 0).ToList(); // ToArray()
scores[2] = 2;
foreach (var item in evenScores)
{
   txtLog.WriteLine(item);
}
```

Output:

88
56
78
90

Query Extension Methods ToDictionary, ToLookUp

```
var cars = GetCars();
var carsByVin = cars.ToDictionary(c => c.VIN);
Car myCar = carsByVin["HIJ123"];
txtLog.WriteLine("Car VIN:{0}, Make:{1}, Model:{2} Year:{3}",
                 myCar.VIN, myCar.Make, myCar.Model, myCar.Year);
```

Output:

Car VIN:HIJ123, Make:VW, Model:Bug Year:1956

Query Extension Methods
Cast, OfType

```
int[] scores = {88, 56, 23, 99, 65, 93, 78, 23, 99, 90};
IEnumerable<Object> objects = scores.Cast<object>();

object[] items = new object[] {55, "Hello", 22, "Goodbye"};
foreach (var intItem in items.OfType<int>())
{
   txtLog.WriteLine(intItem);
}
```

Output:

55
22

Query Extension Methods
Max, Min, Average, Sum, Count

```
int[] scores = {88, 56, 23, 99, 65, 93, 78, 23, 99, 90};
txtLog.WriteLine("Max: " + scores.Max());
txtLog.WriteLine("Min: " + scores.Min());
txtLog.WriteLine("Average: " + scores.Average());
txtLog.WriteLine("Sum: " + scores.Sum());
txtLog.WriteLine("Count: " + scores.Count());
```

Output:

Max: 99
Min: 23
Average: 71,4
Sum: 714
Count: 10

Query Extension Methods ElementAt, First, Last

```
int[] scores = {88, 56, 23, 99, 65, 93, 78, 23, 99, 90};
txtLog.WriteLine(scores.ElementAt(4));
txtLog.WriteLine(scores.First());
txtLog.WriteLine(scores.Last());
```

Output:

65
88
90

Query Extension Methods

ElementAtOrDefault, FirstOrDefault, LastOrDefault

```
int[] scores = {};
txtLog.WriteLine(scores.ElementAtOrDefault(4));
txtLog.WriteLine(scores.FirstOrDefault());
txtLog.WriteLine(scores.LastOrDefault());
```

Output:

0
0
0

Query Extension Methods Single, SingleOrDefault

```
int[] scores = {88, 56, 23, 99, 65, 93, 78, 23, 99, 90};
int score1 = scores.Where(x => x > 50 && x < 60).Single();
int score2 = scores.Where(x => x > 100).SingleOrDefault();
txtLog.WriteLine(score1);
txtLog.WriteLine(score2);
```

Output:

56

0

Query Extension Methods DefaultIfEmpty

```
List<Car> cars = new List<Car>();
IEnumerable<Car> oneNullCar = cars.DefaultIfEmpty();
foreach (var car in oneNullCar)
{
   txtLog.WriteLine(car == null ? "Null Car" : "Not Null Car");
}
```

Output: Null Car

Query Extension Methods Contains

```
int[] scores = { 88, 56, 23, 99, 65, 93, 78, 23, 99, 90 };
txtLog.WriteLine(scores.Contains(56));
txtLog.WriteLine(scores.Contains(24));
```

Output:
True
False

Query Extension Methods Distinct

```
int[] scores = { 88, 56, 23, 99, 65, 93, 78, 23, 99, 90 };
foreach (var score in scores.Distinct())
{
   txtLog.Write(score);
}
```

Output: 88, 56, 23, 99, 65, 93, 78, 90

Query Extension Methods Concat

```
int[] lastYearScores = { 88, 56, 23, 99, 65 };
int[] thisYearScores = { 93, 78, 23, 99, 90 };

foreach (var item in lastYearScores.Concat(thisYearScores))
{
   txtLog.Write(item);
}
```

Output: 88, 56, 23, 99, 65, 93, 78, 23, 99, 90

Query Extension Methods
Except

```
int[] lastYearScores = { 88, 56, 23, 99, 65 };
int[] thisYearScores = { 93, 78, 23, 99, 90 };

foreach (var item in lastYearScores.Except(thisYearScores))
{
   txtLog.WriteLine(item);
}
```

Output:

88
56
65

Query Extension Methods Intersect

```
int[] lastYearScores = { 88, 56, 23, 99, 65 };
int[] thisYearScores = { 93, 78, 23, 99, 90 };

foreach (var item in lastYearScores.Intersect(thisYearScores))
{
   txtLog.WriteLine(item);
}
```

Output:

23
99

Query Extension Methods Union

```
int[] lastYearScores = { 88, 56, 23, 99, 65, 56 };
int[] thisYearScores = { 93, 78, 23, 99, 90, 99 };
var allScores = lastYearScores.Union(thisYearScores);
foreach (var item in allScores.OrderBy(s => s))
{
   txtLog.WriteLine(item);
}
```

Output: 23, 56, 65, 78, 88, 90, 93, 99

Query Extension Methods
Zip

```
var numbers = Enumerable.Range(1, 1000);
var cars = GetCars();
var zip = numbers.Zip(cars, (i, c) => new
                        {
                            Number = i,
                            CarMake = c.Make
                        });
foreach (var it in zip)
{
   txtLog.WriteLine("Number:{0} Make:{1}", it.Number, it.CarMake);
}
```

Output:

```
Number:1 CarMake:Ford
Number:2 CarMake:BMW
Number:3 CarMake:Audi
Number:4 CarMake:VW
Number:5 CarMake:Ford
```

Query Extension Methods Reverse

```
int[] scores = { 88, 56, 23, 99, 65, 93, 78, 23, 99, 90 };
foreach (var score in scores.Reverse())
{
   txtLog.Write(score);
}
```

Output: 90, 99, 23, 78, 93, 65, 99, 23, 56, 88

Query Extension Methods SequenceEqual

```
List<int> lastYearScores = new List<int> {93, 78, 23, 99, 91};
List<int> thisYearScores = new List<int> {93, 78, 23, 99, 90};
txtLog.WriteLine(lastYearScores.SequenceEqual(thisYearScores));
lastYearScores[4] = 90;
txtLog.WriteLine(lastYearScores.SequenceEqual(thisYearScores));
```

Output:

False

True

Query Extension Methods
Skip, SkipWhile

```
int[] scores = { 88, 56, 23, 99, 65, 93, 78, 23, 99, 90 };

foreach (var s in scores.OrderBy(i => i).Skip(9))
{ txtLog.WriteLine(s); }
```

Output: 99

```
foreach (var s in scores.OrderBy(i => i).SkipWhile(s => s < 80))
{ txtLog.Write(s); }
```

Output: 88, 90, 93, 99, 99

```
foreach (var s in scores.SkipWhile(s => s < 80))
{ txtLog.Write(s); }
```

Output: 88, 56, 23, 99, 65, 93, 78, 23, 99, 90

Query Extension Methods
Take, TakeWhile

```
int[] scores = { 88, 56, 23, 99, 65, 93, 78, 23, 99, 90 };

foreach (var item in scores.OrderBy(i => i).Skip(3).Take(2))
{
   txtLog.Write(item);
}
```

Output: 65, 78

```
foreach (var item in scores.OrderBy(i => i).TakeWhile(s => s < 80))
{
   txtLog.WriteLine(item);
}
```

Output: 23, 23, 56, 65, 78

Query Extension Methods GroupBy

```
var cars = GetCars();
var query = cars.GroupBy(c => c.Make);
foreach (IGrouping<string, Car> group in query)
{
   txtLog.WriteLine("Key:{0}", group.Key);
   foreach (Car c in group)
   { txtLog.WriteLine("Car VIN:{0} Make:{1}", c.VIN, c.Make); }
}
```

Output:

```
Key:Ford
Car VIN:ABC123 Make:Ford
Car VIN:DEF456 Make:Ford
Key:BMW
Car VIN:DEF123 Make:BMW
Key:Audi
Car VIN:ABC456 Make:Audi
Key:VW
Car VIN:HIJ123 Make:VW
```

Query Extension Methods

OrderBy, OrderByDescending, ThenBy, ThenByDescending

```
var cars = GetCars().OrderBy(c => c.Make)
                    .ThenByDescending(c => c.Model)
                    .ThenBy(c => c.Year);
foreach (var item in cars)
{
   txtLog.WriteLine("Car VIN:{0} Make:{1} Model:{2} Year:{3}",
      item.VIN, item.Make, item.Model, item.Year);
}
```

Output:

```
Car VIN:ABC456 Make:Audi Model:TT Year:2008
Car VIN:DEF123 Make:BMW Model:Z-3 Year:2005
Car VIN:ABC123 Make:Ford Model:F-250 Year:2000
Car VIN:DEF456 Make:Ford Model:F-150 Year:1998
Car VIN:HIJ123 Make:VW Model:Bug Year:1956
```

Query Extension Methods Where

```
var cars = GetCars();
foreach (var myCar in cars.Where(c => c.Make == "Ford"))
{
   txtLog.WriteLine("Car VIN:{0}, Make:{1}, Model:{2} Year:{3}",
                    myCar.VIN, myCar.Make, myCar.Model, myCar.Year);
}
```

Output:

Car VIN:ABC123, Make:Ford, Model:F-250 Year:2000
Car VIN:DEF456, Make:Ford, Model:F-150 Year:1998

Query Extension Methods
Select

```
var vehicles = new List<Tuple<string, string, int>>
        {
            Tuple.Create("123", "VW", 1999),
            Tuple.Create("234", "Ford", 2009),
            Tuple.Create("567", "Audi", 2005),
            Tuple.Create("678", "Ford", 2003),
            Tuple.Create("789", "Mazda", 2003),
            Tuple.Create("999", "Ford", 1965)
        };
```

Query Extension Methods
Select

```
var fordCars = vehicles
                    .Where(v => v.Item2 == "Ford")
                    .Select(v => new Car
                    {
                        VIN = v.Item1,
                        Make = v.Item2,
                        Year = v.Item3
                    });
foreach (var item in fordCars)
{
    txtLog.WriteLine("Car VIN:{0} Make:{1} Year:{2}",
            item.VIN, item.Make, item.Year);
}
```

Query Extension Methods Select

Output:

Car VIN:234 Make:Ford Year:2009
Car VIN:678 Make:Ford Year:2003
Car VIN:999 Make:Ford Year:1965

Query Extension Methods
Select

```
var fordCars = from v in vehicles
               let makeYear = v.Item2 + " " + v.Item3
               where makeYear.StartsWith("Ford")
               select new
                      {
                         VIN = v.Item1,
                         MakeYear = makeYear
                      };
foreach (var item in fordCars)
{
   txtLog.WriteLine("Car VIN:{0} MakeYear:{1}",
                    item.VIN, item.MakeYear);
}
```

Query Extension Methods Select

Output:

Car VIN:234 MakeYear:Ford 2009
Car VIN:678 MakeYear:Ford 2003
Car VIN:999 MakeYear:Ford 1965

Query Extension Methods SelectMany

```
var repairs = new List<Tuple<string, List<string>>>
                {
                    Tuple.Create("ABC123",
                            new List<string> {"Rotate Tires", "Change oil"}),
                    Tuple.Create("DEF123",
                            new List<string> {"Fix Flat", "Wash Vehicle"}),
                    Tuple.Create("ABC456",
                            new List<string> {"Alignment", "Vacuum", "Wax"}),
                    Tuple.Create("HIJ123",
                            new List<string> {"Spark plugs", "Air filter"}),
                    Tuple.Create("DEF456",
                            new List<string> {"Wiper blades", "PVC valve"}),
                };
```

Query Extension Methods SelectMany

```
var query = repairs.SelectMany(t =>
      t.Item2.Select(r => new { VIN = t.Item1, Repair = r }));

foreach (var item in query)
{
   txtLog.WriteLine("VIN:{0} Repair:{1}", item.VIN, item.Repair);
}
```

Query Extension Methods SelectMany

Output:

VIN:ABC123 Repair:Rotate Tires
VIN:ABC123 Repair:Change oil
VIN:DEF123 Repair:Fix Flat
VIN:DEF123 Repair:Wash Vehicle
VIN:ABC456 Repair:Alignment
VIN:ABC456 Repair:Vacuum
VIN:ABC456 Repair:Wax
VIN:HIJ123 Repair:Spark plugs
VIN:HIJ123 Repair:Air filter
VIN:DEF456 Repair:Wiper blades
VIN:DEF456 Repair:PVC valve

Query Extension Methods
Join

```
var makes = new string[] { "Audi", "BMW", "Ford", "Mazda", "VW" };
var cars = GetCars();
var query = makes.Join(cars,
   make => make, car => car.Make,
   (make, innerCar) => new { Make = make, Car = innerCar });
foreach (var item in query)
{
   txtLog.WriteLine("Make: {0}, Car:{1} {2} {3}",
                    item.Make, item.Car.VIN, item.Car.Make, item.Car.Model);
}
```

Output:

Make: Audi, Car:ABC456 Audi TT
Make: BMW, Car:DEF123 BMW Z-3
Make: Ford, Car:ABC123 Ford F-250
Make: Ford, Car:DEF456 Ford F-150
Make: VW, Car:HIJ123 VW Bug

Query Extension Methods GroupJoin

```
var makes = new string[] { "Audi", "BMW", "Ford", "Mazda", "VW" };
var cars = GetCars();
var query = makes.GroupJoin(cars,
   make => make, car => car.Make,
   (make, innerCars) => new { Make = make, Cars = innerCars });
foreach (var item in query)
{
   txtLog.WriteLine("Make: {0}", item.Make);
   foreach (var car in item.Cars)
   { txtLog.WriteLine("Car VIN:{0}, Model:{1}", car.VIN, car.Model); }
}
```

Output:

```
Make: Audi
Car VIN:ABC456, Model:TT
Make: BMW
Car VIN:DEF123, Model:Z-3
Make: Ford
Car VIN:ABC123, Model:F-250
Car VIN:DEF456, Model:F-150
```

LINQ Joins

```
public class Repair {
    public string VIN { get; set; }
    public string Desc { get; set; }
    public decimal Cost { get; set; }
}
private List<Repair> GetRepairs()
{
    return new List<Repair> {
        new Repair {VIN = "ABC123", Desc = "Change Oil", Cost = 29.99m},
        new Repair {VIN = "DEF123", Desc = "Rotate Tires",  Cost =19.99m},
        new Repair {VIN = "HIJ123", Desc = "Replace Brakes",   Cost = 200},
        new Repair {VIN = "DEF456", Desc = "Alignment", Cost = 30},
        new Repair {VIN = "ABC123", Desc = "Fix Flat Tire", Cost = 15},
        new Repair {VIN = "DEF123", Desc = "Fix Windshield",  Cost =420},
        new Repair {VIN = "ABC123", Desc = "Replace Wipers", Cost = 20},
        new Repair {VIN = "HIJ123", Desc = "Replace Tires",   Cost = 1000},
        new Repair {VIN = "DEF456", Desc = "Change Oil", Cost = 30} };
}
```

LINQ Joins
Inner join

```
var cars = GetCars();
var repairs = GetRepairs();
var carsWithRepairs = from c in cars
                      join r in repairs
                      on c.VIN equals r.VIN
                      orderby c.VIN, r.Cost
                      select new
                      {
                          c.VIN,
                          c.Make,
                          r.Desc,
                          r.Cost
                      };
foreach (var item in carsWithRepairs)
{
    txtLog.WriteLine("Car VIN:{0}, Make:{1}, Description:{2} Cost:{3:C}",
        item.VIN, item.Make, item.Desc, item.Cost);
}
```

LINQ Joins
Inner join

Output:

Car VIN:ABC123, Make:Ford, Description:Fix Flat Tire Cost:$15.00
Car VIN:ABC123, Make:Ford, Description:Replace Wipers Cost:$20.00
Car VIN:ABC123, Make:Ford, Description:Change Oil Cost:$29.99
Car VIN:DEF123, Make:BMW, Description:Rotate Tires Cost:$19.99
Car VIN:DEF123, Make:BMW, Description:Fix Windshield Cost:$420.00
Car VIN:DEF456, Make:Ford, Description:Alignment Cost:$30.00
Car VIN:DEF456, Make:Ford, Description:Change Oil Cost:$30.00
Car VIN:HIJ123, Make:VW, Description:Replace Brakes Cost:$200.00
Car VIN:HIJ123, Make:VW, Description:Replace Tires Cost:$1,000.00

LINQ Joins
Outer join

```
var carsWithRepairs = from c in cars
                      join r in repairs
                      on c.VIN equals r.VIN into g
                      from r in g.DefaultIfEmpty()
                      orderby c.VIN, r == null ? 0 : r.Cost
                      select new
                      {
                          c.VIN,
                          c.Make,
                          Desc = r == null ? "***No Repairs***" : r.Desc,
                          Cost = r == null ? 0 : r.Cost
                      };

foreach (var item in carsWithRepairs)
{
    txtLog.WriteLine("Car VIN:{0}, Make:{1}, Description:{2} Cost:{3:C}",
        item.VIN, item.Make, item.Desc, item.Cost);
}
```

LINQ Joins
Outer join

Output:

Car VIN:ABC123, Make:Ford, Description:Fix Flat Tire Cost:$15.00
Car VIN:ABC123, Make:Ford, Description:Replace Wipers Cost:$20.00
Car VIN:ABC123, Make:Ford, Description:Change Oil Cost:$29.99
Car VIN:ABC456, Make:Audi, Description:***No Repairs*** Cost:$0.00
Car VIN:DEF123, Make:BMW, Description:Rotate Tires Cost:$19.99
Car VIN:DEF123, Make:BMW, Description:Fix Windshield Cost:$420.00
Car VIN:DEF456, Make:Ford, Description:Alignment Cost:$30.00
Car VIN:DEF456, Make:Ford, Description:Change Oil Cost:$30.00
Car VIN:HIJ123, Make:VW, Description:Replace Brakes Cost:$200.00
Car VIN:HIJ123, Make:VW, Description:Replace Tires Cost:$1,000.00

LINQ Joins
Cross join

```
var cars = GetCars();
var colors = new string[] { "Red", "Blue", "Green" };

var carsWithRepairs = from car in cars
                      from color in colors
                      orderby car.VIN, color
                      select new
                      {
                         car.VIN,
                         car.Make,
                         car.Model,
                         Color = color
                      };
foreach (var item in carsWithRepairs)
{
   txtLog.WriteLine("Car VIN:{0}, Make:{1}, Model:{2} Color:{3}",
            item.VIN, item.Make, item.Model, item.Color);
}
```

LINQ Joins
Cross join

Output:

Car VIN:ABC123, Make:Ford, Model:F-250 Color:Blue
Car VIN:ABC123, Make:Ford, Model:F-250 Color:Green
Car VIN:ABC123, Make:Ford, Model:F-250 Color:Red
Car VIN:ABC456, Make:Audi, Model:TT Color:Blue
Car VIN:ABC456, Make:Audi, Model:TT Color:Green
Car VIN:ABC456, Make:Audi, Model:TT Color:Red
Car VIN:DEF123, Make:BMW, Model:Z-3 Color:Blue
Car VIN:DEF123, Make:BMW, Model:Z-3 Color:Green
Car VIN:DEF123, Make:BMW, Model:Z-3 Color:Red
Car VIN:DEF456, Make:Ford, Model:F-150 Color:Blue
Car VIN:DEF456, Make:Ford, Model:F-150 Color:Green
Car VIN:DEF456, Make:Ford, Model:F-150 Color:Red
Car VIN:HIJ123, Make:VW, Model:Bug Color:Blue
Car VIN:HIJ123, Make:VW, Model:Bug Color:Green
Car VIN:HIJ123, Make:VW, Model:Bug Color:Red

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