Code annotation for 3.3:

```c
/** ws2812.c
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 *
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 */

#include <stdio.h>
#include <stdlib.h>

#include "pico/stdlib.h"
#include "hardware/pio.h"
#include "hardware/clocks.h"
#include "ws2812.pio.h"

#define IS_RGBW true
#define NUM_PIXELS 150

#ifdef PICO_DEFAULT_WS2812_PIN
#define WS2812_PIN PICO_DEFAULT_WS2812_PIN
#else
// default to pin 2 if the board doesn't have a default WS2812 pin defined
#define WS2812_PIN 2
#endif

static inline void put_pixel(uint32_t pixel_grb) {
    pio_sm_put_blocking(pio0, 0, pixel_grb << 8u);  //put  24-bit pixels data into FIFO

}

static inline uint32_t urgb_u32(uint8_t r, uint8_t g, uint8_t b) {
    return
            ((uint32_t) (r) << 8) |
            ((uint32_t) (g) << 16) |  //23~16:green 15~8:red 7~0:blue
            (uint32_t) (b);
}

void pattern_snakes(uint len, uint t) {
    for (uint i = 0; i < len; ++i) {
        uint x = (i + (t >> 1)) % 64;
        if (x < 10)
            put_pixel(urgb_u32(0xff, 0, 0)); //[r,0x00,0x00] into FIFO
        else if (x >= 15 && x < 25)
            put_pixel(urgb_u32(0, 0xff, 0));//[0x00,g,0x00] into FIFO
        else if (x >= 30 && x < 40)
            put_pixel(urgb_u32(0, 0, 0xff));//[0x00,0x00,b] into FIFO
        else
            put_pixel(0); //all 24 bits in FIFO are 0
    }
}

void pattern_random(uint len, uint t) {  //print random color of LED
    if (t % 8)
        return;
    for (int i = 0; i < len; ++i)
        put_pixel(rand()); //
}

void pattern_sparkle(uint len, uint t) { //step 24/27
    if (t % 8)
        return;
    for (int i = 0; i < len; ++i)   //LED color decided by t
        put_pixel(rand() % 16 ? 0 : 0xffffffff);
}

void pattern_greys(uint len, uint t) {  //step 24/27
    int max = 100; // let's not draw too much current!
    t %= max;
    for (int i = 0; i < len; ++i) {
        put_pixel(t * 0x10101);
        if (++t >= max) t = 0;
    }
}

typedef void (*pattern)(uint len, uint t);
const struct {
    pattern pat;
    const char *name;
} pattern_table[] = {               //step 27/step 24
        {pattern_snakes,  "Snakes!"},//step
        {pattern_random,  "Random data"},
        {pattern_sparkle, "Sparkles"},
        {pattern_greys,   "Greys"},
};

int main() {
    //set_sys_clock_48();
    stdio_init_all();                          //step 1
    printf("WS2812 Smoke Test, using pin %d", WS2812_PIN); //step2

    // todo get free sm
    PIO pio = pio0;  //step 3
    int sm = 0;     //step
    uint offset = pio_add_program(pio, &ws2812_program);  //step5

    ws2812_program_init(pio, sm, offset, WS2812_PIN, 800000, IS_RGBW);  //step6

    int t = 0;//step 22
    while (1) {
        int pat = rand() % count_of(pattern_table); //step 23
        int dir = (rand() >> 30) & 1 ? 1 : -1;//step 23
        puts(pattern_table[pat].name); //step 24
        puts(dir == 1 ? "(forward)" : "(backward)"); //step 25
        for (int i = 0; i < 1000; ++i) { //step 26
            pattern_table[pat].pat(NUM_PIXELS, t);//step 27
            sleep_ms(10);//step 28
            t += dir;//step 29
        }
    }
}

//ws2812.pio.h
// -------------------------------------------------- //
// This file is autogenerated by pioasm; do not edit! //
// -------------------------------------------------- //
#pragma once
#if !PICO_NO_HARDWARE
#include "hardware/pio.h"
#endif
// ------ //
// ws2812 //
// ------ //
#define ws2812_wrap_target 0
#define ws2812_wrap 3
#define ws2812_T1 2
#define ws2812_T2 5
#define ws2812_T3 3
static const uint16_t ws2812_program_instructions[] = {
            //     .wrap_target
    0x6221, //  0: out    x, 1            side 0 [2]
    0x1123, //  1: jmp    !x, 3           side 1 [1]
    0x1400, //  2: jmp    0               side 1 [4]
    0xa442, //  3: nop                    side 0 [4]
            //     .wrap
};

#if !PICO_NO_HARDWARE
static const struct pio_program ws2812_program = {
    .instructions = ws2812_program_instructions,
    .length = 4,
    .origin = -1,
};

static inline pio_sm_config ws2812_program_get_default_config(uint offset) { //step 9
    pio_sm_config c = pio_get_default_sm_config(); //step 10
    sm_config_set_wrap(&c, offset + ws2812_wrap_target, offset + ws2812_wrap);//step 11
    sm_config_set_sideset(&c, 1, false, false);//step 12
    return c;//step 13
}

#include "hardware/clocks.h"
static inline void ws2812_program_init(PIO pio, uint sm, uint offset, uint pin, float freq, bool rgbw) {
    pio_gpio_init(pio, pin);  //step7
    pio_sm_set_consecutive_pindirs(pio, sm, pin, 1, true); //step8
    pio_sm_config c = ws2812_program_get_default_config(offset); //step 9
    sm_config_set_sideset_pins(&c, pin);//step 14
    sm_config_set_out_shift(&c, false, true, rgbw ? 32 : 24);//step 15
    sm_config_set_fifo_join(&c, PIO_FIFO_JOIN_TX);//step 16
    int cycles_per_bit = ws2812_T1 + ws2812_T2 + ws2812_T3;//step 17
    float div = clock_get_hz(clk_sys) / (freq * cycles_per_bit);//step 18
    sm_config_set_clkdiv(&c, div);//step 19
    pio_sm_init(pio, sm, offset, &c);//step 20
    pio_sm_set_enabled(pio, sm, true);//step 21
}

#endif

// --------------- //
// ws2812_parallel //
// --------------- //

#define ws2812_parallel_wrap_target 0
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#define ws2812_parallel_wrap 3

#define ws2812_parallel_T1 2
#define ws2812_parallel_T2 5
#define ws2812_parallel_T3 3

static const uint16_t ws2812_parallel_program_instructions[] = {
            //     .wrap_target
    0x6020, //  0: out    x, 32
    0xa10b, //  1: mov    pins, !null            [1]
    0xa401, //  2: mov    pins, x                [4]
    0xa103, //  3: mov    pins, null             [1]
            //     .wrap
};

#if !PICO_NO_HARDWARE
static const struct pio_program ws2812_parallel_program = {
    .instructions = ws2812_parallel_program_instructions,
    .length = 4,
    .origin = -1,
};

static inline pio_sm_config ws2812_parallel_program_get_default_config(uint offset) {
    pio_sm_config c = pio_get_default_sm_config();
    sm_config_set_wrap(&c, offset + ws2812_parallel_wrap_target, offset + ws2812_parallel_wrap);
    return c;
}

#include "hardware/clocks.h"
static inline void ws2812_parallel_program_init(PIO pio, uint sm, uint offset, uint pin_base, uint pin_count, float freq) {
    for(uint i=pin_base; i<pin_base+pin_count; i++) {
        pio_gpio_init(pio, i);
    }
    pio_sm_set_consecutive_pindirs(pio, sm, pin_base, pin_count, true);
    pio_sm_config c = ws2812_parallel_program_get_default_config(offset);
    sm_config_set_out_shift(&c, true, true, 32);
    sm_config_set_out_pins(&c, pin_base, pin_count);
    sm_config_set_set_pins(&c, pin_base, pin_count);
    sm_config_set_fifo_join(&c, PIO_FIFO_JOIN_TX);
    int cycles_per_bit = ws2812_parallel_T1 + ws2812_parallel_T2 + ws2812_parallel_T3;
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    float div = clock_get_hz(clk_sys) / (freq * cycles_per_bit);
    sm_config_set_clkdiv(&c, div);
    pio_sm_init(pio, sm, offset, &c);
    pio_sm_set_enabled(pio, sm, true);
}

#endif
```